EISSN 2667-6370

Turkish Journal of Anaesthesiology & Reanimation

Volume 54 • Issue 2 • April 2026

Official journal of the TURKISH SOCIETY OF ANAESTHESIOLOGY AND REANIMATION

turkjanaesthesiolreanim.org

Turkish Journal of Anaesthesiology & Reanimation

Turkish Journal of Anaesthesiology & Reanimation

Turkish Journal of Anaesthesiology & Reanimation

EDITORIAL BOARD

Publisher Contact
Address: Molla Gürani Mah. Kaçamak Sk. No: 21/1
34093 İstanbul, Türkiye
Phone: +90 (530) 177 30 97
E-mail: info@galenos.com.tr/yayin@galenos.com.tr
Web: www.galenos.com.tr
Publisher Certificate Number: 14521

Publishing Date: April 2026
E-ISSN: 2667-6370
International scientific journal published bimonthly.

Turkish Journal of Anaesthesiology & Reanimation

Please refer to the journal's webpage (**https://turkjanaesthesiolreanim.org/**) for "Ethical Policy", "Instructions to Authors" and "Instructions to Reviewers".

The editorial and publication process of the Turkish Journal of Anaesthesiology and Reanimation are shaped in accordance with the guidelines of the International Committee of Medical Journal Editors (ICMJE), World Association of Medical Editors (WAME), Council of Science Editors (CSE), Committee on Publication Ethics (COPE), European Association of Science Editors (EASE), and National Information Standards Organization (NISO). The journal is in conformity with the Principles of Transparency and Best Practice in Scholarly Publishing. Turkish Journal of Anaesthesiology and Reanimation is indexed in **PubMed Central, Web of Science - Emerging Sources Citation Index, Scopus, DOAJ, TUBITAK ULAKBIM TR Index, China National Knowledge Infrastructure (CNKI), EMBASE, EmCare, CINAHL, ProQuest** and **Gale**.

The journal is published online.

Owner: Prof. Jülide Ergil on behalf of the Turkish Anaesthesiology and Reanimation Association

Responsible Manager: Zekeriyya Alanoğlu

Turkish Journal of Anaesthesiology & Reanimation

Contents

Original Articles

Case Reports

Turkish Journal of Anaesthesiology & Reanimation

Contents

Turkish Journal of Anaesthesiology & Reanimation

Editorial

In Memory of Prof. Dr., Filiz Tüzüner

Reflections from a Colleague and Her Students

My dear friend, my companion-months have passed since your loss, yet I have not been able to grow accustomed to your absence, nor have I been able to forget you. We worked together for many years, and during that time I had the privilege of getting to know you closely. They say that people are best understood while traveling together. We shared many journeys, and in each of them we created wonderful memories marked by harmony and solidarity.

Professor Filiz always had exceptional interpersonal skills. She knew how to win people's hearts and approached everyone with understanding and kindness. With these qualities, she served successfully for many years as the Chair of the Department of Anaesthesiology and Reanimation at Ankara University Faculty of Medicine. During her tenure, significant progress was achieved in the fields of anaesthesia, intensive care, and pain medicine. Her successful career was not limited to the university environment. She also served as the President of the Turkish Society of Anaesthesiology and Reanimation, achieving important accomplishments both nationally and internationally.

With her openness to scientific innovation, she helped pave the way for many important developments. She made invaluable contributions to the growth of anaesthesiology and to the establishment and advancement of the Pain and Intensive Care divisions.

Beyond her professional life, one of the first things that stood out about Professor Filiz was that she was a loving and devoted mother and a wonderful spouse. Despite belonging to a demanding profession, she managed to combine academic success with a rich social life, becoming an exemplary model of a Turkish woman.

My dear friend, you will always be remembered with love, respect, and longing-for the valuable work you accomplished and for your warm and embracing personality. You will never be forgotten.

Prof. Dr., Yüksel Keçik

Ankara University Faculty of Medicine,

Retired Professor of Anaesthesiology and Reanimation

Turkish Journal of Anaesthesiology & Reanimation

Dear Prof. Dr., Filiz Tüzüner,

On the day I applied to the Department of Anaesthesiology, I was taking the oral examination and felt extremely anxious. As I was walking up the stairs of the Morphology Building, I saw the senior professors approaching. You looked at me with such warmth; those kind and familiar eyes I remembered from my student years were smiling at me once again. From that day on, you never withheld that affectionate gaze from me, my dear mentor.

You were the master of my profession, and I was a student who felt truly privileged and happy to be your apprentice. Throughout every stage of my professional life, you guided me and your vision illuminated my path. You always expressed inspiring and honorable thoughts about being a physician, about our profession, and about being an academic at Ankara Medical School. These values and ideals are now being passed down from generation to generation and continue to reach the anaesthesiologists we train.

You stood by me—not only as my mentor but as a part of my family—when I got married, when I took my specialty examinations, when my children were born and grew up, and throughout my academic promotions, from associate professorship to full professorship. Your loving heart embraced all of us.

You taught us how to be not only good anaesthesiologists, but also good human beings, principled academics, and proud members of Ankara Medical School. You were an extraordinarily hardworking and strong woman. In your presence, we felt both free and supported, while your authority gently encompassed us all.

I have always taken your philosophy of life as my guide. I never witnessed you harbor ill intentions toward anyone. You consistently focused on the positive aspects of people and events and helped us to recognize them as well.

When you retired, I remember thinking how much I would miss you and wondering how I would manage in your absence. Now, as I experience the sorrow of your loss, I realize that I am never truly without you. In every situation, I still feel your guidance. Whenever I ask myself, "What would Prof. Filiz do in this situation?," your words immediately show me the way.

My esteemed and beloved mentor,

You will always be with us. I am deeply grateful to have been your student, and to have been like a daughter to you.

I love you dearly, and you will forever remain in my heart and by my side.

Prof. Dr., Neslihan Alkış

Ankara University Faculty of Medicine, Chair,
Department of Anaesthesiology and Reanimation

Turkish Journal of Anaesthesiology & Reanimation

In Memory of Prof. Dr., Filiz Tüzüner: A Legacy that Inspires Future Generations

Prof. Dr., Filiz Tüzüner, a highly respected leader in the field of anaesthesiology, has passed away, leaving behind a legacy that will not be forgotten. Her dedication to her profession, unwavering ethical principles, and academic excellence influenced not only her own generation but also countless physicians who followed.

She was a generous mentor who sincerely supported young colleagues, guiding them with both knowledge and kindness. For many physicians, she played a pivotal role in shaping their careers. Beyond her professional achievements, she will also be remembered for her warmth, grace, and the genuine connections she built with those around her.

To honor her memory, our journal is establishing an annual award for authors under the age of 35. Each year, the editorial board will select first-, second-, and third-place winners. The prizes will be 1,000 USD for first place, 650 USD for second place, and 350 USD for third place. This award reflects her commitment to supporting young physicians and aims to inspire the next generation to continue along the path she helped define.

We remember Prof. Dr., Filiz Tüzüner with deep respect and gratitude.

Prof. Dr., Zekeriyya Alanoğlu

Washington University in St. Louis, School of Medicine, Department of Anaesthesiology

St. Louis, United States

Editor-in-Chief Turkish Journal of Anaesthesiology and Reanimation

Original Article
Outpatient Anaesthesia

DOI: 10.4274/TJAR.2025.252044
Turk J Anaesthesiol Reanim 2026;54(2):83-88

Turkish Journal of Anaesthesiology & Reanimation

Knowledge, Practices, and Awareness Regarding Out-of-operating Room Sedation Among Non-anaesthesia Health Professionals: A Questionnaire Study

Yaşar Gökhan Gül[1], Selçuk Alver[2], Burak Ömür[1], Ayşe Nurmen Akın[1], Birzat Emre Gölboyu[3], Bahadır Çiftçi[1]

[1]İstanbul Medipol University Faculty of Medicine, Department of Anaesthesiology and Reanimation, İstanbul, Türkiye
[2]Biruni University Faculty of Medicine, Department of Anaesthesiology, İstanbul, Türkiye
[3]İzmir Katip Çelebi University Faculty of Medicine, Department of Anaesthesiology, İzmir, Türkiye

Abstract

Objective: The efficacy and safety of sedation administered by non-anaesthesia healthcare professionals should be evaluated within the framework of evidence-based protocols, and approaches should be adopted to ensure patient safety at the highest level. We aimed, with a scientific approach, to evaluate non-operating-room anaesthesia applications performed by non-anaesthesia health professionals in terms of patient safety, quality, and consistency, and to identify areas of deficiency.

Methods: After obtaining ethical approval, a questionnaire was prepared to evaluate practitioners' awareness of the anaesthesia and sedation processes administered to patients during procedures performed in their clinics. An electronic questionnaire (Google Form) was used to collect data.

Results: This study revealed that non-operating-room sedation applications are widely practiced across various specialties in our country, but levels of knowledge and skill regarding these applications are not standardized. Extending in-service training, developing practical skills in managing complications, and using objective criteria for patient follow-up after sedation are of great importance for patient safety and clinical efficacy.

Conclusion: Standardization of sedation practices can be achieved through multidisciplinary cooperation and the adoption of protocols based on current guidelines. In this context, it is recommended that structured training programs and clinical guidelines be established for non-anaesthesia healthcare professionals.

Keywords: Anaesthesiology, non-anaesthesia health professionals, outpatient anaesthesia, questionnaire, sedation

Main Points

- Faster discharge rates, reduced health expenditures, and increased comfort demands from patients and physicians are increasing demand for non-operating-room anaesthesia (NORA) applications.
- Sedation competence requires practitioners to have knowledge of, and skills in, airway management, hemodynamic monitoring, and drug titration.
- The efficacy and safety of sedation administered by non-anaesthesia healthcare professionals should be evaluated within the framework of evidence-based protocols and approaches should be adopted to ensure patient safety at the highest level.
- In our study, we aimed to evaluate, using a scientific approach, the NORA applications performed by non-anaesthesia health professionals in terms of patient safety, quality, and consistency, and to identify areas of deficiency.

Corresponding author: Bahadır Çiftçi MD **E-mail:** bciftci@medipol.edu.tr, baha_cftci@hotmail.com
Received: May 02, 2025 **Accepted:** November 03, 2025 **Epub:** November 11, 2025 **Published date:** April 15, 2026
Cite this article as: Gül YG, Alver S, Ömür B, Akın AN, Gölboyu BE, Çiftçi B. Knowledge, practices, and awareness regarding out-of-operating room sedation among non-anaesthesia health professionals: a questionnaire study. *Turk J Anaesthesiol Reanim*. 2026;54(2):83-88

Introduction

Today, the rapid development of medical technologies has made it possible for physicians to diagnose health problems more rapidly and initiate treatment promptly. Pain and anxiety experienced by patients during non-operative diagnostic and treatment procedures are important problems that reduce patient comfort and delay patients' return to daily life after the procedure. Faster discharge rates, reduction of health expenditures, and comfort demands of patients and physicians are increasing the demand for non-operating-room anaesthesia (NORA) applications.[1-3]

Demands by health professionals on anaesthesiologists have led to the emergence of new areas of practice. Sedation and analgesia are administered to patients during diagnosis and treatment in ear, nose and throat, dental, gastroenterology, psychiatry, cardiology, neurology, radiation oncology, and urology clinics.[4-7] Sedation procedures are also used in various non-operating-room settings, including complex imaging-guided interventions in radiology and diagnostic and therapeutic endoscopic procedures in gastroenterology.

The wide working area increases the workload of anaesthesia professionals and prevents anaesthesiologists from accessing all areas of the workspace. While national guidelines for sedation exist, they are primarily directed at anaesthesiologists. The regulations governing sedation administered by non-anaesthesia healthcare professionals are less well defined, creating a potential gap in standardized practice and patient safety.

Sedation competence requires practitioners to have knowledge and skills in airway management, hemodynamic monitoring and drug titration.[8-10] The responsibility for anaesthesia and sedation administered by non-anaesthesia professionals during NORA applications rests with the physician performing the procedure. Therefore, the efficacy and safety of sedation administered by non-anaesthesia healthcare professionals should be evaluated within the framework of evidence-based protocols, and approaches should be adopted to ensure the highest level of patient safety.

In our study, it was aimed to evaluate the NORA applications performed by non-anaesthesia health professionals with a scientific approach in terms of patient safety, quality, and consistency and to identify the areas of deficiency.

Methods

Compliance with Ethical Standards

This survey study was approved by the Istanbul Medipol University Non-invasive Clinical Research Ethics Committee (approval no.:1006, date: 07.12.2023).

Study Design

After obtaining ethical approval, the questionnaire questions were prepared to evaluate the awareness levels of the practitioners in the process of anaesthesia and sedation given to the patient during the procedures they performed in their clinics. An electronic questionnaire form (Google Form) was used to collect data. All participants consented to participation, data processing, and inclusion of their data in medical research at the beginning of the survey. Informed consent was obtained from the participants. The prepared questionnaire was distributed to assistants, specialists, and faculty members in the clinics at our hospital where anaesthesia and sedation are administered outside the operating room, via a WhatsApp link.

Participants were presented with an informative text in the introductory section of the questionnaire that described the purpose and nature of the study. The questions were determined by a consensus of the authors and were subsequently reviewed for content validity, clarity, and relevance by an expert panel consisting of (five senior anaesthesiologists and three senior physicians from procedural specialties) before distribution, and 16 questions were prepared to measure the duration of experience of the practitioners, their experience of anaesthesia and sedation in the procedures they frequently performed in their branch, the importance of preoperative evaluation, whether the physicians participated in in-service training, the complications they experienced and their causes, the discharge criteria after the procedure, and their awareness of the effects and side effects of anaesthetic and analgesic drugs. A questionnaire was sent to 150 practitioners, and data from the 118 practitioners who completed the questionnaire within the specified dates were analyzed. A formal sample size calculation was not performed because this was an exploratory, descriptive, questionnaire-based study. We used a convenience sample by sending the questionnaire to 150 practitioners.

The survey questions did not impose any age-group or specialty restrictions. Based on responses to all questions, the impact of sedation and analgesia applications performed outside the operating room by non-anaesthesia professionals on patient and operator safety was evaluated.

It is not known from which personal phone the link originated, and the confidentiality of personal information is maintained. Survey participants are informed about the protection of personal data before starting the survey. People who agree to participate in the survey are committed to volunteerism. Responses were collected and statistical findings were obtained. The survey questions are presented in Table 1.

Table 1. Survey Questions
What is your gender?
Your educational background?
Total length of professional service?
What is your specialty?
Have you received in-service training for sedation applications outside the operating room?
Do you feel adequate about the maximum and minimum doses of the drugs you use in your non-operating room sedation experience?
Which drugs do you prefer in your non-operating room sedation experience?
Do you have information about the fasting times to be observed before the procedure in your non-operating room sedation experience?
Have you experienced any complications during the procedure due to the medications used in your out-of-the-operating room sedation experience?
Do you feel competent in managing complications that may occur due to the medications you used in your out-of-the-operating room sedation experience?
Did you call a code blue in your out-of-the-operating room sedation experience?
Do you use any assessment scales when planning discharge after the procedure in your non-operating room sedation experience?
Which age range of patients do you work with the most in your out-of-the-operating room sedation experience?
Did you have any fears or concerns before out-of-the-operating room sedation?
What are the disadvantages of sedation outside the operating room?
What are the advantages of sedation outside the operating room?
When do you prefer to apply sedation?

Statistical Analysis

The collected data were analyzed using SPSS 22.0 statistical software (IBM Corp., Armonk, NY, USA). Frequency distributions were calculated and presented as numbers and percentages.

Results

In this study, a questionnaire form about sedation practices outside the operating room was delivered to 118 participants, and the questionnaire was delivered to 118 participants, and all responses were analyzed. Of the participants, 59.4% were male (n = 70) and 40.6% were female (n = 48). By educational status, 33 (27.9%) were residents, 16 (13.5%) were specialist doctors, 24 (20.3%) were assistant professors, 9 (7.6%) were associate professors, and 36 (30.5%) were professors.

When the duration of professional experience of the participants was analyzed, 29 (24.5%) had 0-5 years of experience 17 (14.1%) 6-10 years, 15 (12.7%) had 11-15 years, 9 (7.6%) had 16-20 years, and 48 (40.6%) had 21 years or more (Figure 1).

While 24.6% (n = 29) of the participants stated that they received in-service training on sedation practices outside the operating room, 72.8% (n = 86) stated that they did not receive training, and 2.5% (n = 3) stated that they had no opinion on this issue.

When the perception of adequacy regarding drug doses was analyzed, 29 participants (24.6%) reported that the doses were adequate, 76 (64.4%) reported that the doses were inadequate, and 13 (11%) had no opinion on this issue (Figure 2).

While 74.5% (n = 88) of the participants reported having information about the fasting period before the procedure, 10.1% (n = 12) reported that they did not have information, and 15.2% (n = 18) were undecided.

Of the participants, 23 participants (19.5%) reported experiencing medication-related complications, 75 (63.5%)

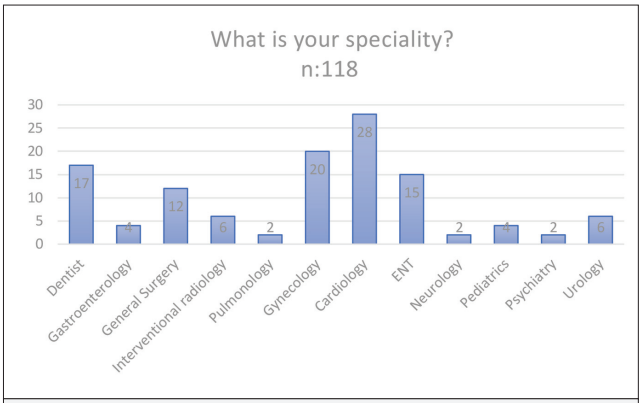


Figure 1. Specialization areas of the participants.
ENT, ear, nose, and throat.

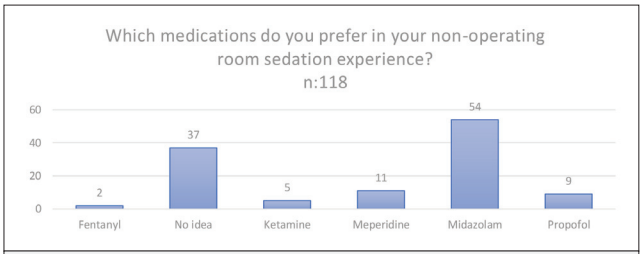


Figure 2. The sedative agents preferred by the participants.

did not, and 20 (16.9%) were unsure. Figure 3 illustrates the disadvantages of administering sedation outside the operating room. These reported complications were generally minor adverse drug reactions (e.g., nausea, vomiting, and dizziness) and did not necessitate a Code Blue call; this was assessed separately.

When the participants perception of competence in complication management was evaluated, 35 participants (29.6%) reported feeling competent, 68 (57.6%) reported not feeling competent, and 15 (12.7%) were undecided. While the specific reason for activation was not collected in the survey, Code Blue events during procedural sedation are most commonly initiated by life-threatening respiratory events (e.g., respiratory failure or apnea) or by profound cardiovascular instability (e.g., cardiac arrest or severe hypotension).

When the status of issuing a "Code Blue" alert was analyzed, 20 participants (16.9%) stated that they issued the reported issuing the alert, 82 (69.5%) did not, and 16 (13.5%) were undecided.

When asked about the use of assessment scales in discharge planning, only 6 participants (5%) reported using a scale, 79 (66.9%) reported not using one, and 33 participants (27.9%) were undecided.

Regarding the patient age-group they most frequently worked with, 16 participants (13.5%) worked with patients aged 0-8 years, 2 participants (1.6%) with patients aged 9-16 years; 60 participants (50.8%) with patients aged 17-64 years; 15 participants (12.7%) with patients aged 65+ years and older, and 25 participants (21.1%) were undecided.

In the case of regarding fear or anxiety about the possibility of complications prior to non-operating-room sedation, 28 people (23.7%) stated that they were concerned, 49 people (41.5%) reported not being concerned, and 41 people (34.7%) were undecided.

Figure 3 shows the disadvantages of sedation outside the operating room and Figure 4 illustrates the advantages of sedation administered outside the operating room.

When the time of sedation preference was questioned, when participants were asked about the timing of sedation, 46

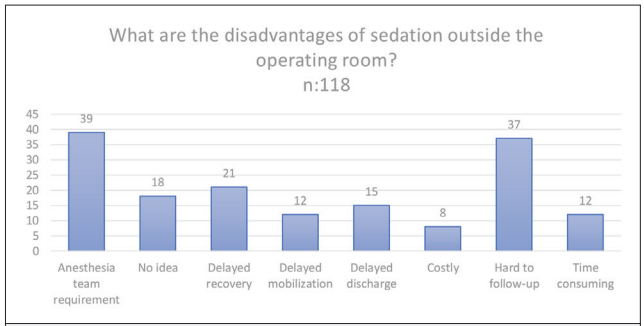


Figure 3. The disadvantages of sedation outside the operating room.

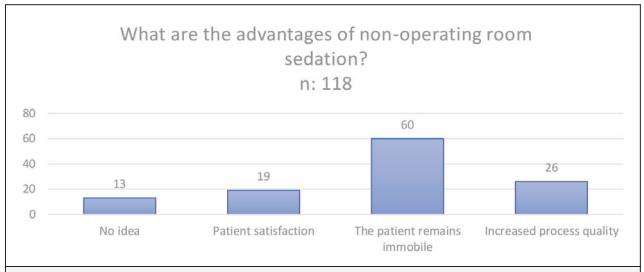


Figure 4. The advantages of sedation outside the operating room.

(38.9%) stated that they preferred sedation at the patient's request, 47 (39.3%) stated that they preferred sedation inthat they preferred sedation during complex procedures, 10 (8.4%) cited other reasons, and 14 (11.6%) were undecided. Figure 4 shows the advantages of sedation outside the operating room.

Discussion

In this study, we evaluated physicians from different specialties regarding their knowledge, clinical practice habits, and complication-management competencies for sedation administered outside the operating room. The findings revealed that many participants lacked knowledge in certain areas necessary for the safe and effective administration of sedation.

Sedation is a widely used technique to ensure patient comfort and reduce anxiety and pain during medical and interventional procedures. This method, which can be applied in a spectrum ranging from light sedation to deep sedationa cross a spectrum from light to deep sedation, helps the patient maintain hemodynamic stability by preserving the level of consciousness during the procedure. Appropriate management of sedation is critical to prevent complications such as respiratory depression, aspiration, and cardiovascular instability.[1-5]

To perform these procedures safely and effectively, it is important to determine appropriate sedation protocols and

to evaluate the effectiveness of their application by non-anaesthesia health professionals.[11,12] Various complications related to a procedure or to anaesthesia may occur during the procedures.[11,13,14] Patients should be thoroughly evaluated prior to the procedure to reduce complication rates. The properties of the anaesthetic and analgesic drugs to be used during the procedure should be well known; the patient's tolerance and allergy status should be assessed and appropriate agents should be selected. Non-anaesthesia branch physicians who will perform the procedures should attend in-service sedation and analgesia training.[4-7]

Only one-fourth of the participants (24.6%) reported receiving in-service training in sedation, highlighting the need for up-to-date guidelines and training programs.[1] The higher rates of mortality and morbidity observed in patients receiving sedation in NORA settings compared with those in the operating room are primarily due to inadequate care and failures to adhere to safe practices.[2] The American Society of Anesthesiologists emphasizes that standardization and quality control measures are essential to mitigate these risks in remote locations.[15] Similarly, the proportion of participants who reported feeling competent in drug dosing and complication management was low. This situation raises potential risks to patient safety in sedation practices.[3] Despite low self-perceived competence in drug dosage and complication management and a lack of formal training, non-anaesthesia professionals continue to perform these procedures. We speculate that this may be due to high clinical demand, pressure to increase throughput, and a shortage of anaesthesia professionals. We explicitly state that this discrepancy highlights a potentially significant risk to patient safety. Although 74.5% of the participants had information on the duration of fasting before the procedure, the fact that a significant proportion (25.5%) had insufficient information on this subject represents an important deficiency for preventing serious complications such as the risk of aspiration.[4] That evaluation scales were not used extensively when making discharge decisions (66.9%) indicates that these decisions rely on subjective assessments. Complex interventions and patient demand stand out as the most common reasons for sedation. This finding indicates that sedation is not only a medical intervention but is also important for increasing patient satisfaction.[5] Although monitored anaesthesia care implemented in non-operating-room settings increases patient comfort and procedural efficiency, safety considerations are also taken into account, thereby optimizing patient care.[6] Approximately one-fifth of the participants (19.5%) reported drug-related complications, but the percentage who felt adequate in managing complications remained at 29.6%. This suggests that skills for intervening in complications should be improved.[7] In sedation-induced airway management, early recognition and intervention are essential to prevent permanent sequelae. Keeping the necessary equipment and medications ready and accessible, knowing the management steps to be followed, and displaying them in the rooms, if necessary, are recommended to prevent complications.[10] Ultimately, standardization of NORA practices will be possible only with multidisciplinary collaboration guided by published professional standards. The Anesthesia Patient Safety Foundation and other professional bodies have issued recent recommendations focusing on infrastructure, staffing, and continuous quality improvement necessary for the safe conduct of NORA.[16-18]

Study Limitations

This study has some limitations. The sample size was small. A formal sample size calculation was not performed for this descriptive study; we used a convenience sample. On the other hand, the study was conducted at a single center. Multicenter and international studies would be beneficial to the literature. Finally, our survey asked only whether a "Code Blue" was called, not the specific reason for the activation.

Conclusion

This study revealed that non-operating room sedation applications are widely practiced in various branches in our country, but the level of knowledge and skills regarding these applications is not standardized. Extending in-service trainings, developing practical skills in complication management, and using objective criteria in patient follow-up after sedation are of great importance in terms of patient safety and clinical efficacy.[8]

Standardization of sedation practices will be possible with multidisciplinary cooperation and adoption of protocols based on current guidelines. In this context, it is recommended to establish structured training programs and clinical guidelines for non-anaesthesia healthcare professionals.[9]

Ethics

Ethics Committee Approval: This survey study was approved by the Istanbul Medipol University Non-invasive Clinical Research Ethics Committee (approval no.: 1006, date: 07.12.2023).

Informed Consent: Informed consent was obtained from the participants.

Footnotes

Author Contributions: Surgical and Medical Practices - Y.G.G., S.A., B.Ö., A.N.A., B.Ç.; Concept - Y.G.G., S.A., B.Ö., A.N.A., B.E.G., B.Ç.; Design - Y.G.G., S.A., B.Ö., A.N.A., B.E.G., B.Ç.; Data Collection and/or/Processing - Y.G.G., S.A., B.Ö., A.N.A., B.Ç.; Analysis and/or/ Interpretation - A.N.A., B.E.G.; Literature Review - Y.G.G., S.A., B.Ö., A.N.A., B.E.G., B.Ç.; Writing - Y.G.G., S.A., B.Ö., A.N.A., B.E.G., B.Ç.

Declaration of Interests: The authors declare no conflict of interests.

Funding: No funding was received for the study.

References

1. Coté CJ, Wilson S; American Academy of Pediatrics; American Academy of Pediatric Dentistry. Guidelines for monitoring and management of pediatric patients before, during, and after sedation for diagnostic and therapeutic procedures: update 2016. *Pediatrics.* 2016;138(1):e20161212. [CrossRef]
2. Walls JD, Weiss MS. Safety in non-operating room anesthesia (NORA). *APSF Newsletter.* 2019;34(1):3-4. [CrossRef]
3. Practice Guidelines for Moderate Procedural Sedation and Analgesia 2018: a report by the American Society of Anesthesiologists Task Force on Moderate Procedural Sedation and Analgesia, the American Association of Oral and Maxillofacial Surgeons, American College of Radiology, American Dental Association, American Society of Dentist Anesthesiologists, and Society of Interventional Radiology. *Anesthesiology.* 2018;128(3):437-479. [CrossRef]
4. Cravero JP, Beach ML, Blike GT, Gallagher SM, Hertzog JH. The incidence and nature of adverse events during pediatric sedation/anesthesia with propofol for procedures outside the operating room. *Anesth Analg.* 2009;108(3):795-804. [CrossRef]
5. Owusu-Agyemang P, Tsai JY, Kapoor R, et al. Survey of anesthesia, sedation, and non-sedation practices for children undergoing repetitive cranial or craniospinal radiotherapy. Cureus. 2022;14(4):e24075. [CrossRef]
6. Shah D, Sen J, Bawiskar D. Non-operating room anesthesia (NORA): a comprehensive review of monitored anesthesia care. *Cureus.* 2024;16(8):e68024. [CrossRef]
7. Rupreht J. Education and training in anaesthesia — a plea for one standard in europe. In: Gullo A, eds. Anaesthesia, Pain, Intensive Care and Emergency Medicine - A.P.I.C.E.. Springer Milano; 1997:949-952. [CrossRef]
8. Sury MR, Arumainathan R, Belhaj AM, MacG Palmer JH, Cook TM, Pandit JJ. The state of UK pediatric anesthesia: a survey of National Health Service activity. Paediatr Anaesth. 2015;25(11):1085-1092. [CrossRef]
9. Youn AM, Ko YK, Kim YH. Anesthesia and sedation outside of the operating room. Korean J Anesthesiol. 2015;68(4):323-331. [CrossRef]
10. Tobias JD, Leder M. Procedural sedation: a review of sedative agents, monitoring, and management of complications. *Saudi J Anaesth.* 2011;5(4):395-410. [CrossRef]
11. Pigò F, Gottin M, Conigliaro R. The incidence of adverse events in adults undergoing procedural sedation with propofol administered by non-anesthetists: a systematic review and meta-analysis. *Diagnostics (Basel).* 2025;15(10):1234. [CrossRef]
12. Youn AM, Ko YK, Kim YH. Anesthesia and sedation outside of the operating room. *Korean J Anesthesiol.* 2015;68(4):323-331. [CrossRef]
13. Cabadas Avión R, Baluja A, Ojea Cendón M, et al. Effectiveness and safety of gastrointestinal endoscopy during a specific sedation training program for non-anesthesiologists. *Rev Esp Enferm Dig.* 2019;111(3):199-208. [CrossRef]
14. Karamnov S, Sarkisian N, Grammer R, Gross WL, Urman RD. Analysis of adverse events associated with adult moderate procedural sedation outside the operating room. *J Patient Saf.* 2017;13(3):111-121. [CrossRef]
15. Khorsand S, Karamchandani K, Joshi GP. Sedation-analgesia techniques for nonoperating room anesthesia: an update. *Curr Opin Anaesthesiol.* 2022;35(4):450-456. [CrossRef]
16. Beard J, Methangkool E, Angus S, Urman RD, Cole DJ. Consensus recommendations for the safe conduct of nonoperating room anesthesia: a meeting report from the 2022 stoelting conference of the anesthesia patient safety foundation. *Anesth Analg.* 2023;137(2):e8-e11. [CrossRef]
17. Muir A, Hart R. Non-operating room anaesthesia: general considerations. *Anaesthesia & Intensive Care Medicine.* 2023;24(7):412-415[CrossRef]
18. Bridges KH, Wilson PR, Tobin CD. Nonoperating room anesthesia: what is new? What is controversial? *Current Anesthesiology Reports.* 2024;14(1):101-109. [CrossRef]

Original Article
Other

DOI: 10.4274/TJAR.2025.2083
Turk J Anaesthesiol Reanim 2026;54(2):89-96

Turkish Journal of Anaesthesiology & Reanimation

General and Regional Anaesthesia in Cancer Surgery: A 20-year Bibliometric Analysis

Gökçen Kültüroğlu

University of Health Sciences Türkiye, Ankara Etlik City Hospital, Clinic of Anaesthesiology and Reanimation, Ankara, Türkiye

Abstract

Objective: In recent years, there has been growing interest in the potential effects of anaesthetic agents in cancer surgery. Although the impact of anaesthetic management on long-term oncological outcomes has yet to be definitively established, emerging studies are increasingly exploring interactions with the tumour microenvironment and epigenetic mechanisms. This bibliometric analysis aims to evaluate the existing literature on the use of general and regional anaesthesia in cancer surgery, thereby identifying prevailing trends and informing future research directions.

Methods: This was a retrospective bibliometric study designed to examine publications addressing both "cancer" and "anaesthesia" between 2005 and 2024. A search of the Web of Science database using specified keywords retrieved relevant articles, which were subsequently analysed based on parameters such as publication year, authors, journal, citation count, and country. Data were visualized using software, with network analyses conducted to reveal trends, collaboration networks, and research foci in the literature.

Results: The analysis reviewed 391 articles; the highest number of publications was recorded in 2021 and 2022. These articles collectively garnered 9,068 citations. The most frequently cited studies came from Ireland and the United States, with Dr. Donal Buggy emerging as the leading researcher in the field. The mapping analysis indicated that journals such as Anesthesiology and the British Journal of Anaesthesia were the dominant publication venues.

Conclusion: This study provides valuable insights into the evolving relationship between cancer and anaesthesia over the past two decades. The findings provide a significant foundation for future research and guide scientific development in this field.

Keywords: Anaesthesia, bibliometric analysis, cancer, metastasis, recurrence

Main Points

- The potential impact of anaesthetic agents on oncological outcomes in cancer surgery is being increasingly investigated.
- Bibliometric analysis has mapped the main publication trends, key researchers, and collaboration networks in this field.
- Although the United States has produced the highest number of publications on cancer and anaesthesia in the past 20 years, the most prolific and influential author in the field is MD, Donal J. Buggy from Ireland.

Introduction

Cancer remains a major public health concern worldwide, with approximately 20 million new cases diagnosed each year.[1] Approximately 65% of cancer patients require at least one surgical procedure for diagnostic or therapeutic purposes during the course of their disease.[2] In recent years, it has been increasingly suggested that the success of surgical procedures is influenced not only by the surgical techniques used but also by the anaesthetic methods employed. In particular, a growing number of studies have investigated the potential effects of anaesthetic agents on metabolic, neuroendocrine, inflammatory, and immunological responses, highlighting the importance of optimal anaesthetic management in cancer surgery.[3,4]

It has been hypothesised that anaesthetic agents may, in certain circumstances, interact with tumour biology through mechanisms that either promote tumour progression or, conversely, suppress tumour development.[2] Volatile anaesthetics have been proposed to suppress the immune response by reducing natural killer (NK) cell activity and increasing levels

Corresponding author: Gökçen Kültüroğlu MD **E-mail:** gokcenkulturoglu@hotmail.com
Received: May 13, 2025 **Accepted:** November 11, 2025 **Published date:** April 15, 2026
Cite this article as: Kültüroğlu G. General and regional anaesthesia in cancer surgery: a 20-year bibliometric analysis. *Turk J Anaesthesiol Reanim*. 2026;54(2):89-96

of pro-inflammatory cytokines [tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6), and IL-12], thereby promoting angiogenesis, facilitating tumour cell migration, and potentially supporting tumour progression via these mechanisms. Similarly, recent studies have explored the mechanisms by which opioids may promote tumour growth and have found that they occur either by directly stimulating cancer cells or by enhancing angiogenesis.[5] In contrast, it has been hypothesised that propofol may exert antiangiogenic effects and preserve immune cell function. Similarly, regional anaesthesia may reduce catecholamine levels through sympathetic blockade and suppress cortisol release by inhibiting the hypothalamic-pituitary-adrenal axis, thereby potentially preventing immunosuppression. Preclinical and some retrospective studies have reported that lidocaine may exert antitumour effects by inhibiting oncogene expression, while non-steroidal anti-inflammatory drugs may limit both inflammation and tumour progression by reducing the expression of inflammatory cytokines (nuclear factor kappa-light-chain-enhancer of activated B cells, TNF-α and IL-6) and suppressing related signalling pathways.[6-8] These findings suggest that the choice of anaesthetic technique may influence long-term outcomes after cancer surgery. However, the results of several large-scale clinical studies have failed to support these hypotheses.[9-12] Studies to date have consistently suggested that certain routine anaesthetic and analgesic techniques used during cancer surgery have not shown long-term oncological effects.[2] However, recent studies have focused more on the effects of anaesthesia on interactions with the tumour microenvironment [e.g.,neutrophil extracellular traps (NETs)] rather than on isolating cellular processes.[13] In addition to NET formation (NETosis), emerging studies indicate that cancer epigenetics may also play a significant role in the cancer-anaesthesia relationship.[14-16] Given that large patient cohorts, long-term follow-up of oncological outcomes (e.g., metastasis, disease-free survival, and mortality), and a robust registry system are required to provide definitive evidence and ensure sufficient statistical power, these studies may alter our understanding of the relationship between cancer and anaesthesia.

Bibliometric analysis is essential for assessing the current state of a research field and pinpointing future trends, especially in disciplines that rely on thorough literature reviews. It plays a key role in uncovering critical clusters, landmark studies, and leading centres of expertise within a given domain. As such, it serves as a foundational step enabling researchers to make informed decisions about the areas in which they aim to make advances.[17] Recent evidence has raised interest in the potential influence of anaesthetic techniques on cancer biology, particularly with regard to tumour recurrence and metastasis. Within this context, the role of general (inhalation or intravenous) versus regional anaesthesia remains a subject of ongoing debate. To systematically explore this area, a bibliometric analysis was conducted on studies specifically addressing these anaesthetic approaches in the context of cancer surgery. The most influential publications, authors, citation networks, and research trends in the field of "anaesthetic techniques and cancer" were evaluated based on the available data, thereby providing researchers in this area with a guiding perspective.

Methods

Ethical Statement

The present study was a bibliometric analysis and did not require ethics committee approval because it was conducted using publicly available data.

Study Design

The present study was a retrospective observational analysis designed to examine the bibliometric characteristics of publications on cancer and general-regional anaesthesia. The Strengthening the Reporting of Observational Studies in Epidemiology guidelines were used for reporting.

Data Sources and Search Strategy

A search on the study topic of cancer and general-regional anaesthesia was conducted on December 28, 2024, in the Web of Science (WoS) Science Citation Index Expanded (SCIE) database (Clarivate Analytics, Philadelphia, PA, USA; https://www.webofscience.com/wos/). The search was performed by entering the keywords “cancer” and “general” and “regional” and “anaesthesia” into the topic field. The results were limited to publications from 2005 to 2024. Retracted and duplicate articles were excluded. Data were collected using bibliometric parameters, such as title, authors, year of publication, journal, number of citations, and country of origin. The database search strategically selected the keywords ("cancer" and "general" and "regional" and "anaesthesia") to identify studies on anaesthetic techniques most frequently examined in relation to cancer. Although various anaesthesia-related factors may affect cancer outcomes, the analysis focused solely on general and regional anaesthesia.

Data Extraction and Visualisation

The articles retrieved from the WoS database were exported using the Export Records to Tab Delimited File and Excel formats. The exported data included complete record information related to citations, as well as detailed reference information for each source. Microsoft Excel 2019 (Microsoft Corporation, Santa Rosa, CA, USA) and Visualization of Similarities viewer (VOSviewer) (version 1.6.18; Leiden University, the Netherlands) were used for the analyses. VOSviewer enables the visual representation of bibliographic data and performs network-based analyses. In the figures, the size of the data points represents the number of associated documents, while the colour gradient indicates cluster identity in the network visualisations. The

thickness of the lines connecting the data points reflects the strength of the links between them and depends on the analysed subject (e.g., journal, author, or keyword).

Statistical Analysis

No inferential statistical analysis was performed in this study. Descriptive bibliometric indicators — including total citations, average citations per article, and the h-index — were calculated from the bibliographic data obtained from WoS. Network analyses (co-authorship, co-citation, and keyword co-occurrence) were conducted using VOSviewer (version 1.6.18) and tabulated using Microsoft Excel 2019.

Results

A total of 419 articles were identified by searching the WoS database using the keywords. After restricting the time frame to 2005-2024, 393 articles remained. Following the exclusion of retracted (n=1) and duplicate (n=1) articles, 391 articles were included for further analysis.

Number of Publications and Trends

The number of articles on the study topic increased after periods of stagnation that typically lasted approximately three years between 2005 and 2024. Evaluation of publication numbers showed that 2022 marked the peak, with 48 publications and 1,078 citations (Figure 1). An analysis of fluctuations and periods of stability over the past two decades revealed that the overall trend in publication volume remained relatively steady. Based on the growth regression model represented by the equation $y=3.298 \cdot e^{(0.097 \cdot t)}$, approximately 23 publications in this field are projected for 2025. Overall, these findings suggest a decline in research activity on regional and general anaesthesia in cancer surgery.

According to the citation analysis, the total number of citations for the 391 publications was 9,068. After self-citations by the authors were excluded, 7,885 citations were identified. The average number of citations per publication was 23.13, and the H-index was 47. Of the publications, 96% were written in English, and 75% were indexed in the SCIE database (Table 1).

The first article published in 2005, marking the beginning of the search strategy, appeared in Anaesthesia & Analgesia (Journal Citation Indicator: 2.04, Q1) under the title "Inhibition of the stress response to breast cancer surgery by regional anaesthesia and analgesia does not affect vascular endothelial growth factor and prostaglandin E2". This study, authored by O'Riain SC, Buggy DJ, Kerin MJ, and colleagues, has received 96 citations. The corresponding author is MD, Seosamh O'Riain, and the study was conducted in the Department of Anaesthesia at Mater Misericordiae University Hospital, Dublin, Ireland.[18] The details of the top five most-cited articles according to the search criteria are summarised in Table 2. The most cited article (n=650) was published in Anesthesiology (Journal Citation Indicator: 3.43, Q1) in 2006. The study, titled "Can anaesthetic technique for primary breast cancer surgery affect recurrence or metastasis?" was authored by Exadaktylos AK, et al.[19]. The corresponding author was MD, Donald J. Buggy, and the study was conducted at the Department of Anaesthesia, Mater Misericordiae University Hospital, Dublin, Ireland.

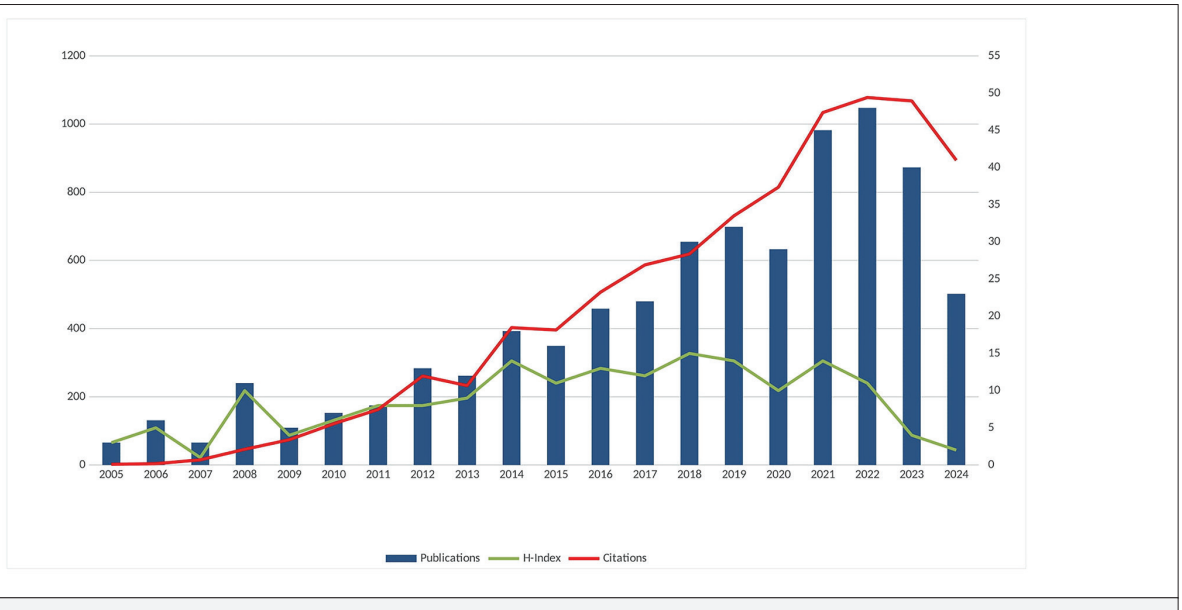


Figure 1. Annual distribution of publications and citations in the literature.

Table 1. Language, Index Coverage, and Citation Information of Articles

Language	n	Index	n	Citation	n
English	375	SCIE	295	Citing article	5,227
German	6	ESCI	88	Citing article (excluding self-citations)	4,969
Spanish	6	Conference	6	Number of citations	9,068
French	3	Proceeding	1	Number of citations (excluding self-citations)	7,885
Portuguese	1	Book chapter	1	H-index	47

SCIE, Science Citation index Expanded; ESCI, Emerging Sources Citation index; H-index, Hirsch index

Table 2. Most Cited Articles Based on Search Criteria

	Publication	First three authors	Published journal	Year	Number of citations
1	Can anaesthetic technique for primary breast cancer surgery affect recurrence or metastasis?[19]	Exadaktylos AK. Buggy DJ. Moriarty DC.	Anaesthesiology	2006	650
2	Anaesthetic technique for radical prostatectomy surgery affects cancer recurrence - a retrospective analysis.[20]	Biki B. Mascha E. Moriarty DC.	Anaesthesiology	2008	478
3	Effect of anaesthetic technique and other perioperative factors on cancer recurrence.[21]	Snyder GL. Greenberg S.	British Journal of Anesthesiology	2010	373
4	The effect of anaesthetic technique on survival in human cancers: a meta-analysis of retrospective and prospective studies.[22]	Chen WK. Miao CH.	PLoS One	2013	171
5	Can anaesthetic and analgesic techniques affect cancer recurrence or metastasis?[5]	Heaney A. Buggy DJ.	British Journal of Anesthesiology	2012	166

Analysis of the clinical studies included in the research data revealed that breast cancer was the most frequently investigated malignancy, representing 63.3% of the studies. This was followed by lung cancer, which accounted for 14.6%, and prostate cancer at 10.2%, highlighting the relative focus of current clinical research on these cancer types.

Based on the title data of publications in the WoS database, an analysis of journals containing sources cited at least 20 times identified six clusters using the VOSviewer mapping technique. The strongest cluster (Cluster 1) included 59 journals, the most prominent of which were Anaesthesiology and the British Journal of Anesthesiology. Cluster 2 features notable journals such as Anaesthesia & Analgesia, Regional Anesthesia and Pain Medicine, Journal of Clinical Anesthesia, and Anaesthesia (Figure 2).

Keyword Analysis

A visualisation analysis of all included publications was performed using 49 keywords that appeared more than five times, resulting in seven clusters (Figure 3). Keywords such as "anaesthesia," "cancer," "regional anaesthesia," and "general anaesthesia" were frequently used because they represented the main topics of the study. Other notable keywords were "breast surgery," "breast cancer surgery," "mastectomy," and "cancer recurrence".

Country Analysis

According to an analysis of WoS articles over the past 20 years, the five countries with the highest number of publications in the field of cancer and anaesthesia were the US (n = 101), China (n = 53), Italy (n = 36), India (n = 33), and Germany (n = 29). However, the countries with the highest number of citations were the US (n = 4,998), Ireland (n = 2,169), and China (n = 934). The US ranks highest in terms of both publication volume and citations. Notably, while Ireland lags behind other countries in terms of publication output, it ranks second (after the US) in citation count.

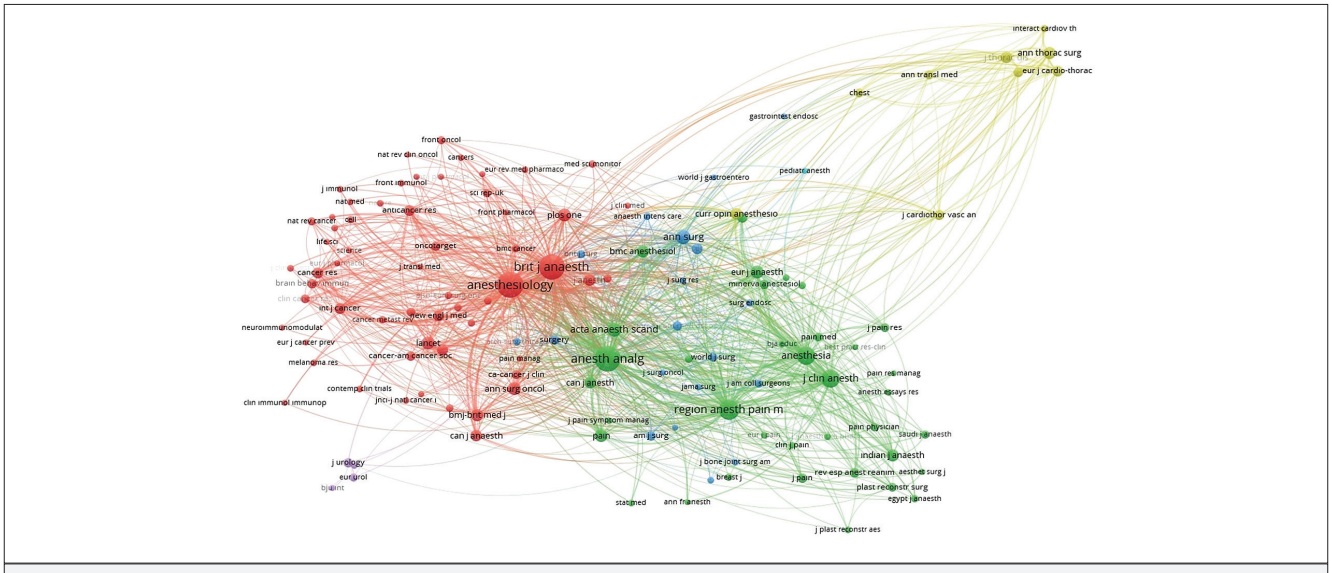


Figure 2. VOSviewer co-citation network visualisation.

VOSviewer, visualization of similarities viewer.

Table 3. Authors with the Most Publications and Citations, and Their Affiliated Institutions

Author	Number of publications	Number of citations	Institution	Country
Donal Buggy	16	1229	Mater Misericordiae University Hospital	Ireland
Daniel I. Sessler	8	916	Cleveland Clinic	US
Juan Cata	6	113	MD Anderson Cancer Center	US
Ming-Hui Hung	5	94	National Taiwan University Hospital	Taiwan
Alan D. Kaye	5	60	Louisiana State University	US

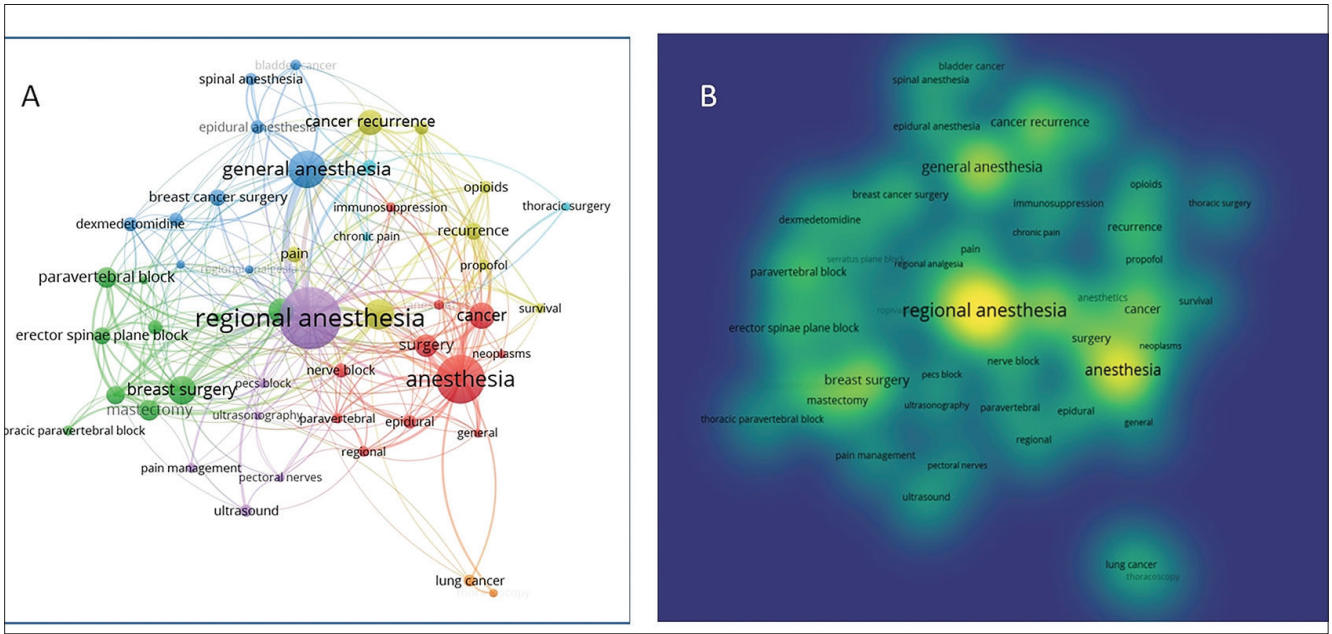


Figure 3. A) VOSviewer keyword network visualisation, B) VOSviewer keyword density visualisation (the depth of colour is proportional to the frequency of occurrence).

VOSviewer, visualization of similarities viewer.

Institution and Author Analysis

The five most productive authors on the research topic are listed in Table 3. The author with the highest number of publications and citations is Dr Donald J. Buggy. Citations for articles authored by those listed in Table 3 accounted for 37.21% of all citations in the research area.

Discussion

In the present study, a bibliometric analysis was conducted of articles published over the last 20 years that combined the terms "general and regional anaesthesia" and "cancer". The findings revealed that the years 2021 and 2022 had the highest number of articles published, with English the dominant language of the articles. The US was the leading country in terms of both publication volume and citations. The author with the most publications and citations in the research field was Prof. MD, Donald J. Buggy, based in Ireland. The most frequently cited articles were published in Anaesthesiology and the British Journal of Anesthesiology.

Although the impact of anaesthetic and analgesic methods on cancer outcomes was first raised 40 years ago,[23] it was not until 2006 that an observational study highlighted this issue.[19] In the highly cited study published by Exadaktylos et al.,[19], the authors investigated whether the choice of anaesthetic technique in breast cancer surgery influences the risk of cancer recurrence or metastasis. Their findings suggest that patients who received paravertebral anaesthesia and analgesia had a significantly lower risk of recurrence or metastasis compared with those managed with general anaesthesia and morphine-based analgesia alone. The authors hypothesised that preservation of immune function, achieved through attenuation of the surgical stress response and reduced opioid consumption, may underlie this potential benefit. This retrospective study also emphasises the need for prospective clinical trials to elucidate the impact of regional anaesthesia on long-term oncological outcomes.[19] Another highly cited study retrospectively examined the effect of anaesthetic technique on cancer recurrence in patients undergoing radical prostatectomy. The authors reported that the combination of epidural anaesthesia and analgesia with general anaesthesia significantly reduced the risk of recurrence compared with general anaesthesia and postoperative opioid use alone. It was further suggested that regional anaesthesia may help preserve immune function by attenuating the surgical stress response, reducing anaesthetic requirements, and minimising opioid exposure.[20] In addition, a highly cited review examines the potential effects of surgical and anaesthetic techniques, as well as other perioperative factors, on cancer recurrence. It primarily emphasises the concept that surgery and the anaesthetic methods employed may weaken the patient's immune system, thereby facilitating the dissemination and metastasis of cancer cells. Particular attention is drawn to the critical role of cellular immune mechanisms, such as NK cell activity, in the postoperative period. The review discusses the potential influence of intravenous and volatile anaesthetics, local anaesthetics, opioids, and non-steroidal anti-inflammatory drugs, as well as other factors including blood transfusion, pain, stress, and hypothermia, on cancer prognosis. It also suggests that evidence supporting the potential benefits of regional anaesthesia is steadily increasing.[21]

These and many similar studies have focused on the effects of anaesthetics on the behaviour of cancer cells. While preclinical research in this area is highly compelling, clinical findings remain inconclusive and continue to be a subject of debate.[24-29] This may be because cancer is not a single disease, and cancer types and subtypes may respond differently to therapeutic interventions. Another reason is that patient-specific tumour genomic alterations may be the primary determinants of the relationship between a drug and its outcomes.[30] Genomic research suggests that, beyond cancer subtypes, interpatient differences in tumour genomes could modify the dose-response relationship between intraoperative opioid dosage and tumour recurrence. In patients with specific tumour types, such as those with lung or colon adenocarcinoma, a relationship between opioid dosage and recurrence has been identified.[14,31] A transcriptomic study of renal cell carcinoma from The Cancer Genome Atlas Program, a large cancer-genomic research initiative, has identified gene networks, associated with survival, that can be modulated by opioids.[32] Differences in the expression of these tumour gene networks have also been shown to affect individual patient outcomes in response to intraoperative opioid doses.[33] Importantly, this finding is not limited to opioids, but also applies to all anaesthetic and analgesic agents.[34] From this perspective, supporting our anaesthesia and analgesia interventions with tumour-specific genomic sequencing and data on their effects on cancer subtypes seems to pave the way for personalised treatment. This suggests that additional research is likely to be conducted on the relationship between cancer and anaesthesia. At this point, recognising the leading papers, authors, institutions, and countries related to this topic will help guide new researchers and other readers interested in this field.

Although numerous publications included in this bibliometric analysis have reported varying results over the years, current evidence presents a consistent picture regarding the impact of anaesthetic techniques on long-term oncological outcomes. A comprehensive review published in Anaesthesiology & Analgesia in April 2025, with contributions from Donal Buggy and other leading researchers in the field, summarised nearly two decades of research and demonstrated that, apart from peritumoural lidocaine infiltration, most anaesthetic

approaches exert a neutral effect on cancer recurrence and metastasis.[2] Similarly, a recent review reported that regional anaesthesia has a neutral effect on oncological outcomes following tumour resection, and evidence regarding propofol-based total intravenous anaesthesia versus volatile anaesthesia is also tending towards a neutral effect.[35,36] While preclinical studies continue to provide mechanistic insights, the precise pathways through which anaesthetics may influence oncological processes, including patient-specific tumour genomics and tumour subtypes, remain unclear. Future research may further elucidate the role of genetic variability and epigenetic mechanisms in the interaction between anaesthetics and cancer biology.

Study Limitations

The present bibliometric study provided information on the prevalence of articles related to 'general and regional anaesthesia with cancer', the journals in which the most frequently cited papers are published, the authors who have contributed to this field and the institutions they are affiliated with. However, this study has some limitations. First, as it relied solely on the WoS database, relevant publications indexed in other databases may have been overlooked. Second, recently published studies might not have been extensively cited due to their shorter publication timelines. Third, one limitation of our study is the restricted set of search terms employed (cancer and general and regional and anaesthesia). While this strategy allowed us to maintain a clear focus on anaesthetic techniques in cancer surgery, it may have led to the exclusion of potentially relevant articles that did not explicitly include these keywords. Therefore, interpretation of the findings should be considered within the context of this methodological constraint. Finally, the study provided only the quantitative characteristics of the publications on the research topic. Despite these limitations, the present study provided valuable reference material for understanding global research trends and focal points regarding general and regional anaesthesia and cancer.

Conclusion

In the present study, biomedical research trends in general and regional anaesthesia in cancer over the past 20 years were analysed using bibliometric methods. The most influential papers, researchers, journals, institutions and countries that had shaped the scientific development of the field were identified, and their contributions were examined in detail. The findings provide an important reference to guide future research in the field and to inform strategic planning of scientific studies.

Ethics

Ethics Committee Approval: The present study was a bibliometric analysis and did not require ethics committee approval because it was conducted using publicly available data.

Informed Consent: Due to the retrospective nature of the study, an informed consent was not required.

Funding: No funding was received for this study.

References

1. Bray F, Laversanne M, Sung H, et al. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin*. 2024;74(3):229-263. [CrossRef]
2. Ramly MS, Buggy DJ. Anesthetic techniques and cancer outcomes: what ıs the current evidence? *Anesth Analg.* 2025;140(4):768-777. [CrossRef]
3. Cassinello F, Prieto I, del Olmo M, Rivas S, Strichartz GR. Cancer surgery: how may anesthesia influence outcome? *J Clin Anesth.* 2015;27(3):262-272. [CrossRef]
4. Sessler DI, Pei L, Huang Y, et al. Recurrence of breast cancer after regional or general anaesthesia: a randomised controlled trial. *Lancet.* 2019;394(10211):1807-1815. [CrossRef]
5. Heaney A, Buggy DJ. Can anaesthetic and analgesic techniques affect cancer recurrence or metastasis? *Br J Anaesth.* 2012;109(Suppl1):i17-i28. [CrossRef]
6. Soltanizadeh S, Degett TH, Gögenur I. Outcomes of cancer surgery after inhalational and intravenous anesthesia: a systematic review. *J Clin Anesth.* 2017;42:19-25. [CrossRef]
7. Sekandarzad MW, van Zundert AAJ, Lirk PB, Doornebal CW, Hollmann MW. Perioperative anesthesia care and tumor progression. *Anesth Analg* 2017;124(5):1697-1708. [CrossRef]
8. Kim R. Anesthetic technique and cancer recurrence in oncologic surgery: unraveling the puzzle. *Cancer Metastasis Rev.* 2017;36(1):159-177. [CrossRef]
9. O'Bryan LJ, Atkins KJ, Lipszyc A, Scott DA, Silbert BS, Evered LA. Inflammatory biomarker levels after propofol or sevoflurane anesthesia: a meta-analysis. *Anesth Analg* 2022;134(1):69-81. [CrossRef]
10. Makito K, Matsui H, Fushimi K, Yasunaga H. Volatile versus total ıntravenous anesthesia for cancer prognosis in patients having digestive cancer surgery. *Anesthesiology.* 2020;133(4):764-773. [CrossRef]
11. Hasselager RP, Hallas J, Gögenur I. Epidural analgesia and recurrence after colorectal cancer surgery: a danish retrospective registry-based cohort study. *Anesthesiology.* 2022;136(3):459-471. [CrossRef]
12. Ang E, Ng KT, Lee ZX, Ti LK, Chaw SH, Wang CY. Effect of regional anaesthesia only versus general anaesthesia on cancer recurrence rate: a systematic review and meta-analysis with trial sequential analysis. *J Clin Anesth.* 2020;67:110023. [CrossRef]
13. Aghamelu O, Buggy P, Smith G, Inzitari R, Wall T, Buggy DJ. Serum NETosis expression and recurrence risk after regional or volatile anaesthesia during breast cancer surgery: a pilot, prospective, randomised single-blind clinical trial. *Acta Anaesthesiol Scand.* 2021;65(3):313-319. [CrossRef]
14. Connolly JG, Tan KS, Mastrogiacomo B, et al. Intraoperative opioid exposure, tumour genomic alterations, and survival differences in people with lung adenocarcinoma. *Br J Anaesth.* 2021;127(1):75-84. [CrossRef]
15. Montagna G, Gupta HV, Hannum M, et al. Intraoperative opioids are associated with improved recurrence-free survival in triple-negative breast cancer. *Br J Anaesth.* 2021;126(2):367-376. [CrossRef]

16. Silagy AW, Hannum ML, Mano R, et al. Impact of intraoperative opioid and adjunct analgesic use on renal cell carcinoma recurrence: role for onco-anaesthesia. *Br J Anaesth.* 2020;125(5):e402-e404. [CrossRef]
17. Greener S. Evaluating literature with bibliometrics. *Interact Learn Environ.* 2022;30(7):1168-1169. [CrossRef]
18. O'Riain SC, Buggy DJ, Kerin MJ, Watson RWG, Moriarty DC. Inhibition of the stress response to breast cancer surgery by regional anesthesia and analgesia does not affect vascular endothelial growth factor and prostaglandin E2. *Anesth Analg.* 2005;100(1):244-249. [CrossRef]
19. Exadaktylos AK, Buggy DJ, Moriarty DC, Mascha E, Sessler DI. Can anesthetic technique for primary breast cancer surgery affect recurrence or metastasis? *Anesthesiology.* 2006;105(4):660-664. [CrossRef]
20. Biki B, Mascha E, Moriarty DC, Fitzpatrick JM, Sessler DI, Buggy DJ. Anesthetic technique for radical prostatectomy surgery affects cancer recurrence: a retrospective analysis. *Anesthesiology*. 2008;109(2):180-187. [CrossRef]
21. Snyder GL, Greenberg S. Effect of anaesthetic technique and other perioperative factors on cancer recurrence. *Br J Anaesth.* 2010;105(2):106-115. [CrossRef]
22. Chen WK, Miao CH. The effect of anesthetic technique on survival in human cancers: a meta-analysis of retrospective and prospective studies. *PLoS One.* 2013;8(2):e56540. [CrossRef]
23. Shapiro J, Jersky J, Katzav S, Feldman M, Segal S. Anesthetic drugs accelerate the progression of postoperative metastases of mouse tumors. *J Clin Invest.* 1981;68(3):678-685. [CrossRef]
24. Gao M, Guo R, Lu X, Xu G, Luo S. Propofol suppresses hypoxia-induced esophageal cancer cell migration, invasion, and EMT through regulating lncRNA TMPO-AS1/miR-498 axis. *Thorac Cancer.* 2020;11(9):2398-2405. [CrossRef]
25. Benzonana LL, Perry NJ, Watts HR, et al. Isoflurane, a commonly used volatile anesthetic, enhances renal cancer growth and malignant potential via the hypoxia-inducible factor cellular signaling pathway in vitro. *Anesthesiology.* 2013;119(3):593-605. [CrossRef]
26. Yin D, Liu L, Shi Z, Zhang L, Yang Y. Ropivacaine İnhibits cell proliferation, migration and invasion, whereas induces oxidative stress and cell apoptosis by circSCAF11/miR-145-5p axis in glioma. *Cancer Manag Res.* 2020;12:11145-11155. [CrossRef]
27. Kwon JH, Kim J, Yeo H, et al. Recurrence-free survival after hepatectomy using propofol-based total intravenous anaesthesia and sevoflurane-based inhalational anaesthesia: a randomised controlled study. *Anaesthesia.* 2025;80(4):366-377. [CrossRef]
28. Badwe RA, Parmar V, Nair N, et al. Effect of peritumoral infiltration of local anesthetic before surgery on survival in early breast cancer. *J Clin Oncol.* 2023;41(18):3318-3328. Erratum in: *J Clin Oncol.* 2023;41(30):4825. [CrossRef]
29. Yap A, Lopez-Olivo MA, Dubowitz J, Hiller J, Riedel B; Global Onco-Anesthesia Research Collaboration Group. Anesthetic technique and cancer outcomes: a meta-analysis of total intravenous versus volatile anesthesia. *Can J Anaesth.* 2019;66(5):546-561. English. [CrossRef]
30. Cao SJ, Zhang Y, Zhang YX, et al. Long-term survival in older patients given propofol or sevoflurane anaesthesia for major cancer surgery: follow-up of a multicentre randomised trial. *Br J Anaesth.* 2023;131(2):266-275. [CrossRef]
31. Yuval JB, Lee J, Wu F, et al. Intraoperative opioids are associated with decreased recurrence rates in colon adenocarcinoma: a retrospective observational cohort study. *Br J Anaesth.* 2022;129(2):172-181. [CrossRef]
32. Ricketts CJ, De Cubas AA, Fan H, et al. The cancer genome atlas comprehensive molecular characterization of renal cell carcinoma. *Cell Rep.* 2018;23(1):313-326.e5. Erratum in: *Cell Rep.* 2018;23(12):3698. Erratum in: *Cell Rep.* 2024;43(4):113063. [CrossRef]
33. Scarpa JR, DiNatale RG, Mano R, et al. Identifying clear cell renal cell carcinoma coexpression networks associated with opioid signaling and survival. *Cancer Res.* 2021;81(4):1101-1110. [CrossRef]
34. Mincer JS, Buggy DJ. Anaesthesia, analgesia, and cancer outcomes: time to think like oncologists? *Br J Anaesth.* 2023;131(2):193-196. [CrossRef]
35. Owolabi A, Tsai E. Anesthetic considerations in cancer care. *Curr Opin Anaesthesiol.* 2025;38(3):287-293. [CrossRef]
36. Murphy O, Forget P, Ma D, Buggy DJ. Tumour excisional surgery, anaesthetic-analgesic techniques, and oncologic outcomes: a narrative review. *Br J Anaesth.* 2023;131(6):989-1001. [CrossRef]

Original Article
Orthopaedic Anaesthesia

DOI: 10.4274/TJAR.2026.252329
Turk J Anaesthesiol Reanim 2026;54(2):97-106

Turkish Journal of Anaesthesiology & Reanimation

Impact of Preoperative Anaemia on Blood Transfusion and Clinical Outcomes in Total Knee Arthroplasty: A Retrospective Observational Study

Gülencan Yumuşak Ergin, Ayşe Tıraş Çetin, Asiye Ceylan, Sümeyye Önal Altınkaya, Eyyüp Çetin

Aksaray University Training and Research Hospital, Department of Anaesthesiology and Reanimation, Aksaray, Türkiye

Abstract

Objective: Preoperative anemia is a common, yet inadequately managed condition in patients undergoing total knee arthroplasty (TKA) and is associated with an increased need for perioperative blood transfusions. However, variability in physicians' transfusion practices remains understudied. This study investigated the influence of preoperative anaemia on transfusion rates and clinical outcomes and examined inter-physician variability in transfusion procedures.

Methods: This study included 265 patients who underwent TKA. Preoperative anaemia was defined as haemoglobin <13 g dL^{-1}. Demographic characteristics, perioperative variables, laboratory parameters, transfusion data, and postoperative outcomes were recorded. Transfusion rates, complications, and lengths of hospital stay were compared between anemic and non-anemic groups. Inter-physician variability in transfusion decisions was also analysed.

Results: Preoperative anaemia was present in 43% of individuals. Transfusion rates were significantly higher in patients with anaemia (69.3% vs. 54.3%, P=0.013). When postoperative outcomes were analysed according to anaemia and transfusion status, anaemia was not independently associated with postoperative complications (P=0.072). Perioperative blood transfusion was associated with significantly higher complication rates (31.7% vs. 15.4%, P=0.003) and a prolonged hospital stay (P < 0.001). Receiver operating characteristic analysis showed modest discrimination for predicting transfusion (area under the receiver operating characteristic curve =0.61; cut-off =13.15 g dL^{-1}). Significant inter-physician variability was observed, independent of anaemia status (P < 0.05).

Conclusion: Preoperative anemia is common among TKA patients and has been associated with higher transfusion rates. Transfusion was associated with adverse clinical outcomes, including prolonged hospitalisation and higher complication rates. The substantial physician-related variability observed in transfusion practices underscores the need for standardised, evidence-based perioperative transfusion protocols.

Keywords: Anaemia, blood transfusion, perioperative care

Main Points

- Anaemia is common among patients undergoing total knee arthroplasty and contributes significantly to the need for blood transfusions.
- Blood transfusions are linked to greater postoperative morbidity and longer hospital stays.
- Substantial physician-related variability exists in transfusion practices, underscoring the need for standardised, evidence-based perioperative transfusion protocols and comprehensive patient blood management strategies.

Introduction

Total knee arthroplasty (TKA) is commonly used to relieve pain and restore function in individuals with advanced knee osteoarthritis. The lifetime prevalence of symptomatic knee arthritis is estimated to be as high as 44.7%.[1] Population ageing, together with an increasing number of primary procedures, has resulted in a growing demand for revision TKA. This trend is driven by the success of primary TKAs, patients' desire to maintain active lifestyles, and the expansion of surgical indications to include younger individuals.[2] Despite its well-established benefits and excellent long-term outcomes, including implant

Corresponding author: Gülencan Yumuşak Ergin MD **E-mail:** gulencanyumusak@gmail.com
Received: November 06, 2025 **Accepted:** January 23, 2026 **Epub:** February 09, 2026 **Published date:** April 15, 2026
Cite this article as: Yumuşak Ergin G, Tıraş Çetin A, Ceylan A, Önal Altınkaya S, Çetin E. Impact of preoperative anaemia on blood transfusion and clinical outcomes in total knee arthroplasty: a retrospective observational study. *Turk J Anaesthesiol Reanim.* 2026;54(2):97-106

survival exceeding 90%, TKA remains associated with substantial perioperative risks, including significant blood loss, cardiovascular complications, and other postoperative adverse events.[3]

A primary objective of perioperative care is to optimise patient outcomes by reducing morbidity and mortality while facilitating early mobilisation and shorter hospital stays.[4] Among these optimisation strategies, the management of preoperative anaemia has gained increasing attention. It is most commonly associated with iron deficiency.[5] The frequency of anaemia rises with advancing age and reaches particularly high levels in individuals over 65 years.[6] Preoperative anemia is commonly seen in patients undergoing major orthopaedic procedures, such as TKA,[7-9] and is consistently linked to elevated postoperative morbidity, mortality, and a greater likelihood of requiring allogeneic blood transfusions.[10-12] Timely recognition and appropriate management of preoperative anaemia are critical for optimising surgical readiness, reducing transfusion requirements, and improving clinical outcomes. In this context, patient blood management (PBM) provides a structured, evidence-based strategy designed to correct anaemia and minimise blood loss. PBM also aims to optimise the utilisation of blood products and improve overall perioperative outcomes. The implementation of PBM has been shown to enhance patient safety, reduce transfusion-related complications, and improve cost-effectiveness.[13] However, in real-world clinical practice, preoperative anaemia is often overlooked, resulting in potentially avoidable transfusions and increased exposure to associated risks. Additionally, transfusion decision-making varies substantially among physicians and is often guided by individual clinical judgement rather than standardised criteria.[14] This inconsistency represents an important quality-of-care concern.

In major orthopaedic surgery, perioperative blood loss and transfusion remain important clinical concerns, prompting the adoption of evidence-based blood management strategies. Prophylactic use of antifibrinolytic agents, particularly tranexamic acid administered orally, intravenously, and/or topically, has been shown to effectively reduce perioperative blood loss and transfusion requirements in patients undergoing high-bleeding-risk orthopaedic procedures. In contrast, routine use of intraoperative tourniquets or surgical drains has not consistently demonstrated a reduction in overall perioperative blood loss or transfusion rates in TKA.[15]

Current recommendations further emphasize restrictive transfusion approaches and goal-directed decision-making based on haemoglobin concentrations and physiological indicators rather than fixed numerical thresholds. Restrictive strategies generally support haemoglobin targets of approximately 7-8 g dL^{-1} in clinically stable patients, with higher targets reserved for those with ongoing bleeding or limited cardiopulmonary reserve.[15,16]

In orthopaedic patients, particularly those undergoing major joint arthroplasty, early identification of perioperative anaemia, postoperative haemoglobin monitoring, and timely intravenous iron supplementation when indicated are considered essential components of PBM.[15] Despite the availability of evidence-based perioperative blood management strategies, substantial variability in transfusion thresholds and continued reliance on traditional haemoglobin triggers persist in orthopaedic practice, providing a rationale for further evaluation of perioperative anaemia and transfusion patterns in total joint arthroplasty.

This study aims to assess the impact of untreated preoperative anaemia on perioperative transfusion rates and clinical outcomes in individuals undergoing primary TKA. In addition, physician-related variability in transfusion decisions is evaluated to highlight the influence of individual clinical decision-making on perioperative blood management.

Methods

Study Design and Setting

This research was carried out as a single-centre retrospective observational study. Ethical approval has been obtained from the Aksaray University Health Sciences Scientific Research Ethics Committee (approval no.: SAGATİK 2025-001, date: 30.01.2025). The study population consisted of patients who underwent TKA between January and December 2024 at Aksaray University Training and Research Hospital.

During the study period, no standardized institutional transfusion protocol was in place. Transfusion decisions were made by the attending surgeon or anaesthesiologist based on individual clinical judgment, including perioperative haemoglobin levels and overall patient condition.

Patient Selection

Adult patients (≥18 years) who underwent primary or revision TKA were eligible for inclusion. Patients with incomplete or missing medical records were excluded. Figure 1 illustrates the patient selection process.

Data Collection

Patient information was retrieved from electronic medical records and institutional patient files. Demographic variables, including age, sex, and body mass index (BMI), as well as the American Society of Anaesthesiologists' physical status and comorbidities, were recorded. Perioperative variables included laterality (unilateral or bilateral), surgical duration, anaesthesia modality (regional or general), and laboratory parameters. Preoperative and postoperative haemoglobin

and creatinine levels were measured. Transfusion data included timing (intraoperative, postoperative, or both) and the number of red blood cell units administered. Postoperative outcomes included complications, intensive care unit admission, length of hospital stay, and in-hospital mortality. The operating surgeon and the anaesthesiologist for each case were documented.

Postoperative events were graded according to the Clavien-Dindo system, and complications at grade 2 or higher were taken as clinically relevant.[17] Preoperative anaemia was defined as a haemoglobin concentration <13 g dL^{-1} in male and female patients.[18,19]

Statistical Analysis

Categorical data were expressed as numbers and percentages. Continuous variables were summarised as mean ± standard deviation or median (range), depending on their distribution. Group comparisons were made using chi-square test or Fisher's exact test for categorical variables, and t-test or Mann-Whitney U test for continuous variables. When more than two non-normally distributed groups were analysed, the Kruskal-Wallis test was used.

Baseline haemoglobin as a predictor of transfusion was evaluated with receiver operating characteristic (ROC) analysis, and the area under the curve (AUC) and optimal cut-off (Youden index) were calculated. Diagnostic accuracy at this cut-off was also reported. The relationship between haemoglobin level and the number of transfused units was assessed using Spearman's rank correlation coefficient. In addition, multivariable logistic regression analysis was performed to identify factors independently associated with perioperative blood transfusion. Model fit was assessed using the Hosmer-Lemeshow goodness-of-fit test, and the proportion of variance explained by the model was evaluated using Cox & Snell and Nagelkerke R^2 statistics. A *P* value of <0.05 was considered statistically significant. Analyses were performed with SPSS version 29.0 (IBM Corp., Armonk, NY, USA).

Results

A total of 265 patients were analyzed. The median age was 67 years (range: 45-89), and the median BMI was 31.3 kg m^{2-1} (range: 22.0-47.8). Most patients were female (89.4%). Hypertension was the most common comorbidity (54.7%), followed by diabetes mellitus (42.3%), coronary artery disease (22.3%), pulmonary disease (18.5%), and chronic kidney disease (3.0%). Regional anaesthesia was the predominant anaesthetic technique (90.6%). Most patients (90.6%) underwent primary surgery, whereas 9.4% underwent revision procedures. Table 1 summarises the baseline demographic and clinical characteristics.

Preoperative anaemia was present in 114 patients (43.0%). The Median baseline haemoglobin level for the entire cohort was 13.2 g dL^{-1} (range, 9.1-18.3). Baseline demographic profiles were similar in patients with and without anaemia (Table 2). Haemoglobin values differed significantly between the groups at all measured time points (Table 3). Median preoperative haemoglobin was 13.8 g dL^{-1} (range: 13.0-18.3) in the non-anaemic group and 12.2 g dL^{-1} (range: 9.1-12.9) in the anaemic group ($P < 0.001$). Mean postoperative haemoglobin was also significantly lower in patients with anaemia (10.5±1.2 g dL^{-1} vs. 12.2±1.2 g dL^{-1}, $P < 0.001$). The nadir haemoglobin level during hospitalisation was lower in the anaemic group [9.1 g dL^{-1} (6.7-12.5) vs. 9.9 g dL^{-1} (5.7-13.6), $P < 0.001$]. At discharge, mean haemoglobin concentration remained significantly lower among patients with anaemia (10.2±0.9 g dL^{-1} vs. 10.6±1.2 g dL^{-1}; P=0.002).

At least one unit of red blood cell transfusion was administered to 69.3% of patients with anaemia and 54.3%

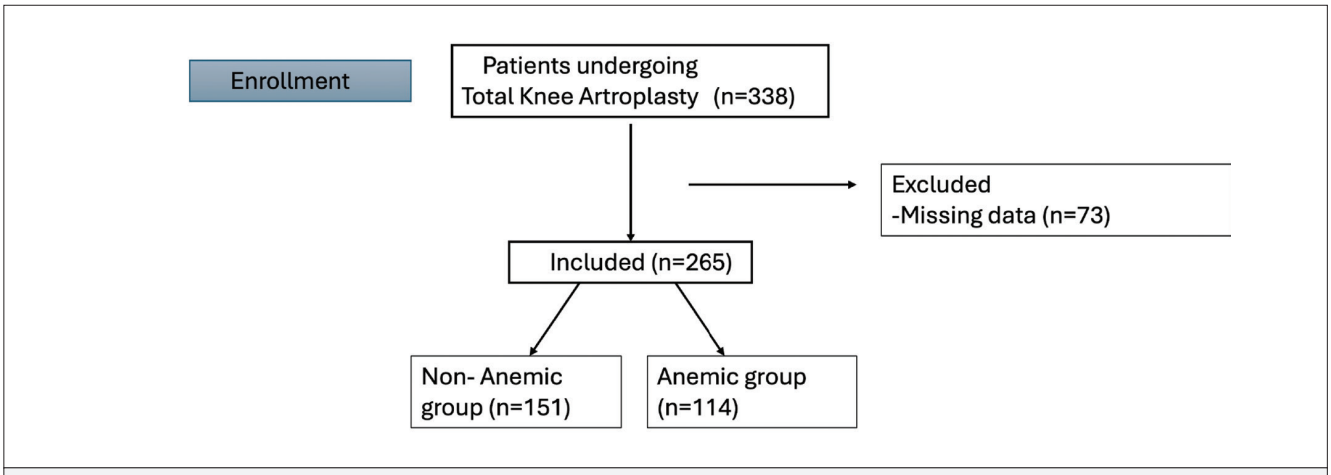


Figure 1. Patient flow diagram of the study population.

of patients without anaemia (*P*=0.013). Among patients who received transfusions, no significant difference was found in transfusion timing between groups (*P*=0.642). Intraoperative-only transfusions were performed in 13.4% of patients without anaemia and in 8.9% of patients with anaemia, whereas postoperative-only transfusions were the most common in both groups (75.6% and 78.5%, respectively). Combined intraoperative and postoperative transfusions occurred in 11.0% and 12.7% of patients in the non-anaemic and anaemic groups, respectively (Table 4). A statistically significant inverse relationship was observed between baseline hemoglobin levels and the number of blood units transfused. (r = -0.248, $P < 0.001$).

In the adjusted analysis, multivariable logistic regression was performed to identify factors independently associated with perioperative blood transfusion (Table 5). Increasing age was independently associated with a higher likelihood of transfusion [odds ratio (OR): 1.06, 95% confidence interval (CI): 1.02-1.10; *P*=0.002]. Bilateral surgery emerged as the strongest independent predictor of transfusion requirement (OR: 5.98, 95% CI: 3.13-11.43; $P < 0.001$). Coronary artery disease was associated with increased odds of transfusion (OR: 2.61, 95% CI: 1.18-5.77, *P*=0.018), whereas other comorbidities, revision surgery, and anaesthesia type were not independently associated with transfusion.

Clinical outcomes were assessed based on anaemia status and transfusion exposure. Complication rates were initially analysed using the standard Clavien-Dindo classification (CDC). A secondary analysis was subsequently performed, excluding blood transfusion from the composite outcome to evaluate postoperative complications other than transfusion.

According to the standard composite outcome, the overall rate of CDC grade ≥2 complications was numerically higher in the anaemic group (66.7% vs. 54.9%), although this difference did not reach statistical significance (*P*=0.072). After excluding blood transfusion from the composite outcome, complication rates were nearly identical between groups (25.4% vs. 25.2%; *P*=0.960). Acute kidney injury occurred more frequently in patients with anaemia than in those without (2.6% vs. 0%), but this difference did not reach statistical significance (*P*=0.094). Intensive care unit admission rates were similar between groups (6.0% vs. 8.8%; *P*=0.380). The median length of hospital stay did not change substantially [7 days (range: 0-20) vs. 7 days (range: 2-60); *P*=0.183]. Additionally, the proportion of patients

Table 1. Patient Demographic Data

	Mean ± SD	Median (min-max)
Age (years)	65.5±8.4	67 (45-89)
BMI	32.3±4.9	31.3 (22-47.8)
Sex, n (%)		
Female	237 (89.4)	
Male	28 (10.6)	
ASA physical status, n (%)		
I	16 (6.0)	
II	223 (84.2)	
III	26 (9.8)	
Anaesthesia management, n (%)		
Regional anaesthesia	251 (94.7)	
General anaesthesia	14 (5.2)	
Procedure type, n (%)		
Unilateral	154 (58.1)	
Bilateral	111 (41.9)	
Procedure type, n (%)		
Primary surgery	240 (90.6)	
Revision surgery	25 (9.4)	
Preoperative anaemia, n (%)	114 (43.0)	
Baseline Hb (g dL^{-1})	13.2 (9.1-18.3)	
Intraoperative RBC units transfused	0.14±0.35	0 (0-1)
Postoperative RBC units transfused	1.15±1.5	1 (0-11)

ASA, American Society of Anaesthesiologists; BMI, body mass index; Hb, haemoglobin; RBC, red blood cell; SD, standard deviation; min-max, minimum-maximum

Table 2. Distribution of Patients and Clinical Characteristics According to Preoperative Anaemia Status

Variables	Non-anaemic group (n = 151)	Anaemic group (n = 114)	*P* value
Age (years), median (min-max)	65 (48-84)	67.5 (45-89)	0.234[a]
Female, n (%)[b]	128 (84.8)	109 (95.6)	0.004[c]
BMI, median (min-max)	32.4 (22-47.8)	31.2 (23.4-45.4)	0.056[a]
ASA physical status, n (%)[b]			
1	11 (7.3)	5 (4.4)	
2	127 (84.1)	96 (84.2)	0.491[c]
3	13 (8.6)	13 (11.4)	
Laterality, n (%)[b]			
Unilateral	90 (59.6)	64 (56.1)	0.572[c]
Bilateral	61 (40.4)	50 (43.9)	
Surgical type, n (%)[b]			
Primary surgery	140 (92.7)	100 (87.7)	0.168[c]
Revision surgery	12 (7.3)	14 (12.3)	
Duration of surgery (minute), median (min-max)	75 (30-150)	75 (12-140)	0.552[a]
Comorbidities, n (%)[b]			
Hypertension	73 (48.3)	72 (63.2)	0.016[c]
Diabetes mellitus	56 (37.1)	56 (49.1)	0.050[c]
Pulmonary disease	25 (16.6)	24 (21.1)	0.351[c]
Coronary artery disease	28 (18.5)	31 (27.2)	0.094[c]
Chronic kidney disease	4 (2.6)	4 (3.5)	0.729[d]
Neurological disorder	3 (2.0)	6 (5.3)	0.179[d]

[a]: Mann-Whitney U test; [b]: column percentage; [c]: Pearson's chi-square test; [d]: Fisher's exact test; ASA, American Society of Anaesthesiologists; BMI, body mass index; min-max, minimum-maximum

Table 3. Haemoglobin Values and Changes According to Anaemia Status

Haemoglobin parameters (g dL^{-1})	Non-anaemic group (n = 151)	Anaemic group (n = 114)	*P* value
Preop Hb	13.8 (13.0-18.3)	12.2 (9.1-12.9)	<0.001[a]
Postop Hb	12.2±1.2	10.5±1.2	<0.001[b]
Nadir Hb	9.9 (5.7-13.6)	9.1 (6.7-12.5)	<0.001[a]
Discharge Hb	10.6±1.2	10.2±0.9	0.002[b]

[a]: Mann-Whitney U test; [b]: Student t-test; Hb, haemoglobin

Table 4. Relationship Between Preoperative Anaemia and Blood Transfusion

	Non-anaemic group (n = 151)	Anaemic group (n = 114)	*P* value
At least one transfusion, n (%)	82 (54.3)	79 (69.3)	0.013[a]
Among patients who received transfusions, n (%)			
Intraoperative only	11 (13.4)	7 (8.9)	0.642[a]
Postoperative only	62 (75.6)	62 (78.5)	
Intraoperative and postoperative	9 (11.0)	10 (12.7)	

[a]: Pearson chi-square test

with prolonged hospitalization (≥10 days) was comparable (9.9% vs. 14.9%; *P*=0.218).

When clinical outcomes were analysed according to transfusion status, transfused patients exhibited significantly higher rates of CDC grade ≥2 complications, both when blood transfusion was included in the Clavien-Dindo composite outcome (96.5% vs. 17.4%, $P < 0.001$) and when it was excluded (31.7% vs. 15.4%, *P*=0.003). Although acute kidney injury occurred more frequently among transfused patients (10.6% vs. 4.8%), this difference was not statistically significant (*P*=0.152). Intensive care unit admission rates were comparable between the groups (8.1% vs. 5.8; *P*=0.478). However, transfused patients had a significantly longer median hospital stay [7 days (range: 3-60) vs. 6 days (range: 0-13); $P < 0.001$] and a greater proportion experienced prolonged hospitalisation (≥10 days: 17.4% vs. 3.8%; $P < 0.001$).

No significant differences were observed in complication rates between unilateral and bilateral procedures (*P*=0.222). The length of hospital stay did not differ significantly (*P*=0.057), although the *P* value was close to the threshold for significance, suggesting a possible trend toward longer hospitalisation after bilateral surgery.

The ability of baseline haemoglobin to predict perioperative blood transfusion was evaluated using ROC analysis (Figure 2). The AUC was 0.61 (95% CI: 0.54-0.68, *P*=0.002), indicating modest discriminative ability. The optimal cut-off value was 13.15 g dL^{-1}, yielding a sensitivity of 55%, specificity of 64%, positive predictive value of 70%, negative predictive value of 48%, and an overall accuracy of 58% (Table 6).

Only surgeons and anaesthesiologists who managed at least 10 patients were included in the analysis of physician-related transfusion practices. Marked variability in transfusion rates was observed across physicians. Among surgeons, the proportion of patients with anaemia receiving transfusions ranged from 42.1% to 100%, and from 28.6% to 92.6% among patients without anaemia. Similarly, anaesthesiologists displayed wide variation in transfusion rates ranging from 18.8% to 100% in patients with anaemia and from 28.6% to 75.0% in patients without anaemia (Figure 3). Statistical testing showed significant variability in transfusion decisions among physicians in both the anaemic and non-anaemic groups ($P < 0.05$).

Table 5. Multivariable Logistic Regression Analysis for Factors Associated with Perioperative Blood Transfusion

Variable	OR	95% CI	*P* value
Age (per year increase)	**1.06**	1.02-1.10	**0.002**
Sex (female vs male)	0.53	0.21-1.32	0.171
Surgical type (bilateral vs unilateral)	**5.98**	3.13-11.43	**<0.001**
Revision surgery	2.19	0.81-5.91	0.122
Hypertension	0.61	0.33-1.15	0.127
Diabetes mellitus	1.05	0.59-1.87	0.862
Pulmonary disease	0.66	0.32-1.35	0.256
Coronary artery disease	**2.61**	1.18-5.77	**0.018**
Chronic kidney disease	8.88	0.79-99.64	0.077
Neurological disease	0.39	0.08-1.82	0.229
Anaesthesia type (regional vs general)	0.56	0.14-2.25	0.412

Model performance: Nagelkerke $R^2 = 0.24$; Cox & Snell $R^2 = 0.18$; Hosmer-Lemeshow goodness-of-fit test, *P*=0.843
ORs with 95% CIs were calculated using multivariable logistic regression. A *P* value <0.05 was considered statistically significant
CI, confidence interval; OR, odds ratio

Table 6. Diagnostic performance of preoperative haemoglobin levels for predicting perioperative transfusion

Variable	Cut-off	Sensitivity	Specificity	PPV	NPV	Accuracy	AUC	95% CI	*P* value
Hb (g dL^{-1})	13.15	55%	64%	70%	48%	58 %	0.61	0.54-0.68	0.002

AUC, area under the curve; CI, confidence interval; Hb, haemoglobin; NPV, negative predictive value; PPV, positive predictive value

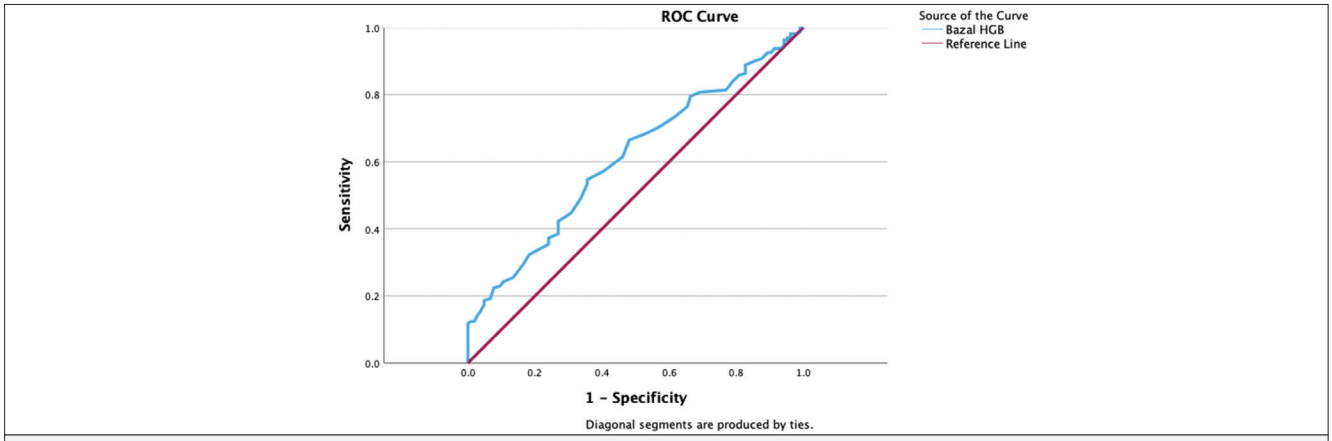


Figure 2. ROC curve analysis of haemoglobin thresholds for predicting perioperative transfusion requirements. ROC, receiver operating characteristic; HGB, hemoglobin.

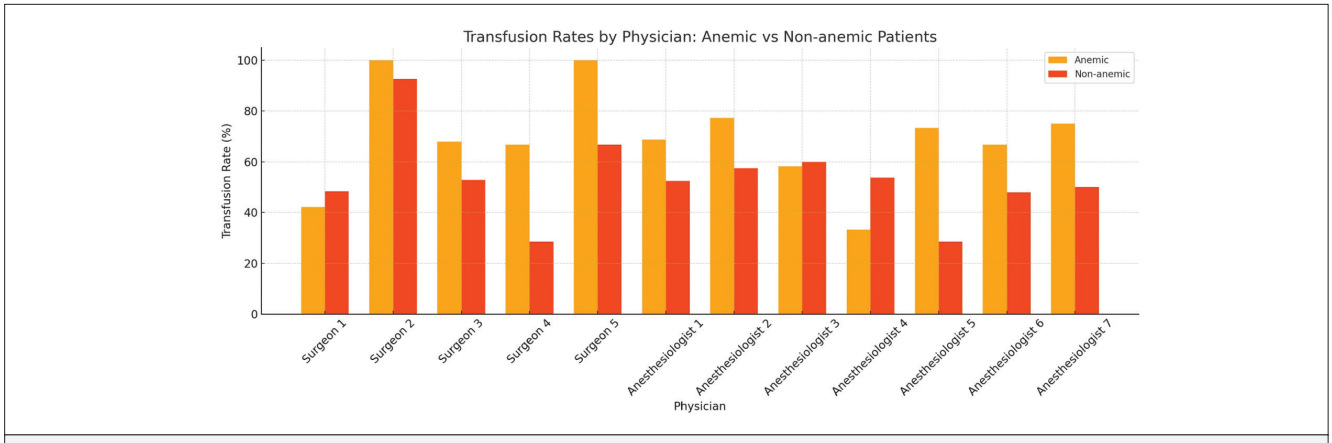


Figure 3. Variation in transfusion rates among surgeons and anaesthesiologists, stratified by anaemia status.

Discussion

This retrospective observational study investigated the impact of preoperative anaemia on transfusion requirements and clinical outcomes in patients undergoing TKA. The principal findings were that preoperative anaemia was common and significantly associated with an increased likelihood of perioperative blood transfusion, whereas transfusion itself was linked to worse postoperative outcomes. In addition, substantial physician-related variability in transfusion practices was observed, highlighting the need for greater standardisation in perioperative blood management. Taken together, these findings suggest that transfusion exposure, rather than preoperative anaemia itself, is more closely associated with adverse postoperative outcomes.

In this study, preoperative anaemia was defined as haemoglobin <13 g dL^{-1} in both sexes, adopting a uniform cut-off, consistent with contemporary perioperative anaemia definitions and recommendations that favour sex-independent criteria to enable standardised risk stratification, despite the widespread use of sex-specific thresholds.[18,19] Using this definition, 43% of patients were classified as anaemic, reinforcing the substantial burden of this modifiable risk factor in patients undergoing TKA. Consistent with previous studies, anaemia emerged as a major determinant of transfusion in our cohort.[10,20-22]

Recent evidence indicates a progressive increase in the predictive value of anaemia for transfusion risk.[10] Supporting this trend, a recent temporal analysis revealed that the OR for anaemia as a predictor of transfusion increased markedly over time, from 3.[1] (95% CI: 2.1-4.6) in 2010 to 14.0 (95% CI: 8.9-24) in 2021, underscoring its growing importance in perioperative risk assessment.[10] In our cohort, baseline haemoglobin demonstrated only modest ability to predict transfusion (AUC=0.61), yet the derived threshold (13.15 g dL^{-1}) suggests that patients within the low-normal range may warrant closer attention. This finding aligns with emerging evidence indicating that lower preoperative haemoglobin

is associated with impaired recovery and a higher risk of complications, even within contemporary perioperative care pathways.[23,24]

Although previous studies have found a direct link between preoperative anaemia and postoperative morbidity[22,23,25] this investigation found no statistically significant association between anaemia and overall complications. In contrast, transfused patients experienced significantly higher complication rates, suggesting that adverse outcomes may be more closely related to transfusion exposure than to anaemia alone.

Our findings are consistent with previous reports demonstrating associations with transfusion requirement, intensive care unit admission, prolonged hospitalisation, and major postoperative complications. Consistent with this, prior studies have reported an increased risk of adverse outcomes, including surgical site infection, sepsis, and pulmonary embolism, among transfused patients.[26,27] In our cohort, transfusion was similarly associated with a prolonged hospital stay, which is known to contribute to both clinical and economic burdens.[28] Prolonged hospitalisation has also been linked to secondary complications, including delirium, particularly in older adults.[29] However, postoperative cognitive outcomes could not be systematically evaluated in the present study due to limitations inherent in the retrospective design.

Our findings are consistent with the Turkish National Perioperative Transfusion Study (TULIP), a large, multicentre, observational study, nationwide. The TULIP study demonstrated substantial variability in perioperative transfusion practices among centres and clinicians and identified preoperative anaemia as a key determinant of transfusion requirements rather than as an independent predictor of adverse clinical outcomes. In addition, the wide variation in transfusion rates reported in the TULIP study was largely attributed to differences in transfusion thresholds and individual clinical decision-making.[14] Taken together, these findings suggest that transfusion-related complications may reflect underlying patient characteristics and perioperative management strategies rather than preoperative anaemia itself. This observation further underscores the importance of evidence-based, standardized PBM approaches and closer collaboration between surgical and anaesthesia teams.

Although preoperative anaemia significantly increased the likelihood of perioperative blood transfusion, transfusion exposure was not confined to anaemic patients in our cohort. A substantial proportion of non-anaemic patients required transfusion, suggesting that transfusion decisions were influenced by perioperative factors beyond baseline haemoglobin level, such as intraoperative blood loss, bilateral procedures, and physician-dependent transfusion thresholds.

In the adjusted analysis, perioperative blood transfusion remained strongly influenced by patient- and procedure-related factors. Increasing age and bilateral surgery were identified as independent predictors of the need for transfusion, while coronary artery disease was additionally associated with an increased risk of transfusion. Importantly, most other comorbidities and the type of anaesthesia were not independently associated with transfusion after adjustment, suggesting that transfusion decisions are primarily driven by procedural complexity and patient vulnerability rather than the anaesthetic technique. Previous studies have similarly shown that age is an independent predictor of perioperative transfusion, with older patients exhibiting higher odds of transfusion despite adjustment for hemoglobin level and comorbidities.[30]

Similarly, surgical duration was significantly associated with transfusion, which may be explained by the longer operative time required for bilateral procedures. The risk-benefit profile of bilateral versus unilateral knee arthroplasty remains a topic of debate in the literature.[31,32] At our hospital, bilateral arthroplasty is often preferred for patients with multiple complaints or limited access to healthcare; however, no consensus exists among surgeons regarding the superiority of one technique over the other.

In our cohort, unilateral and bilateral procedures had comparable rates of postoperative complications, excluding transfusion, and similar lengths of hospital stay, suggesting that the increased transfusion requirements associated with bilateral procedures does not necessarily translate into a higher burden of postoperative morbidity. The lack of statistical significance in hospitalisation duration may reflect heterogeneity within patient subgroups.

When transfused patients were analyzed separately, transfusion decisions were made in both anaemic and non-anaemic groups, reinforcing that transfusion-related outcomes cannot be attributed solely to baseline anaemia status. In our cohort, substantial variability was observed in transfusion decisions among surgeons and anaesthesiologists. The wide variation among physicians, even after adjusting for anaemia status, suggests that transfusion practices may be influenced not only by clinical indications but also by individual decision-making styles. Such heterogeneity warrants attention, as it directly affects the consistency and quality of patient care and highlights the need for institutional, evidence-based transfusion frameworks. Intraoperative transfusion decisions are inherently multifactorial, shaped by physiological changes induced by anaesthesia, the surgical procedure, and acute intraoperative conditions, rather than by blood loss alone.[33]

Our findings highlight the relevance of systematic preoperative anaemia screening and transfusion practices in patients undergoing TKA. In the context of the

observed association between transfusion exposure and adverse postoperative outcomes, these results support the role of PBM strategies focused on early identification and optimisation of anaemia as part of perioperative care.

Study Limitations

Several constraints should be considered when interpreting these findings. First, the retrospective design limits causal inference, and certain potentially relevant confounders, including iron indices (e.g., ferritin and transferrin saturation), were unavailable. Additionally, the aetiology of anaemia (e.g., iron deficiency, chronic disease, or nutritional deficiency) could not be determined, precluding risk stratification by anaemia subtype.

Direct measurements of intraoperative blood loss were not consistently recorded, limiting our ability to compare blood loss between groups. In addition, the absence of a standardized institutional transfusion protocol and the retrospective nature of the study precluded precise determination of the relative contribution of individual clinical criteria to transfusion decisions. Alternative perioperative anaemia treatments, such as intravenous iron supplementation, were not routinely used during the study period, which may have contributed to the observed reliance on red blood cell transfusion.

Moreover, data on adjunct blood-conservation strategies, including perioperative use of antifibrinolytic agents such as tranexamic acid, were not systematically available and therefore could not be incorporated into the analysis. This limitation may have influenced both transfusion practices and clinical outcomes.

Finally, owing to the number and heterogeneity of recorded complications and limited statistical power, individual complication categories were not analysed separately. Clinically meaningful adverse events were, instead, evaluated according to CDC criteria (≥ grade II), with acute kidney injury and intensive care unit admission analysed as key outcomes.

Despite these limitations, this study provides real-life information on the effects of preoperative anemia and transfusion procedures in TKA.

Conclusion

Preoperative anaemia is a significant determinant of transfusion requirements in patients undergoing TKA, and substantial physician-related variability exists in transfusion practices. These findings emphasise the importance of systematic preoperative anaemia screening, appropriate optimisation strategies, and the implementation of structured PBM programmes in orthopaedic surgery. Future multicentre prospective studies are required to confirm these observations and to establish standardised, evidence-based transfusion thresholds that improve the consistency of care and enhance perioperative patient safety.

Ethics

Ethics Committee Approval: Ethical approval has been obtained from the Aksaray University Health Sciences Scientific Research Ethics Committee (approval no.: SAGATİK 2025-001, date: 30.01.2025).

Informed Consent: Preoperative, intraoperative, and postoperative data were retrospectively retrieved from the medical records of patients who had provided informed consent.

Footnotes

Author Contributions: Surgical and Medical Practices - G.Y.E., A.T.Ç., A.C., S.Ö.A., E.Ç.; Concept - G.Y.E., A.C.; Design - G.Y.E., A.C; Data Collection and/or/Processing - G.Y.E., A.T.Ç., A.C., S.Ö.A., E.Ç.; Analysis and/or/Interpretation - G.Y.E.; Literature Review - G.Y.E., A.C; Writing - G.Y.E.

Declaration of Interests: The authors declare no conflict of interests.

Funding: No funding was received for the study.

References

1. Murphy L, Schwartz TA, Helmick CG, et al. Lifetime risk of symptomatic knee osteoarthritis. *Arthritis Rheum.* 2008;59(9):1207-1213. [CrossRef]
2. Dubin JA, Bains SS, Paulson AE, et al. The current epidemiology of revision total knee arthroplasty in the United States from 2016 to 2022. *J Arthroplasty.* 2024;39(3):760-765. [CrossRef]
3. Delanois RE, Mistry JB, Gwam CU, Mohamed NS, Choksi US, Mont MA. Current epidemiology of revision total knee arthroplasty in the United States. *J Arthroplasty.* 2017;32(9):2663-2668. [CrossRef]
4. Zhang Q, Chen Y, Li Y, et al. Enhanced recovery after surgery in patients after hip and knee arthroplasty: a systematic review and meta-analysis. *Postgrad Med J.* 2024;100(1181):159-173. [CrossRef]
5. Chaparro CM, Suchdev PS. Anemia epidemiology, pathophysiology, and etiology in low- and middle-income countries. *Ann N Y Acad Sci.* 2019;1450(1):15-31. [CrossRef]
6. Guralnik JM, Eisenstaedt RS, Ferrucci L, Klein HG, Woodman RC. Prevalence of anemia in persons 65 years and older in the United States: evidence for a high rate of unexplained anemia. *Blood.* 2004;104(8):2263-2268. [CrossRef]
7. Nissenson AR, Goodnough LT, Dubois RW. Anemia: not just an innocent bystander? *Arch Intern Med.* 2003;163(12):1400-1404. [CrossRef] Erratum in: *Arch Intern Med.* 2003;163(15):1820. [CrossRef]
8. Boumahd S, Piette N, Bonhomme V, Hans G. L'anémie préopératoire: implications pronostiques et prise en charge diagnostique et thérapeutique [Preoperative anemia : a review of its prognostic implications, diagnosis and management]. *Rev Med Liege.* 2024;79(12):766-770. French. [CrossRef]
9. Goodnough LT, Maniatis A, Earnshaw P, et al. Detection, evaluation, and management of preoperative anaemia in the elective orthopaedic surgical patient: NATA guidelines. *Br J Anaesth.* 2011;106(1):13-22. [CrossRef]
10. Schmerler J, Harris AB, Hegde V, Oni JK, Khanuja HS. Over the past decade, preoperative anemia has become a greater predictor of transfusions after total knee arthroplasty. *J Arthroplasty.* 2024;39(11):2714-2719. [CrossRef]

11. Hart A, Khalil JA, Carli A, Huk O, Zukor D, Antoniou J. Blood transfusion in primary total hip and knee arthroplasty. Incidence, risk factors, and thirty-day complication rates. *J Bone Joint Surg Am.* 2014;96(23):1945-1951. [CrossRef]
12. Kolin DA, Sculco PK, Gonzalez Della Valle A, Rodriguez JA, Ast MP, Chalmers BP. Risk factors for blood transfusion and postoperative anaemia following total knee arthroplasty. *Bone Joint J.* 2023;105-B(10):1086-1093. [CrossRef]
13. Parikh S, Bentz T, Crowley S, Greenspan S, Costa A, Bergese S. Perioperative blood management. *J Clin Med.* 2025;14(11):3847. [CrossRef]
14. Unal D, Senayli Y, Polat R, et al. Peri-operative blood transfusion in elective major surgery: incidence, indications and outcome - an observational multicentre study. *Blood Transfus.* 2020;18(4):261-279. [CrossRef]
15. Kietaibl S, Ahmed A, Afshari A, et al. Management of severe peri-operative bleeding: Guidelines from the European Society of Anaesthesiology and Intensive Care: second update 2022. *Eur J Anaesthesiol.* 2023;40(4):226-304. [CrossRef]
16. American Society of Anesthesiologists Task Force on Perioperative Blood Management. Practice guidelines for perioperative blood management: an updated report by the American Society of Anesthesiologists task force on perioperative blood management*. *Anesthesiology*. 2015;122(2):241-275.
17. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 2004;240(2):205-213. [CrossRef]
18. Muñoz M, Gómez-Ramírez S, Kozek-Langeneker S, et al. 'Fit to fly': overcoming barriers to preoperative haemoglobin optimization in surgical patients. *Br J Anaesth.* 2015;115(1):15-24. [CrossRef]
19. Warner MA, Shore-Lesserson L, Shander A, Patel SY, Perelman SI, Guinn NR. Perioperative anemia: prevention, diagnosis, and management throughout the spectrum of perioperative care. *Anesth Analg.* 2020;130(5):1364-1380. [CrossRef]
20. Zhang FQ, Yang YZ, Li PF, et al. Impact of preoperative anemia on patients undergoing total joint replacement of lower extremity: a systematic review and meta-analysis. *J Orthop Surg Res.* 2024;19(1):249.
21. Hung KC, Kao CL, Lai YC, et al. Association between preoperative anemia and the risk of revision after total knee arthroplasty: a multi-institutional retrospective study. *J Arthroplasty.* 2025. [CrossRef]
22. Duarte GC, Catanoce AP, Zabeu JL, et al. Association of preoperative anemia and increased risk of blood transfusion and length of hospital stay in adults undergoing hip and knee arthroplasty: an observational study in a single tertiary center. *Health Sci Rep.* 2021;4(4):e448. [CrossRef]
23. Chaudhry YP, MacMahon A, Rao SS, et al. Predictors and outcomes of postoperative hemoglobin of <8 g/dL in total joint arthroplasty. *J Bone Joint Surg Am.* 2022;104(2):166-171. [CrossRef]
24. Jørgensen CC, Michelsen C, Petersen T, Kehlet H. Preoperative hemoglobin thresholds for increased risk of "medical" complications in fast-track total hip and knee arthroplasty, a secondary analysis of a machine-learning algorithm. *Transfusion.* 2024;64(3):438-442. [CrossRef]
25. Harris AB, Badin D, Hegde V, Oni JK, Sterling RS, Khanuja HS. preoperative anemia is an independent risk factor for increased complications and mortalities after total knee arthroplasty regardless of postoperative transfusions. *J Arthroplasty.* 2023;38(7 Suppl 2):S177-S181. [CrossRef]
26. Maman D, Nandakumar M, Hirschmann MT, et al. Blood transfusion in total knee arthroplasty and total hip arthroplasty: a nationwide study of complications, costs and predictive modelling. *J Exp Orthop.* 2025;12(3):e70317. [CrossRef]
27. Klasan A, Dworschak P, Heyse TJ, et al. Transfusions increase complications and infections after hip and knee arthroplasty: an analysis of 2760 cases. *Technol Health Care.* 2018;26(5):825-832. [CrossRef]
28. Lee WC, Neoh EC, Wong LP, Tan KG. Shorter length of stay and significant cost savings with ambulatory surgery primary unilateral total knee arthroplasty in Asians using enhanced recovery protocols. *J Clin Orthop Trauma.* 2024;50:102379. [CrossRef]
29. Yang Q, Wang J, Chen Y, Lian Q, Shi Z, Zhang Y. Incidence and risk factors of postoperative delirium following total knee arthroplasty: a retrospective nationwide inpatient sample database study. *Knee.* 2022;35:61-70. [CrossRef]
30. Brown CH 4th, Savage WJ, Masear CG, et al. Odds of transfusion for older adults compared to younger adults undergoing surgery. *Anesth Analg.* 2014;118(6):1168-1178.
31. Tu KC, Shih HT, Wang SP, Chen KH. A comparative study of single-stage bilateral vs. unilateral medial unicompartmental knee arthroplasty on complications, clinical outcomes, and costs. *Front Surg* 2024;11:1470421. [CrossRef]
32. Phillips M, Santori N, Gado I, et al. What are the contraindications for performing bilateral total knee arthroplasty under the same anesthesia? *J Arthroplasty.* 2025;40(2):99-101. [CrossRef]
33. Lenet T, Tropiano J, Skanes S, et al. Understanding intraoperative transfusion decision-making variability: a qualitative study. *Transfus Med Rev.* 2023;37(2):150726. [CrossRef]

Original Article
Cardiovascular and Thoracic Anaesthesia

DOI: 10.4274/TJAR.2026.252308
Turk J Anaesthesiol Reanim 2026;54(2):107-116

Turkish Journal of Anaesthesiology & Reanimation

Retrospective Analysis of Totally Implantable Venous Access Ports which was Performed using the Patient's Height as a Guide, and the Effect of Catheter Tip Position on Complications

Hakkıcan Akpolat[1], Serdar Demirgan[1,2], Sezen Kumaş Solak[1], Emine Sönmez[1], Rasim Onur Karaoğlu[1], Ayşin Selcan[1]

[1]University of Health Sciences Türkiye, Bağcılar Training and Research Hospital, Clinic of Anaesthesiology and Reanimation, İstanbul, Türkiye
[2]İstanbul University, Institute of Graduate Studies in Sciences, Department of Molecular Biology and Genetics, İstanbul, Türkiye

Abstract

Objective: Totally implantable venous access ports (TIVAP) provide safe and com-fortable venous access for chemotherapy. This study evaluates the reliability of Lum's measurement technique for central venous catheter tip positioning and its impact on complications.

Methods: Clinical and radiologic data of 297 patients under-going TIVAP implantation were analyzed. The primary endpoint was optimal catheter tip positioning (within 2 cm above to 1 cm below the cavoatrial junction) and its effect on complications. Secondary endpoints included the impact of catheterization site and tip position relative to the carina.

Results: Among 297 patients, 59.9% had catheter tips in the target zone, and 93.9% were below the carina. Target zone positioning did not significantly affect catheter occlusion or thromboembolism (P=0.066, P=0.773). However, thromboembolism (1/18; 5.6% vs. 1/279; 0.4%, P=0.009) and catheter occlusion (2/18; 11.1% vs. 3/279; 1.1%, P=0.001) were more frequent when the tip was above the carina. Patients with tips in the target zone and below the carina had similar complication rates (P=0.565, P=0.748, P=0.644). Catheterisation was performed via the internal jugular vein (IJV) or subclavian vein (SCV). Target zone positioning was more frequent with IJV catheterization (P=0.047), while catheter occlusion was higher with SCV access (P=0.024).

Conclusion: Positioning the catheter tip below the carina and preferring IJV as the first-choice catheterization site may reduce complications

Keywords: Catheter tip positioning, cavoatrial junction, chemotherapy, insertion technique, totally implantable venous access port

Main Points

- Lum's height-based measurement technique achieved correct catheter tip positioning within the predefined cavoatrial junction (CAJ) target zone in approximately 60% of cases, indicating moderate predictive accuracy.
- Catheter tip placement above the carina was significantly associated with higher rates of thromboembolism and catheter occlusion.
- Positioning the catheter tip below the carina appeared to be a more clinically relevant determinant of complication risk than strict adherence to the predefined CAJ target zone.
- The internal jugular vein approach was associated with more optimal tip positioning and fewer catheter occlusions compared with the subclavian vein approach.

Corresponding author: Sezen Kumaş Solak MD **E-mail:** sezenkumassolak@gmail.com
Received: November 19, 2025 **Accepted:** February 02, 2026 **Published date:** April 15, 2026
Cite this article as: Akpolat H, Demirgan S, Kumaş Solak S, Sönmez E, Karaoğlu RO, Selcan A. Retrospective analysis of totally implantable venous access ports which was performed using the patient's height as a guide, and the effect of catheter tip position on complications. *Turk J Anaesthesiol Reanim*. 2026;54(2):107-116

Introduction

Totally implantable venous access ports (TIVAPs) have become essential components of modern oncology practice, providing reliable, long-term venous access for the administration of chemotherapy and other repeated intravenous treatments. Despite their widespread use and the convenience they offer, several procedure- and device-related complications may occur during or after implantation. One of the most important issues is incorrect catheter tip positioning, which is associated with both early and late complications, including venous thrombosis, catheter malfunction, vascular injury, perforation, arrhythmias, valvular trauma, and myocardial damage.[1,2]

Determining the appropriate catheter length and ensuring accurate tip placement within the superior vena cava (SVC) are therefore crucial for minimizing catheter-related complications. Although the ideal location of the central venous catheter (CVC) tip remains controversial,[3,4] most experts agree that the lower segment of the SVC and the cavoatrial junction (CAJ) represent the safest target positions.[5-7] Previous studies have suggested that the CAJ can be approximated on a posteroanterior chest radiograph as a point.[2] Four vertebral body units (VBUs) inferior to the carina.[4]

TIVAPs are commonly indicated for repeated chemotherapy administration, long-term parenteral nutrition, extended antimicrobial therapy, and for patients with limited peripheral venous access. Complications associated with these devices vary over time; early complications include pneumothorax, arterial puncture, and superficial infection, whereas late complications may involve thrombosis, catheter occlusion, malposition, arrhythmias, or myocardial perforation.[1,2] Therefore, ensuring that the catheter tip is positioned in the lower SVC, close to the CAJ, is considered fundamental to safe device placement, although numerical definitions of "optimal" tip position differ among guidelines and published studies.[3,4]

Several techniques are currently used to estimate the optimal catheter length and verify the catheter tip location in clinical practice, including fluoroscopy-guided placement, intracardiac electrocardiography (ECG), anthropometric measurements, surface landmark-based methods, and the catheter-length measurement technique introduced by Lum's measurement technique (LUM).[8-10] LUM's method has gained attention because it is simple, does not require specialized equipment, and can be applied in various clinical settings without extensive training.

The present study retrospectively evaluated the accuracy of LUM's height-based catheter length measurement technique in predicting the correct catheter-tip location using chest X-ray landmarks. In addition, the relationship between catheter tip position and associated complications was analyzed. Patient satisfaction with TIVAP implantation was also assessed.

Methods

Patient Selection

This retrospective study was conducted after ethical approval by the University of Health Sciences Türkiye, Bağcılar Training and Research Hospital Ethics Committee (approval no.: 2023/10/09/065, date: 27.10.2023). Medical records of patients who underwent TIVAP insertion via the right internal jugular vein (IJV) or right subclavian vein (SCV) between January 2021 and January 2023 were reviewed. Of 314 eligible patients, 297 were included in the final analysis. All patients had a confirmed diagnosis of malignant neoplasms and required a totally implantable venous access device for chemotherapy. Written informed consent was obtained from all patients prior to the procedure.

Inclusion criteria were as follows: age between 18 and 75 years; ability to provide informed consent; availability of a postoperative chest X-ray; no clinical requirement for conventional CVC placement; and absence of contraindications to right-sided venous access. Patients were excluded if they were pregnant or had any of the following: a pacemaker, previous central venous access procedures, anatomical alterations due to thoracic surgery, mediastinal invasion by lung cancer, significant pulmonary disease, spinal deformities, or prior spinal surgery.

Demographic and clinical data, including age, sex, height, weight, body mass index (BMI), American Society of Anesthesiologists (ASA) classification, comorbidities, malignancy type, duration of catheterization, insertion site, and catheter tip location, were recorded. All patients were followed for at least six months to monitor early postoperative events, including pneumothorax, accidental arterial puncture, local infection, catheter-associated sepsis, occlusion, tip migration, venous thrombosis, and mortality. Procedural variables such as arrhythmias, puncture site, number of attempts, and ultrasound guidance were also documented. A flow diagram of patient selection is presented in Figure 1.

TIVAP Implantation Technique

All TIVAP insertions were performed by experienced anaesthesiologists in a fully equipped operating room under sterile conditions. Standard monitoring, including ECG, non-invasive blood pressure, and pulse oximetry, was applied to all patients throughout the procedure.

Patients received sedoanalgesia and were continuously monitored to ensure comfort and hemodynamic stability. The procedure was carried out under local anaesthesia

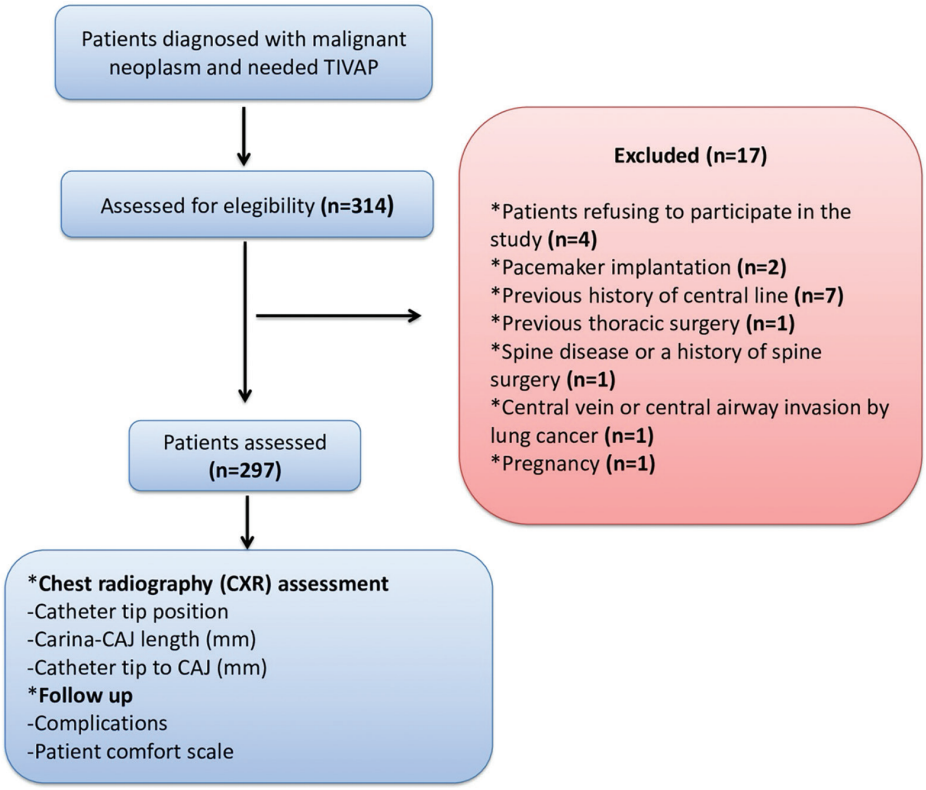


Figure 1. Study flow diagram.

TIVAP, totally implantable venous access ports; CAJ, cavoatrial junction; CXR, chest radiography.

with 2% lidocaine infiltration at the puncture and port pocket sites. No general anaesthesia or deep sedation was administered, and all patients remained conscious and cooperative.

Before the procedure, a detailed medical history was obtained and routine preoperative investigations, including coagulation parameters, complete blood count, ECG, and vascular ultrasonography, were completed. The PORT-A-CATH system (Polysite 4000, Vygon, France) was used in all cases.

For right IJV catheterization, patients were positioned in a 10° Trendelenburg position with their heads gently rotated to the left. For right SCV access, the same Trendelenburg tilt was applied, and the arm was kept adducted to minimize catheter malalignment.[11]

After sterile preparation of the puncture site, venous puncture was performed using an 18-gauge needle, with or without ultrasound guidance (Esaote MyLab Five, Genoa, Italy), depending on operator preference and equipment availability. Catheter placement followed the Seldinger technique. Ultrasound guidance was used whenever available, but was not mandatory due to logistical constraints. The traditional Seldinger method—advancing beyond the posterior vessel wall and withdrawing until a return of blood—was applied.

A straight subcutaneous tunnel was created to prevent catheter kinking, and catheter mobility was confirmed before port attachment. A 3-cm incision parallel to the clavicle was made using a no. 15 scalpel blade. Blunt dissection was used to create an adequate port pocket, and the chamber was positioned subcutaneously below the puncture site.

Catheter length was determined using LUM's height-based measurement technique. For right IJV access, the formula used was height (cm)/10+2 cm; for right SCV access, it was height (cm)/10+1 cm.

Although this method is simple and does not require fluoroscopy or intracardiac ECG, it does not account for individual anatomical variability, which may affect its predictive accuracy and may explain why some catheters were positioned outside the ideal target zone.

A postoperative chest radiograph was obtained to evaluate for early complications and confirm the catheter tip position.

Patient Comfort Assessment

Patient comfort was evaluated using the numeric rating scale (NRS), ranging from 0 (no discomfort) to 10 (worst imaginable discomfort). The assessment was performed on postoperative day 7 by a nurse blinded to catheter tip position. The NRS reflected overall procedural comfort, including pain, anxiety, and procedural tolerance. The NRS is a validated and widely used tool for postoperative comfort assessment.[12]

Radiological Measurements

All postoperative chest radiographs were reviewed by board-certified radiologists. Measurements included the distances between the catheter tip and the CAJ (in millimeters) and between the carina and the CAJ. The position of the catheter tip relative to the carina (superior or inferior) was also recorded. The predefined "target zone" extended from 2 cm above to 1 cm below the CAJ.[13]

A VBU was defined as the vertical distance from the inferior endplate of one vertebra to that of the adjacent lower vertebra, including the intervertebral disc space. The carina was identified radiographically as the point of bronchial bifurcation. The CAJ was assumed to be located 2.4 VBUs below the carina (Figure 2).[3]

Outcomes

The primary outcome was the relationship between catheter tip position relative to the carina and catheter- or procedure-related complications.

Secondary outcomes included the association between complications and catheter tip placement within the predefined CAJ target zone (from 2 cm above to 1 cm below the CAJ), as well as the effects of catheterization site and ultrasound guidance on complication rates.

Statistical Analysis

Statistical analysis was performed using GraphPad Prism version 7 (La Jolla, CA, USA). Normality was assessed with the Shapiro-Wilk test. Continuous variables were expressed as means ± standard deviations or medians with interquartile ranges, as appropriate. Categorical variables were presented as counts and percentages.

The Mann-Whitney U test was used for non-normally distributed continuous variables. Categorical data were analyzed using the chi-square test. Correlations were evaluated using Spearman's correlation coefficient.

A P value < 0.05 was considered statistically significant. Very small P values were reported as $P < 0.0001$. No formal correction for multiple comparisons was applied because subgroup analyses were considered exploratory.

Results

Patient Characteristics

Of the initial cohort of 314 individuals, 297 patients were included in the final analysis (Figure 1). Of these, 154 (51.8%) were women and 143 (48.1%) were men. The median age was 61 years (range: 23-82). The mean height,

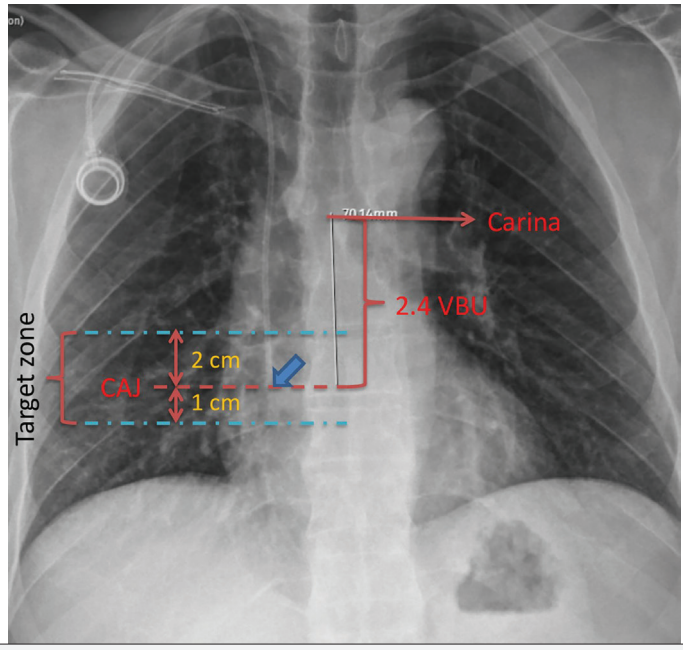


Figure 2. Measurements on chest radiography used to determine catheter tip position. The figure shows a totally implantable venous access port catheter tip positioned exactly at the CAJ. Blue arrow indicates position of catheter tip.

CAJ, cavoatrial junction; VBU, vertebral body units.

weight, and BMI were 165.2±8.3 cm, 68.9±12.7 kg, and 25.3±4.8 kg/m^2, respectively. Hypertension was the most common comorbidity (n = 89), while colorectal malignancy was the most frequent cancer diagnosis (n = 131). Detailed demographic and clinical characteristics are presented in Table 1.

TIVAP Insertion Characteristics and Procedural Safety

The mean duration of catheter use was 234.5 days, and patients received a mean of 12 chemotherapy treatments (range: 1-50). Ultrasound guidance was used in 55% of venous punctures, and two-thirds of all procedures were completed with a single attempt.

In the IJV group, one attempt was sufficient in 70.3% of cases compared with 63.1% in the SCV group; however, this difference was not statistically significant (*P*=0.115). Arterial puncture occurred at similar rates in IJV (8.8%) and SCV (7.4%) catheterizations (*P*=0.658). Pneumothorax occurred in 1.3% of patients in both groups (*P*=0.995). Transient arrhythmias were observed in 84.5% of procedures. In 3.03% of cases, the access site was changed due to failed attempts.

Table 1. Patient's Demographics and Clinical Characteristics

Age	Min-max (median)	23-82 (61)	
	Mean ± SD	59.2±11.8	
Gender	Male/n (%)	143 (48.2)	
	Female/n (%)	154 (51.9)	
Height (cm)	Min-max (median)	140-186 (165)	
	Mean ± SD	165.2±8.3	
Weight (kg)	Min-max (median)	42-108 (67)	
	Mean ± SD	68.9±12.7	
BMI (kg/m^2)	Min-max (median)	15.8-54 (24.4)	
	Mean ± SD	25.3±4.8	
ASA score	Min-max (median)	0-4 (2)	
Comorbidities	**n (%)**		
- AKI	1 (0.3)	IHD	1 (0.3)
Arrhythmia	4 (1.4)	CAD	21(7)
Asthma	5 (1.7)	- HVD	2 (0.7)
- BPH	1 (0.3)	- CKD	2 (0.7)
- DM	74 (25)	- CHF	5 (1.7)
Hypo/hyperthyroidism	13 (4.4)	- COPD	19 (6.4)
- Hypotension	1 (0.3)	Obesity	2(0.7)
- HT	89 (39)	Tuberculosis	1 (0.3)
Cancer type	**n (%)**		
- Lung	3 (1)	Breast	42 (14.1)
- Brain	1 (0.3)	- Testicular	1 (0.3)
- Skin	2 (0.7)	- Tyroid	1 (0.3)
Hematological	1 (0.3)	- Uro-genital	7 (2.4)
Colorectal	131 (44.1)	Upper GI tract	102 (34.3)
- Larynx	6 (2)		
Metastasis	+/n (%)	56 (18.9)	
	−/n (%)	241 (81.1)	

Data presented as mean ± SD, Min-max (median) or count (%).

ASA, American Society of Anesthesiologists; AKI, acute kidney injury; BMI, body mass index; BPH, benign prostate hypertrophy; CAD, coronary artery disease; CHF, congestive heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; HT, hypertension; HVD, heart valve disease; IHD, ischemic heart disease; SD, standard deviation; Min-max, minimum-maximum

The overall complication rate was 11%; the specific complications listed are not mutually exclusive: local infection (0.34%), thromboembolism (0.67%), catheter occlusion (1.7%), pneumothorax (1.7%), and arterial punçture (8.1%). None of the arterial puncture cases resulted in pseudoaneurysm, significant hematoma, hemothorax, hemomediastinum, or inadvertent arterial cannulation.

TIVAPs were inserted via the right IJV in 148 patients and via the right SCV in 149 patients. Significantly more IJV catheters were positioned within the predefined target zone compared with SCV catheters (*P*=0.047). Catheter tips located above the carina showed a greater tip-to-CAJ distance for SCV insertions than for IJV insertions (*P*=0.016). However, the proportion of catheters positioned above versus below the carina did not differ between the two access sites (*P*=0.637) (Figure 3).

Ultrasound guidance was used significantly more often for IJV access (97.3%) than for SCV access (9.6%) (*P* < 0.0001). Catheter occlusion occurred more frequently in SCV catheterizations (3.4%) than in IJV placements (0%) (*P*=0.024). The relationship between insertion site, complications, and patient comfort is summarized in Table 2.

Imaging Findings and Accuracy of Catheter Tip Placement

On chest radiographs, the mean carin-CAJ distance was 57.05±5.86 mm. The mean distance from the catheter tip to the CAJ was 12.71±22.53 mm (range: -44.80 to +110.20 mm). Optimal catheter tip positioning was achieved in 59.9% of evaluable patients (178/279). Most catheter tips (93.9%) were located inferior to the carina (Table 3).

Thromboembolism occurred in only 0.36% (1/279) of patients whose catheter tips were below the carina, but increased to 5.6% (1/18) when tips were positioned above the carina (*P*=0.009). Catheter occlusion was also more frequent among patients with catheter tips positioned above the carina (11.1% vs. 1.1%, *P*=0.001) (Table 4).

Complication rates did not differ significantly between patients with catheter tips inside the target zone and those outside it (occlusion *P*=0.066; thromboembolism *P*=0.773). Catheter longevity was also similar between groups (below the carina: median 200 days vs. above the carina: median 180 days; *P*=0.124).

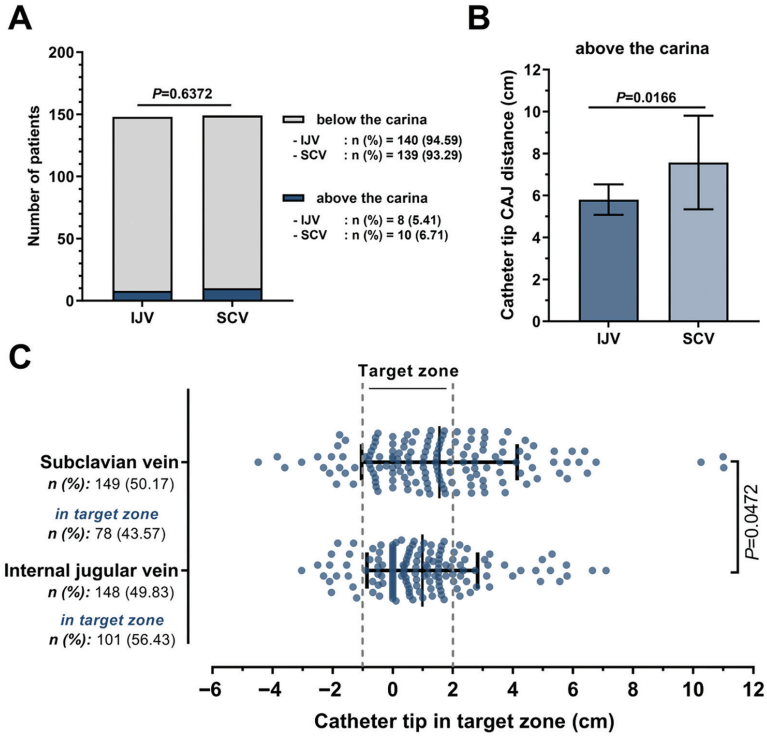


Figure 3. Comparison of IJV and SCV approaches according to catheter tip position. (A) The distribution of patients in terms of the position of the catheter tip relative to the carina was similar between groups (*P*=0.637). (B) Catheter tip-CAJ distance of the patients with catheter tip located above the carina was higher in patients with SCV catheter (*P*=0.016). (C) The number of patients with catheter tips in the target zone was higher in IJV approach (*P*=0.047).

CAJ, cavoatrial junction; IJV, internal jugular vein; SCV, subclavian vein.

When patients with catheter tips either within the target zone or below the carina were compared, similar rates of occlusion and thromboembolism were observed. These findings emphasize the importance of achieving catheter tip placement below the carina—particularly when using the IJV approach—to minimize complication risk.

Correlation Analysis

A moderate positive correlation was observed between patient height and the carina-CAJ distance (r = 0.3851, $P < 0.0001$). No significant association was found between BMI and this measurement (r = 0.0467, P=0.4761) (Figure 4).

Table 2. Effect of Catheterization Site on Complications and Patient Comfort Scale

		Internal jugular vein (n = 148)	Subclavian vein (n = 149)	*P* value
USG guidance	n (%)	144 (97.3)	20 (9.6)	<0.0001[a]
Number of venous puncture attempts	1 n (%)	104 (70.3)	94 (63.1)	0.1160[a]
	2 n (%)	31 (21)	30 (20.1)	
	3 and above n (%)	13 (8.8)	25 (16.8)	
Arterial puncture	n (%)	13 (8.8)	11 (7.4)	0.6577[a]
Pneumothorax	n (%)	2 (1.4)	2 (1.3)	0.9946[a]
Thromboembolism	n (%)	0 (0.00)	2 (1.3)	0.1573[a]
Catheter occlusion	n (%)	0 (0.00)	5 (3.4)	0.0246[a]
Local infection	n (%)	0 (0.00)	1 (0.7)	0.3181[a]
Patient comfort scale	Min-max (median)	0-3 (0)	0-5 (0)	0.1519[b]

[a]: *P* value was determined by chi-square test. [b]: *P* value was determined by Mann-Whitney U test
USG, ultrasonography; Min-max, minimum-maximum

Table 3. Imaging Measurement on CXR

Catheter tip to CAJ (mm)	Min-max (median)	-44.80/110.20 (10.2)
	Mean ± SD	12.71±22.53
Carina to CAJ (mm)	Min-max (median)	41.70-72.70 (56.4)
	Mean ± SD	57.05±5.86
Position of the catheter tip relative to the carina	Below/n (%)	279 (93.9)
	Above/n (%)	18 (6.1)
Catheter tip in target zone	Yes/n (%)	178 (59.9)
	No/n (%)	119 (40.1)

Data presented as mean ± SD, min-max (median) or count (%)
CAJ, cavoatrial junction; CXR, chest radiography; SD, standard deviation; Min-max, minimum-maximum

Table 4. The Effect of the Catheter tip Position Relative to the Carina on Postoperative Complications and the Number of Catheter Days

		Below the carina (n=279)	Above the carina (n=18)	*P* value
Thromboembolism	n (%)	1 (0.4)	1 (5.6)	0.0090[a]
Catheter occlusion	n (%)	3 (1.1)	2 (11.1)	0.0013[a]
Number of catheter days	Min-max (median)	1-720 (200)	1-450 (180)	0.1243[b]
	Mean ± SD	236.60±149.80	175.40±110.70	

Data presented as mean ± SD, Min-max (median) or count (%). [a]: *P* value was determined by chi-square test. [b]: *P* value was determined by Mann-Whitney U test
SD, standard deviation; Min-max, minimum-maximum

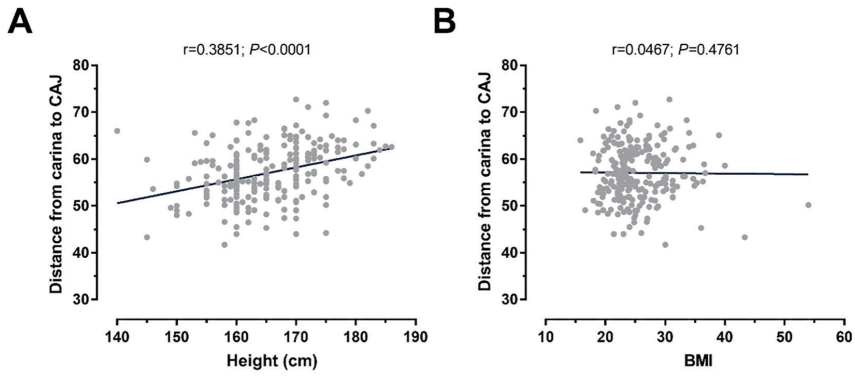


Figure 4. Correlation analyses. (A) Distance between carina and CAJ positively correlated with patients' height (r = 0.3851; *P* < 0.0001). (B) A significant but weak correlation was found between age and mortality (r = 0.2776; *P* < 0.0001).

CAJ, cavoatrial junction; BMI, body mass index.

Mortality showed a weak but statistically significant correlation with age (r = 0.2776, *P* < 0.0001). No significant correlation was observed between mortality and ASA classification or the presence of metastatic disease.

Discussion

In this retrospective analysis, we examined the reliability of LUM's height-based CVC measurement method for predicting the final tip position of TIVAP catheters placed via the right internal jugular or SCV and assessed whether tip location influenced complication rates in 297 patients. Our data indicate that the technique achieved accurate positioning in approximately 60% of cases on postoperative chest radiographs, suggesting only moderate clinical effectiveness. Importantly, most catheters (93.9%) were located inferior to the carina, and these patients experienced fewer complications. In contrast, tip placement above the carina was significantly associated with higher rates of thromboembolism and catheter occlusion.

This observation supports existing physiological explanations that catheter tips situated below the carina are exposed to more stable blood flow patterns and to less mechanical irritation of the vessel wall, thereby reducing adverse events.[4] Additionally, our results demonstrated that the IJV approach yielded higher rates of correct tip placement and fewer catheter occlusions compared with the SCV approach.

LUM's formula, which determines catheter length according to patient height and puncture site, is appealing because it requires no specialized equipment and is adaptable to many clinical scenarios. Nevertheless, inaccurate tip positioning can lead to several complications, including thrombosis, malfunction, or infection, particularly when the catheter terminates too proximally within the SVC.[3] Although most of the literature identifies the ideal termination point as the lower segment of the SVC near the CAJ,[14-16] European recommendations also regard a position up to 2 cm below the CAJ as clinically acceptable.[17] Although only 59.9% of catheters were positioned within the predefined target zone, placement within this zone did not independently predict complications in this study. Instead, catheter position relative to the carina was the dominant determinant of clinical outcomes.

When patients whose catheter tips were either in the target zone or positioned below the carina were compared, complication rates were similar. These findings suggest that achieving subcarinal tip placement may be sufficient for clinical safety and may be consistent with international guideline recommendations.

The right internal jugular and SCVs are the most frequently used access sites for CVC.[18] Although both approaches were used equally in our cohort, the SCV route was associated with higher rates of thromboembolism and catheter occlusion. This difference appeared to be influenced primarily by the final tip position rather than by the access site itself. Catheters inserted via the IJV were more frequently positioned within the optimal zone. These findings are consistent with previous reports, including a meta-analysis of 3,905 patients demonstrating fewer mechanical complications with IJV access than with SCV access.[19]

Cardiac arrhythmias are well-documented events during CVC placement.[20] In our cohort, transient arrhythmias occurred in approximately 85% of procedures. Importantly, all arrhythmias were self-limiting and clinically insignificant, and no hemodynamic instability was observed. Patient comfort levels, as reflected by NRS scores, remained acceptable.

The arterial puncture rate in our study (approximately 9%) was higher than that reported in some earlier studies.[2,12] This

may reflect operator experience during the study period, use of static rather than continuous real-time ultrasound guidance in some cases, and anatomical factors such as small IJV diameter or close proximity of the carotid artery.

Using VBUs as a radiographic reference for estimating catheter tip position offers several advantages.[3] The thoracic spine is minimally affected by magnification and remains stable across postural changes.[4] In our cohort, the mean carina-CAJ distance was 57.05±5.86 mm and correlated positively with patient height but not BMI. The correlation with height, but not with BMI, is physiologically plausible because thoracic skeletal dimensions are primarily determined by bone structure rather than by adiposity.

Mortality correlated weakly with age but not with ASA classification or metastatic disease. Because all ports were inserted on the right side in this study, future studies should compare bilateral approaches and incorporate multivariable modeling to better identify independent predictors of optimal catheter tip placement.

Study Limitations

Several limitations should be acknowledged. First, the retrospective single-center design limits the generalizability of the findings. Second, although all patients were followed for at least six months, late catheter-related complications may have been underestimated. Third, the absence of multivariable analysis limits the identification of independent predictors of complications. Finally, the study population consisted solely of Turkish patients, which may further limit the external validity.

All catheterizations were performed on the right side, which limits extrapolation of the results to left-sided venous access. Therefore, caution is required when applying these findings to left internal jugular or SCV catheterizations.

Conclusion

Our findings provide compelling evidence that ensuring the TIVAP catheter tip is positioned inferior to the carina and using the IJV as the preferred access route significantly reduce clinically relevant complications, particularly thromboembolism and catheter occlusion. Sub-carinal tip placement combined with IJV access should therefore be regarded as a best-practice strategy for safe TIVAP implantation.

Although LUM's height-based measurement method offers a practical and equipment-free estimation tool, its moderate accuracy highlights the necessity of radiological confirmation of the the catheter-tip position. Future multicenter prospective studies with extended follow-up and comprehensive multivariable analysis are warranted to validate these findings.

Ethics

Ethics Committee Approval: This retrospective study was conducted after ethical approval by the University of Health Sciences Türkiye, Bağcılar Training and Research Hospital Ethics Committee (approval no.: 2023/10/09/065, date: 27.10.2023).

Informed Consent: Written informed consent was obtained from all patients prior to the procedure.

Footnotes

Author Contributions

Surgical and Medical Practices - H.A., S.D., S.K.S., A.S.; Concept - S.D., S.K.S.; Design - S.D., S.K.S.; Analysis or Interpretation - H.A., E.S.; Literature Search - H.A., S.D., S.K.S., E.S., R.O.K., A.S.; Writing - S.D., S.K.S., R.O.K.

Declaration of Interests: The authors declare no conflicts of interest.

Funding: No funding was received for this study.

Supplementary Materials: https://d2v96fxpocvxx.cloudfront.net/cf9d60d6-523c-458a-a2e6-78728d3ffbb0/content-images/378994b5-c1cd-4404-a7f1-6b11d71e371d.pdf

References

1. Biffi R, Toro A, Pozzi S, Di Carlo I. Totally implantable vascular access devices 30 years after the first procedure. What has changed and what is still unsolved? *Support Care Cancer.* 2014;22(6):1705-1714. [CrossRef]
2. Wang YC, Lin PL, Chou WH, Lin CP, Huang CH. Long-term outcomes of totally implantable venous access devices. *Support Care Cancer.* 2017;25(7):2049-2054. [CrossRef]
3. Wang YC, Lin PL, Chou WH, Lin CP, Huang CH. Long-term outcomes of totally implantable venous access devices. *Support Care Cancer.* 2017;25(7):2049-2054. [CrossRef]
4. Baskin KM, Jimenez RM, Cahill AM, Jawad AF, Towbin RB. Cavoatrial junction and central venous anatomy: implications for central venous access tip position. *J Vasc Interv Radiol.* 2008;19(3):359-365. [CrossRef]
5. Fletcher SJ, Bodenham AR. Safe placement of central venous catheters: where should the tip of the catheter lie? *Br J Anaesth.* 2000;85(2):188-191. [CrossRef]
6. Stoneham GW. Re: the malpositioned central venous catheter: a noninvasive technique for repositioning the catheter tip. *Cardiovasc Intervent Radiol.* 2001;24(3):204-205. [CrossRef]
7. Petersen J, Delaney JH, Brakstad MT, Rowbotham RK, Bagley CM Jr. Silicone venous access devices positioned with their tips high in the superior vena cava are more likely to malfunction. *Am J Surg.* 1999;178(1):38-41. [CrossRef]
8. Li J, Chen W, Zhao W, et al. Surface measurement, intracardiac electrocardiogram and tracheal bifurcation techniques for locating the catheter tips of totally implantable venous access port. *Comput Methods Programs Biomed.* 2020;187:105238. [CrossRef]
9. Vardy J, Engelhardt K, Cox K, et al. Long-term outcome of radiological-guided insertion of implanted central venous access port devices (CVAPD) for the delivery of chemotherapy in cancer patients: institutional experience and review of the literature. *Br J Cancer.* 2004;91(6):1045-1049. [CrossRef]
10. Yuan L, Li R, Meng A, et al. Superior success rate of intracavitary electrocardiogram guidance for peripherally inserted central catheter placement in patients with cancer: a randomized open-label controlled multicenter study. *PLoS One.* 2017;12(3):e0171630. [CrossRef]

11. Ahn JH, Kim IS, Shin KM, et al. Influence of arm position on catheter placement during real-time ultrasound-guided right infraclavicular proximal axillary venous catheterization. *Br J Anaesth.* 2016;116(3):363-369. [CrossRef]
12. Chen YB, Bao HS, Hu TT, et al. Comparison of comfort and complications of implantable venous access port (IVAP) with ultrasound guided internal jugular vein (IJV) and axillary vein/subclavian vein (AxV/SCV) puncture in breast cancer patients: a randomized controlled study. *BMC Cancer.* 2022;22(1):248. [CrossRef]
13. Ahn JH, Kim IS, Yang JH, Lee IG, Seo DH, Kim SP. Transoesophageal echocardiographic evaluation of central venous catheter positioning using Peres' formula or a radiological landmark-based approach: a prospective randomized single-centre study. *Br J Anaesth.* 2017;118(2):215-222. [CrossRef]
14. Lum P. A new formula based measurement guide for of central venous catheters. *JAVA.* 2004;9(2):80-85. [CrossRef]
15. Infusion Nurses Society. Infusion nursing standards of practice. *J Infus Nurs.* 2006;29(1 Suppl):S1-92. [CrossRef]
16. Vesely TM. Central venous catheter tip position: a continuing controversy. *J Vasc Interv Radiol.* 2003;14(5):527-534. [CrossRef]
17. Pittiruti M, Hamilton H, Biffi R, MacFie J, Pertkiewicz M; ESPEN. ESPEN Guidelines on parenteral nutrition: central venous catheters (access, care, diagnosis and therapy of complications). *Clin Nutr.* 2009;28(4):365-377. [CrossRef]
18. Gallieni M, Pittiruti M, Biffi R. Vascular access in oncology patients. *CA Cancer J Clin.* 2008;58(6):323-346. [CrossRef]
19. Wu S, Huang J, Jiang Z, et al. Internal jugular vein versus subclavian vein as the percutaneous insertion site for totally implantable venous access devices: a meta-analysis of comparative studies. *BMC Cancer.* 2016;16:747. [CrossRef]
20. Cheng KI, Chu KS, Chen LT, Tang CS. Correct positioning of the venous port-a-cath catheter: comparison of intravascular electrocardiography signal from guidewire and sodium bicarbonate flushed catheter. *Anaesth Intensive Care.* 2002;30(5):603-607. [CrossRef]

Original Article
Other

DOI: 10.4274/TJAR.2026.252337
Turk J Anaesthesiol Reanim 2026;54(2):117-124

Turkish Journal of Anaesthesiology & Reanimation

Pregnancy and Motherhood Experiences of Turkish Women Anaesthesiologists in Training and Work Life

Aslıhan Güleç Kılıç[1], Beyza Büyükgebiz Yeşil[2], Selin Erel[3]

[1]Göksun State Hospital, Clinic of Anaesthesiology and Reanimation, Kahramanmaraş, Türkiye
[2]Kahramanmaraş State Hospital, Clinic Anaesthesiology and Reanimation, Kahramanmaraş, Türkiye
[3]Gazi University Faculty of Medicine, Department of Anaesthesiology and Reanimation, Ankara, Türkiye

Abstract

Objective: To evaluate the experiences and perceived obstacles related to pregnancy and motherhood among Turkish women anaesthesiologists and to identify work-related factors associated with considering resignation during pregnancy.

Methods: This cross-sectional survey targeted female anaesthesiologists working in or trained in Türkiye. Participants responded to 39 items across five domains: (1) demographics and professional background, (2) fertility intentions and childbearing decisions, (3) pregnancy history and obstetric outcomes, (4) impact of pregnancy on training, work-life, and academic productivity, and (5) breastfeeding practices and workplace support. Responses were collected over a two-week period without reminder emails and subsequently analyzed.

Results: A total of 334 women anaesthesiologists completed the survey; 55.7% had at least one child and 36.8% were childless. Among those without children, 41.3% still desired motherhood, and working conditions were significantly associated with uncertainty or reluctance toward childbearing ($P < 0.001$). 39.8% of participants delayed antenatal visits due to workload. Most participants (84.2%) returned early from maternity leave, and 75.5% reported reduced academic productivity during pregnancy or motherhood. Among those who breastfed or pumped at work, 47.8% discontinued earlier than intended, largely because of work-related constraints. Overall, 35.2% considered resigning during pregnancy, and work-related disruption of antenatal care was the only independent predictor of intent to resign (odds ratio 0.28, 95% confidence interval 0.12-0.61, P=0.001).

Conclusion: Turkish pregnant anaesthesiologists frequently experienced disruptions in antenatal care, shortened maternity leave, reduced academic productivity, and inadequate breastfeeding support. Working conditions significantly influence both fertility decisions and intentions to resign.

Keywords: Anaesthesiology, breast feeding, pregnancy, survey

Main Points

- Pregnancy and motherhood are common among Turkish women anaesthesiologists, yet working conditions frequently disrupt antenatal care and shorten maternity leave.
- Departmental workloads, shift patterns, and cultural expectations strongly influence fertility planning, leading many individuals to delay or reconsider childbearing.
- Workplace breastfeeding support remains insufficient, with structural and cultural barriers leading to early discontinuation of breastfeeding.
- Disrupted access to antenatal care independently predicted an intent to resign, emphasising the need for institutional policies that safeguard maternal well-being and workforce retention.

Introduction

The proportion of women in the Turkish and international medical workforce has increased steadily over the past decade.[1,2] While women now represent a substantial share of physicians and medical residents globally, the gender distribution in Türkiye presents a unique pattern. Although the total number of female physicians in Türkiye remains lower than that of male physicians, the field of anaesthesiology exhibits a notable female predominance.[3]

Corresponding author: Aslıhan Güleç Kılıç MD **E-mail:** asligulec@yahoo.com
Received: December 16, 2025 **Accepted:** January 22, 2026 **Epub:** March 10, 2026 **Published date:** April 15, 2026
Cite this article as: Güleç Kılıç A, Büyükgebiz Yeşil B, Erel S. Pregnancy and motherhood experiences of Turkish women anaesthesiologists in training and work life. *Turk J Anaesthesiol Reanim*. 2026;54(2):117-124

Despite the increasing representation of female anaesthesiologists over the years, women continue to encounter significant obstacles in their professional lives. These challenges include persistent traditional gender norms, the gender pay gap, and underrepresentation in academic leadership roles.[4-8] Among these issues, the difficulties faced during pregnancy and early motherhood are particularly prominent. Studies conducted among female physicians indicate that societal expectations regarding childcare and the unequal distribution of domestic responsibilities continue to shape career experiences. These factors heavily influence the professional lives of women, particularly during pregnancy and the postpartum period.[4,5]

These challenges may be amplified in anaesthesiology, a specialty characterised by demanding on-call schedules, night shifts, occupational exposure concerns, and a high degree of clinical responsibility — factors known to influence working conditions for pregnant clinicians.[9] A nationwide survey of women anaesthesiologists conducted by the American Society of Anesthesiologists (ASA) found that work demands frequently led women to delay childbearing, alter desired family size, or modify career plans.[10] Similarly, studies from Europe have documented substantial variation in institutional support for pregnant anaesthesiologists, inconsistent occupational adaptations, and persistent concerns regarding environmental exposures in the operating room.[11,12] In addition to these structural barriers, several studies describe a perceived "motherhood penalty" among female anaesthesiology residents. Program directors in the United States report concerns that pregnancy or parental leave negatively affects female residents' academic progression and procedural experience, despite a lack of objective evidence supporting these perceptions.[13] Other surveys identify difficulties related to breastfeeding arrangements, stigma surrounding maternity leave, and reduced access to mentorship for women who become mothers during training.[14,15]

Despite growing international attention to this topic, data regarding pregnancy, motherhood, and career progression among women anaesthesiologists in Türkiye remain limited. Findings from American or European settings may not be directly generalizable to Türkiye given the country's unique sociocultural context, specific maternity legislation, institutional structures, and significantly higher patient-to-doctor ratios. Therefore, understanding how Turkish women anaesthesiologists perceive pregnancy and motherhood is essential for shaping workplace policies, improving educational environments, and supporting career sustainability within the specialty.

The present study aims to evaluate the attitudes, perceived barriers, and lived experiences of Turkish women anaesthesiologists regarding pregnancy and motherhood during training and professional life.

Methods

This study was designed as a national, cross-sectional, web-based survey to evaluate the attitudes, experiences, and perceived challenges related to pregnancy and motherhood among women anaesthesiologists in Türkiye. Ethical approval for the study was obtained from Gazi University Rectorate Ethics Commission (approval no.: 2025-1882, date: 11/11/2025). Participation was voluntary, anonymous, and self-administered. No financial incentives were offered to survey participants, and all participants provided electronic informed consent prior to initiating the survey. This study adheres to the Checklist for Reporting Results of Internet E-Surveys guidelines, which outline methodological and reporting standards for the design, conduct, and presentation of internet-based survey research.[16]

The questionnaire was developed by the authors based on the survey instrument used in a previous study.[14] The authors subsequently modified it in line with their opinions and adapted it to the specific context of Turkish anaesthesiology training and work culture. The final instrument consisted of 39 items, structured into five domains: demographics and professional background; fertility intentions and childbearing decisions; pregnancy history and obstetric outcomes; impact of pregnancy on training, work-life, and academic productivity; and breastfeeding practices and workplace support (Supplement 1). The item formats included single-choice questions, multiple-choice questions, numerical entries, and five-point Likert scales scored from 1 (strongly disagree) to 5 (strongly agree).

The survey was created and hosted using Typeform® (Typeform S.L., Barcelona, Spain), a secure online survey platform. The survey link was distributed through multiple channels to ensure wide national reach via email lists of the Turkish Society of Anesthesiology and Reanimation (TSAR) and via peer-to-peer professional email addresses for a two-week period. Reminder emails were intentionally omitted to reduce the risk of survey fatigue and to ensure that participation remained entirely voluntary, without any perceived pressure. Participants were able to complete the survey once. To ensure data integrity, IP addresses were monitored to prevent duplicate entries and were subsequently deleted from the final dataset to maintain complete anonymity. With respect to participant selection and data quality, the study population was strictly limited to women anaesthesiologists, and male colleagues were excluded. Additionally, only fully completed questionnaires were included in the final analysis; incomplete submissions were excluded. All responses were stored on a secure and password-protected server accessible only to the study team.

Statistical Analysis

Data are analysed using SPSS (version 26, IBM Corp., Armonk, NY). Categorical variables are summarised as frequencies and percentages. Continuous variables are presented as mean ± standard deviation or median (interquartile range), depending on distribution.

Comparisons between subgroups (e.g., residents vs specialists; mothers vs. non-mothers) are performed using χ^2 or Fisher's exact tests for categorical data, and independent-samples t-tests or Mann-Whitney U tests for continuous variables, as appropriate. Statistical significance is defined as $P < 0.05$.

Variables associated with intent to resign at the univariable level ($P < 0.05$) were entered into a multivariable logistic regression using a backward stepwise (likelihood-ratio) method. Resignation intent was modelled as a binary outcome. Predictors were sequentially removed based on their contribution to model fit, with odds ratios (ORs) and 95% confidence intervals (CIs) reported for variables retained in the final model. Model adequacy was assessed using the Omnibus test, the Hosmer-Lemeshow test, and Nagelkerke R^2.

Results

The responses of 334 women anaesthesiologists who completed the survey were included in the analysis. An additional 173 participants initiated the survey but did not complete it. Based on unpublished administrative data obtained directly from TSAR, the email list includes 5,206 female anaesthesiologists (residents and specialists), yielding an estimated response rate of 6.4%. However, as the survey was also disseminated through peer-to-peer contacts via personal emails and the access routes of individual respondents could not be identified, the true denominator remains uncertain. Therefore, this estimate should be interpreted as an approximate lower-bound response rate. Most respondents were between 31 and 40 years of age, were attending anaesthesiologists, and had completed their residency in state university hospitals. Demographic characteristics and details of the residency institutions are summarized in Table 1.

Among the 334 respondents, 10 (3.0%) they were currently pregnant, 186 (55.7%) they had at least one child, and 138 (41.3%) had no children. Among those without children, 41.3% indicated that they wished to have children, while the remainder were either unsure or did not plan to become mothers. Among all 334 respondents, 196 (58.7%) either did not wish to have (more) children or were unsure about future childbearing, regardless of whether they already had children; working and training conditions were significantly associated with their decision (Table 2). While 43.8% of those who did not want children reported that working conditions influenced their decision, this proportion increased sharply to 81.4% among those who were unsure.

When comparing respondents who had never been pregnant with those who had been pregnant at least once, a significant overall difference in pregnancy-related workplace perception scores was observed ($P < 0.05$; Table 3). Women with previous pregnancy experience more strongly agreed that they felt discouraged about becoming a mother. In contrast, never-pregnant respondents reported greater agreement with perceiving negative attitudes toward pregnancy during training or in the workplace, feeling an increased workload due to a colleague's maternity leave,

Table 1. Demographic Data of the Participants and Characteristic of Their Educational Instution

Demographics and characteristics	n (%), median (Q1-Q3)
Age groups of the participants (years), n (%)	
• 24-30	75 (22.5)
• 31-40	137 (41.0)
• >40	122 (36.5)
Residency/working status, n (%)	
• Junior resident (≤2 years)	35 (10.5)
• Senior resident (>2 years)	85 (25.4)
• Attending anaesthesiologist	176 (52.7)
• Consultant anaesthesiologists with academic title	38 (11.4)
Institutional setting during residency training, n (%)	
• State university hospital	196 (58.7)
• Training and research hospital	109 (32.6)
• City hospital	25 (7.5)
• Private foundation university hospital	4 (1.2)
Co-residents during training, median (Q1-Q3)	
• Average total resident number	30 (18-45)
• Average total female resident number	17 (10-25)
• Average percentage of female resident number	60 (50-68.75)
Academic faculty during training, median (Q1-Q3)	
• Average total academic faculty number	10 (5-14)
• Average total female academic faculty number	5 (2-8)
• Average percentage of female faculty	60 (40-71.43)
Gender of the department head during training, n (%)	
• Female	140 (41.9)
• Male	142 (42.5)
• Both	52 (15.6)
Presence of pregnant co-residents during training, n (%)	306 (91.6)

n, number; Q, quartile

and supporting a reduction in seniority upon returning from maternity leave.

Of the 196 respondents who had ever been pregnant, 64.8% (n = 127) stated that they were pregnant or were mothers during residency training. Overall, 39.8% (n = 78) reported delaying their prenatal care visits due to work demands. When asked whether they had ended their maternity leave earlier than planned, 84.2% (n = 165) reported that they had; the most frequently selected reasons were financial difficulties (49.7%, n = 82), fear of retaliation from the department leadership or hospital administration (30.9%, n = 51), concern about falling behind in knowledge or skills (29.1%, n = 48), and peer pressure (22.4%, n = 37). Seventy-five percent (n = 148) of respondents who had ever been pregnant reported that their academic work performance declined during pregnancy and/or motherhood. The most commonly reported contributors to this decline in academic performance were tiredness or sleep deprivation (77.0%, n = 114), difficulty balancing work and family responsibilities (62.2%, n = 92), insufficient workplace support (51.4%, n = 76), emotional distress (50.7%, n = 75), and, less frequently, discrimination (19.6%, n = 29).

Among the 136 participants who breastfed or pumped during working hours, 24.3% (n = 33) reported inadequate support from peers or faculty, and 39.7% (n = 54) experienced guilt during pumping breaks. A total of 47.8% (n = 65) discontinued lactation earlier than intended; of these, 82.9% attributed this to work-related factors. Additionally, 68.4% (n = 93) reported that an appropriate pumping room was either unavailable or inaccessible during their regular work schedule.

Overall, 35.2% (n = 69) reported having considered resigning during pregnancy. Chi-square analyses were conducted to explore the association between individual variables and resignation intent during pregnancy. Several factors were significantly associated with consideration of resignation. These included delays in antenatal follow-up due to workload ($P < 0.001$), pregnancy-related symptoms, such as gastrointestinal disturbance, backache, or memory difficulties ($P=0.003$), and perceived decline in academic work performance ($P=0.04$). To further evaluate the independent contributions of these variables, a backward-stepwise logistic regression was performed (Table 4). After sequential removal of non-contributing predictors, the final model retained two variables and remained significant overall. Work-related disruption of

Table 2. Effect of Working Conditions on Motherhood Intentions

Motherhood intention categories	Perceived impact of working conditions, n (%)			Total	*P* value
	No	Yes	Partially		
Uncertain	8 (18.6)	23 (52.49)	12 (52.17)	43	**<0.001**
Not planning	86 (56.21)	41 (26.8)	26 (16.99)	153	
Total	94	64	38	196	

Chi-square test $P < 0.05$ was considered statistically significant

Table 3. Pregnancy-Related Workplace Perception Scores by Previous Pregnancy Status

Statements	Never pregnant (n = 138) median (Q1-Q3)	Ever pregnant (n = 196) median (Q1-Q3)	*P*
"I felt discouraged from becoming a mother during training/working life"	3 (2-4)	4 (2-5)	**0.014**
"I perceived negative attitudes toward pregnancy during my training/working life"	4 (2-5)	4 (3-5)	**0.004**
"I felt that I carried an unfair workload due to a colleague's maternity leave"	2 (1-4)	2 (1-3)	**0.03**
"An employee returning from maternity leave should have her seniority reduced"	3 (1-4)	2 (1-3)	**0.026**

Mann-Whitney U test, $P < 0.05$ was considered statistically significant; Q, quartile

Table 4. Multivariable Logistic Regression Analysis of Factors Associated with Resignation Intent During Pregnancy Among Anaesthesiologists

	B	SE	Odds ratio (95% CI)	*P*
Work related disruption of antenatal care	-1.29	0.41	0.28 (0.12-0.61)	**0.001**
Experiencing pregnancy associated symptoms	-0.93	0.52	0.39 (0.14-1.08)	0.07

Multivariable backward logistic regression analysis, $P < 0.05$ was considered statistically significant. Outcome variable was coded as 1= consideration of resignation and 0= no consideration. Independent variables were coded as 1= presence of exposure and 0= absence

B, beta coefficient; SE, standard error; CI, confidence interval

antenatal care emerged as the only statistically significant independent predictor of resignation intent (OR: 0.275, 95% CI: 0.124-0.608, *P*=0.001). Anaesthesiologists who experienced work-related disruption of antenatal care were significantly more likely to consider resigning than those without such disruption (OR: 0.28, 95% CI: 0.12-0.61). Pregnancy-related symptoms showed a not statistically significant trend toward an association with the outcome (OR: 0.394, *P*=0.07) and remained in the model based on likelihood-ratio criteria, though it did not reach statistical significance in the multivariable model. The final model demonstrated excellent calibration (Hosmer-Lemeshow *P*=0.95) and explained approximately 18 percent of the variance in resignation intent (Nagelkerke R^2 = 0.18) (Table 4).

Discussion

In this first national survey of Turkish women anaesthesiologists, pregnancy and motherhood were common during residency and were frequently accompanied by delayed antenatal care, shortened maternity leave, reduced academic productivity, and substantial barriers to breastfeeding at work. Working and training conditions strongly shaped fertility intentions and workplace perceptions; many participants described workload, departmental culture, and informal expectations as discouraging childbearing. Never-pregnant respondents were more likely to report feeling burdened by colleagues' maternity leave, suggesting that the absence of structured coverage mechanisms may contribute to tension and stigma. This finding that disruption to antenatal care was the strongest factor associated with considering resignation underscores that current work patterns remain misaligned with basic perinatal needs.

Consistent with global trends, motherhood during anaesthesiology training was highly prevalent in our cohort.[10,14,16] Almost two-thirds of respondents were pregnant or were mothers during residency. Considering reports that infertility rates may be higher among anaesthesiologists than in the general population, this finding is encouraging.[17] On the other hand, it is concerning that working conditions and workplace culture played a major role in the decision of women without children not to pursue motherhood. Among those who were unsure, more than 80% identified workload and training demands as contributing factors; even among those who did not want children, nearly half cited working conditions. These findings suggest that the current structure of anaesthesiology training and service in Türkiye acts as a deterrent to childbearing for some women, rather than serving as a neutral background factor. Occupational hazards, such as exposure to waste anaesthetic gases and radiation, and reports that female anaesthesiologists may be subjected to mobbing more frequently than their male colleagues, could also contribute to these findings.[17-19] Although these factors were not directly assessed in our survey, they provide plausible contextual considerations that may help interpret our findings and should be explored in future studies.

Beyond these well-recognized occupational risks and the traditional forms of workplace hostility encountered in surgical specialties, our findings point to a strained workplace climate regarding pregnancy. Women who had experienced pregnancy felt more discouraged from becoming mothers while in training or at work, whereas never-pregnant anaesthesiologists more often agreed that they bore an unfair share of the workload during colleagues' maternity leave and were more likely to support reducing seniority after maternity leave. This pattern suggests that in the absence of clear staffing policies and formal coverage arrangements, pregnancy-related workload may be perceived as a zero-sum issue at the departmental level. Similar concerns about stigma, resentment over workload redistribution, and a perceived motherhood penalty have been described in surveys of anaesthesiologists and residents from North America and Europe, in which pregnancy is frequently regarded as disruptive both to the individual's career and to colleagues covering clinical duties.[9-14] The divergent perceptions between never-pregnant and ever-pregnant respondents highlight a potentially self-perpetuating cycle. In the absence of clear, institutionally mandated coverage structures, colleagues who repeatedly cover additional calls or shifts for pregnant peers may come to view pregnancy as a private benefit with collective costs. This can increase stigma and make colleagues more supportive of penalising practices, such as reducing seniority following maternity leave. As a result, residents may be less willing to disclose a pregnancy early or to take their full entitlement to leave. Breaking this cycle will require making coverage arrangements a departmental responsibility rather than an informal negotiation among residents.

Among women who became pregnant or who were mothers during residency, many reported that basic perinatal needs were compromised by work. Although women physicians in Türkiye who are covered by the Civil Servants Law No. 657 have strong statutory protections, these provisions may not translate into full real-world use within anaesthesiology. Under Legislation No. 657, maternity leave totals 16 weeks (prenatal plus postnatal), and breastfeeding or lactation time is allocated.[20] In addition, pregnant civil servants from 24 weeks' gestation and those up to two years postpartum cannot be assigned night duty or night shifts. By comparison, at the European Union level, the legal baseline is at least 14 consecutive weeks of maternity-leave, whereas in the United States there is no universal federal paid maternity-leave entitlement for physicians, and the duration of paid leave often depends on employer policy; however, ACGME-

accredited training programs must provide a minimum of 6 weeks of approved paid leave.[21,22] Despite these legal safeguards in Türkiye, the workflow of anaesthesiology, where uninterrupted patient monitoring and staffing continuity are essential, can make it difficult for physicians to consistently take leave, obtain shift exemptions, or access protected break entitlements. In our study, almost 40% of participants reported difficulty attending antenatal visits and 85% ended their maternity leave early. These proportions are similar to findings reported in countries with very different legal frameworks. Almost 40% reported delaying antenatal visits because of workload, a rate consistent with international surveys.[14] These challenges pose a significant problem for pregnant physicians. In our multivariable analysis, work-related disruption of antenatal care was the most significant independent predictor of considering resignation from work during pregnancy. Anaesthesiologists who were unable to attend antenatal appointments because of work demands were more likely to report an intent to resign. Similar findings from European studies, in which pregnancy-related working conditions have led anaesthesiologists to consider leaving training programs, further support this interpretation.[11] From a workforce perspective, ensuring protected time for antenatal care may therefore be a simple but important strategy to reduce avoidable stress and potential attrition among early-career anaesthesiologists.

Maternity leave is a key component of postpartum recovery and mental health.[23,24] Prior qualitative research has shown that an early return to work can heighten stress related to childcare, breastfeeding, and sleep deprivation.[25] Although the specific reasons differ across countries with varying legal and cultural environments, such as rigid schedules, limited or unpaid maternity leave, and the absence of structured return-to-work support, the high rates of early termination of maternity leave in our cohort suggest that the pregnancy experiences of anaesthesiologists cannot be fully safeguarded through legislation alone.[9-11,13-15] Instead, these patterns indicate a broader professional culture in which pregnancy and early motherhood are treated as individual burdens to be absorbed by the mother, rather than predictable and recurrent situations that require explicit accommodation through paid leave, flexible scheduling, and formal protection from informal sanctions.

In the present study, 75% of participants reported a decline in academic productivity during pregnancy and motherhood, which warrants particular attention in the academic setting. In many Turkish training and university hospitals, criteria for academic advancement are heavily weighted toward conference presentations, publications, and uninterrupted clinical activity. Women who become mothers may therefore be structurally disadvantaged, even when their clinical performance remains strong. This self-reported decline is broadly aligned with existing data: a scoping review of pregnancy in physicians found that, although measured work productivity and academic metrics were generally independent of pregnancy, colleagues frequently perceived pregnant physicians as less productive and more burdensome to the team.[26] In residency settings, almost half of female residents and of department heads explicitly describe pregnant colleagues as less productive and believe that pregnancy and motherhood plans affect selection and advancement decisions.[27] Beyond medicine, longitudinal analyses of academic careers show that parenthood explains much of the gender productivity gap by lowering mothers' short-term publication output, even though parents as a group remain at least as productive as non-parents over the long term.[28] Together, these findings suggest that even modest, time-limited reductions in scholarly activity around pregnancy can be magnified within systems that reward continuous output, resulting in a disproportionate productivity penalty for women who have children. These perceived or actual dips in scholarly output are also likely to intersect with impostor phenomenon, which affects an estimated 22-60% of physicians and is more prevalent among women in unsupportive institutional cultures.[29] Recent data in anaesthesiology suggest that impostor syndrome disproportionately affects female and junior anaesthesiologists; pregnancy-related disruptions in academic productivity may therefore reinforce self-doubt and perceived inadequacy among those already at highest risk.[30]

In our cohort, the gender of the department head during residency was not associated with more favourable pregnancy-related perceptions or experiences, including antenatal care disruption, early return from maternity leave, or breastfeeding support. These findings are similar to those from an ASA resident survey, in which the presence of a female programme director or department chair did not meaningfully change leave characteristics, breastfeeding experiences, or feelings of guilt related to pregnancy and parenting during training.[14] These results suggest that the gender of leaders alone is not sufficient; departmental culture, institutional policies, and their implementation appear to be at least as important. Strengthening leadership commitment to supporting working parents, alongside efforts to improve gender representation in leadership, may therefore be a more realistic strategy to recruit and retain women in anaesthesiology.[31]

From a workforce and policy perspective, in light of the challenges reported by survey respondents, structural, rather than individual, solutions are needed for pregnancy-related challenges in anaesthesiology. Departments should establish formal, institutionally supported coverage mechanisms for pregnancy and maternity leave instead of relying on informal peer-based arrangements. Protected time for

antenatal care, predictable scheduling adjustments, and access to breastfeeding facilities should be integrated into departmental workflows. Clearer enforcement of existing legal protections through departmental protocols and leadership accountability may help reduce stigma and support retention of early-career women anaesthesiologists.

Study Limitations

This study has limitations. Its cross-sectional, self-reported design precludes causal inference and is vulnerable to recall and social desirability bias, particularly for events that occurred earlier in participants' careers. The survey instrument used in this study was neither formally validated nor pilot-tested prior to dissemination. As the study was designed to be exploratory and descriptive, the questionnaire aimed to capture a broad snapshot of attitudes rather than function as a validated psychometric tool. While the items were developed based on a review of the relevant literature and aligned with the study objectives, the absence of formal validation may limit the precision and generalisability of the findings. Because the survey link was distributed via professional networks without a defined sampling frame, we could not calculate a true response rate. Similar to previous surveys, non-response bias cannot be excluded; it is possible that women with stronger experiences related to pregnancy or motherhood, whether positive or negative, were more likely to participate than those who felt less affected by these issues.[10,32] The sample was restricted to female anaesthesiologists, so the perspectives of male colleagues and departmental leadership on workload distribution, maternity leave, and breastfeeding policies were not directly assessed. Finally, we measured resignation intent rather than actual turnover and did not link responses to objective career outcomes; longitudinal studies would be required to determine whether the patterns observed here translate into concrete workforce losses.

Conclusion

In this national survey of Turkish women anaesthesiologists, pregnancy and motherhood were common during residency and often accompanied by disrupted antenatal care, shortened maternity leave, perceived declines in academic productivity, and substantial barriers to breastfeeding at work. These findings indicate that pregnancy and early motherhood in anaesthesiology are still treated as individual challenges rather than as predictable workforce needs. The development and consistent implementation of explicit department-level policies, particularly those that ensure protected time for antenatal care, may be critical to retaining women in the specialty and supporting a sustainable, gender-inclusive anaesthesiology workforce in Türkiye.

Ethics

Ethics Committee Approval: Ethical approval for the study was obtained from Gazi University Rectorate Ethics Commission (approval no.: 2025-1882, date: 11/11/2025).

Informed Consent: Participation was voluntary, anonymous, and self-administered. No financial incentives were offered to survey participants, and all participants provided electronic informed consent prior to initiating the survey.

Footnotes

Author Contributions: Concept - A.G.K., B.B.Y., S.E.; Design - A.G.K., B.B.Y., S.E.; Data Collection and/or/Processing - A.G.K., B.B.Y.; Analysis and/or/Interpretation - A.G.K., S.E.; Literature Search - A.G.K., B.B.Y., S.E.; Writing - A.G.K., B.B.Y., S.E.

Declaration of Interests: The authors declare no conflicts of interest.

Funding: The authors declared that this study received no financial support.

Declaration Regarding the Use of AI and AI-Assisted Technologies: During the preparation of this manuscript, the authors used ChatGPT (OpenAI) exclusively for language refinement, including grammar correction, clarity enhancement, and improvements in academic phrasing. All outputs produced by ChatGPT were critically reviewed and revised when necessary. The authors take full responsibility for the accuracy, integrity, and scholarly content of the final manuscript.

References

1. Işık F, Kıyak M, Işık M. Gender mainstreaming in health. *Aurum J Health Sci.* 2020;2(S1):29-32. [CrossRef]
2. OECD. Health at a Glance 2023: OECD Indicators. [CrossRef]
3. Yılmaz N, Alkan A, Ertümer AG, Kuh Z. Evaluation of medical specialties in terms of gender. *Cukurova Med J.* 2021;46(3):1257-1266. [CrossRef]
4. Jolly S, Griffith KA, DeCastro R, Stewart A, Ubel P, Jagsi R. Gender differences in time spent on parenting and domestic responsibilities by high-achieving young physician-researchers. *Ann Intern Med.* 2014;160(5):344-353. [CrossRef]
5. Treister-Goltzman Y, Peleg R. Female physicians and the work-family conflict. *Isr Med Assoc J.* 2016;18(5):261-266. [CrossRef]
6. Hertzberg LB, Miller TR, Byerly S, et al. Gender differences in compensation in anesthesiology in the United States: results of a national survey of anesthesiologists. *Anesth Analg.* 2021;133(4):1009-1018. [CrossRef]
7. McMullen K, Kraus MB, Kosiorek H, Harbell MW. Representation of women as editors in anesthesiology journals. *Anesth Analg* 2022;134(5):956-963. [CrossRef]
8. Ucal M, O'Neil ML, Toktas S. Gender and the wage gap in Turkish academia. *J Balkan Near E Stud.* 2015;17(4):447-464. [CrossRef]
9. Mergler BD, Patel RU, Iyer S, et al. Challenges of motherhood for anesthesiologists: a scoping review. *A A Pract.* 2024;18(12):e01876. [CrossRef]
10. Kraus MB, Dexter F, Patel PV, et al Motherhood and anesthesiology: a survey of the American Society of Anesthesiologists. *Anesth Analg.* 2020;130(5):1296-1302. [CrossRef]
11. Zdravkovic M, Kabon B, Dow O, Klincová M, Bilotta F, Berger-Estilita J; Collaborators. Working conditions during pregnancy: a survey of 3590 European anaesthesiologists and intensivists. *Br J Anaesth.* 2024;133(5):1062-1072. [CrossRef]
12. Matot I, De Hert S, Cohen B, Koch T. Women anaesthesiologists' attitudes and reported barriers to career advancement in anaesthesia: a survey of the European Society of Anaesthesiology. *Br J Anaesth.* 2020;124(3):e171-e177. [CrossRef]

13. Sharpe EE, Ku C, Malinzak EB, et al. A cross-sectional survey study of United States residency program directors' perceptions of parental leave and pregnancy among anesthesiology trainees. *Can J Anaesth.* 2021;68(10):1485-1496. [CrossRef]
14. Kraus MB, Thomson HM, Dexter F, et al. Pregnancy and motherhood for trainees in anesthesiology: a survey of the American Society of Anesthesiologists. *J Educ Perioper Med.* 2021;23(1):E656. [CrossRef]
15. Peters GW, Kuczmarska-Haas A, Holliday EB, Puckett L. Lactation challenges of resident physicians- results of a national survey. *BMC Pregnancy Childbirth.* 2020;20(1):762. [CrossRef]
16. Eysenbach G. Improving the quality of web surveys: the checklist for reporting results of internet e-surveys (CHERRIES). *J Med Internet Res.* 2004;6(3):e34. [CrossRef] Erratum in: [CrossRef]
17. Olika MK, Dessalegn ZM, Mekonin GT, et al. Effect of inhalational anesthetics exposure on reproductive outcomes and its predictors among healthcare personnel in jimma zone public hospitals: a comparative cross-sectional study. *Int J Womens Health.* 2022;14:1555-1568. [CrossRef]
18. Lalabekyan B, Rennie A, Luoma V. Principles of radiation safety for anaesthetists. *BJA Educ.* 2025;25(5):181-190. [CrossRef]
19. Aykut G, Efe EM, Bayraktar S, et al. Mobbing exposure of anaesthesiology residents in Turkey. *Turk J Anaesthesiol Reanim.* 2016;44(4):177-189. [CrossRef]
20. T.C. Cumhurbaşkanlığı Mevzuat Bilgi Sistemi. 657 sayılı Devlet Memurları Kanunu. Accessed on 2 december 2025: [CrossRef]
21. European Union. Protecting pregnant workers and new mothers. *EUR-Lex.* Accessed 17 Jan 2026. Available from: [CrossRef]
22. Accreditation Council for Graduate Medical Education (ACGME). *ACGME Institutional Requirements*. Section 4.8: Vacation and Leaves of Absence. Chicago, IL: ACGME; 2025. Approved September 3, 2025. Accessed 17 January 2026. Available from: [CrossRef]
23. Falletta L, Abbruzzese S, Fischbein R, Shura R, Eng A, Alemagno S. Work reentry after childbirth: predictors of self-rated health in month one among a sample of university faculty and staff. *Saf Health Work.* 2020;11(1):19-25. [CrossRef]
24. Dagher RK, McGovern PM, Dowd BE. Maternity leave duration and postpartum mental and physical health: implications for leave policies. *J Health Polit Policy Law.* 2014;39(2):369-416. [CrossRef]
25. Allen KJ, Chiavaroli N, Reid KJ. Successful return to work in anaesthesia after maternity leave: a qualitative study. *Anaesthesia.* 2024;79(7):706-714. [CrossRef]
26. Casilla-Lennon M, Hanchuk S, Zheng S, et al. Pregnancy in physicians: a scoping review. *Am J Surg.* 2022;223(1):36-46. [CrossRef]
27. Attieh E, Maalouf S, Chalfoun C, Abdayem P, Nemr E, Kesrouani A. Impact of female gender and perspectives of pregnancy on admission in residency programs. *Reprod Health.* 2018;15(1):121. [CrossRef]
28. Morgan AC, Way SF, Hoefer MJD, Larremore DB, Galesic M, Clauset A. The unequal impact of parenthood in academia. *Sci Adv.* 2021;7(9):eabd1996. [CrossRef]
29. Gottlieb M, Chung A, Battaglioli N, Sebok-Syer SS, Kalantari A. Impostor syndrome among physicians and physicians in training: a scoping review. *Med Educ.* 2020;54(2):116-124. [CrossRef]
30. Gisselbaek M, Hontoir S, Pesonen AE, et al. Impostor syndrome in anaesthesiology primarily affects female and junior physicians. *Br J Anaesth.* 2024;132(2):407-409. [CrossRef]
31. Huffmyer JL, Fahy BG. Cracking the motherhood and medicine code. *Anesth Analg.* 2020;130(5):1292-1295. [CrossRef]
32. Story DA, Tait AR. Survey research. *Anesthesiology.* 2019;130(2):192-202. [CrossRef]

Click for Supplementary File 1 access link:

https://d2v96fxpocvxx.cloudfront.net/cf9d60d6-523c-458a-a2e6-78728d3ffbb0/documents/TJAR-2337_APPEND%C4%B0X.docx

Original Article
Perioperative Care

DOI: 10.4274/TJAR.2026.252245
Turk J Anaesthesiol Reanim 2026;54(2):125-133

Turkish Journal of Anaesthesiology & Reanimation

Comparison of Three Different Doses of Dexmedetomidine for Attenuation of the Pressor Response to Laryngoscopy and Intubation by Assessment of Haemodynamic Parameters and Plasma Catecholamine Levels Under Bi-spectral Index Guided Anaesthesia - A Randomised Double Blind Controlled Study

Michell Gulabani[1], Medha Mohta[1], Nitesh Kumar[1], Diwesh Chawla[2], Seema Garg[3], Shashank Tripathi[4], Abhay Singh Chauhan[2]

[1]University Faculty of Medical Sciences and GTB Hospital, Department of Anaesthesiology and Intensive Care, Delhi, India
[2]University College of Medical Sciences and GTB Hospital, Departent of Multi-disciplinary Research Unit, Delhi, India
[3]University College of Medical Sciences and GTB Hospital, Department of Biochemistry, Delhi, India
[4]University College of Medical Sciences and GTB Hospital, Department of Biostatistics and Medical Informatics, Delhi, India

Abstract

Objective: Dexmedetomidine has been studied for attenuation of laryngoscopy and intubation response with varied results, however the depth of anaesthesia and plasma catecholamine levels have not been measured. Considering the lacunae, this study was planned with three doses of dexmedetomidine: 0.5, 0.75 and 1 μg kg^{-1} under bi-spectral index monitoring and plasma catecholamine assessment.

Methods: One hundred sixty-eight consenting adult patients of either sex were divided into 3 groups (56 each) to receive I/V dexmedetomidine 0.5, 0.75 or 1 μg kg^{-1} prior to induction. A baseline sample of catecholamines was taken and study drug was infused over 10 minutes. Thereafter, standard anaesthesia induction followed and haemodynamic parameters were noted at designated time intervals. Another sample of catecholamines was drawn at 3 minutes after intubation. The primary outcome was to compare the change in heart rate and systolic blood pressure. Secondary outcomes included: change in catecholamine levels, sedation scores, propofol dose and adverse events.

Results: All doses of dexmedetomidine successfully obtunded the haemodynamic response; however, no significant difference was seen on inter-group comparison (P >0.05). A significant fall in nor-adrenaline values compared with baseline was noted in all groups, without any significant difference among groups for both catecholamines. Sedation scores reduced from baseline in all groups without any difference on inter- group comparison. Statistically significant reduction in propofol requirement and higher incidence of bradycardia with 1 μg kg^{-1} (P=0.014) were observed.

Conclusion: 0.5 μg kg^{-1} of dexmedetomidine can be used for pressor response attenuation as the incidence of bradycardia was higher with 1 μg kg^{-1} and 0.75 μg kg^{-1} had no added advantage.

Keywords: Bradycardia, catecholamines, dexmedetomidine, endotracheal intubation, hypotension, propofol

Corresponding author: Assoc. Prof., Michell Gulabani **E-mail:** mgulabani@ucms.ac.in
Received: October 2, 2025 **Accepted:** March 03, 2026 **Epub:** 03.04.2026 **Published date:** April 15, 2026
Cite this article as: Gulabani M, Mohta M, Kumar N, et al. Comparison of three different doses of dexmedetomidine for attenuation of the pressor response to laryngoscopy and intubation by assessment of haemodynamic parameters and plasma catecholamine levels under bi-spectral index guided anaesthesia - a randomised double blind controlled study. *Turk J Anaesthesiol Reanim*. 2026;54(2):125-133

Main Points

- Dexmedetomidine: 0.5, 0.75,1 μg kg^{-1} were compared for pressor response attenuation.
- Haemodynamic response were successfully obtunded by all doses of dexmedetomidine.
- The three doses did not differ in haemodynamic parameters, adrenaline, nor-adrenaline levels.
- Reduction in propofol requirement but higher incidence of bradycardia with the 1 μg kg^{-1} dose.
- Dexmedetomidine: 0.5 μg kg^{-1} is beneficial, optimal, cost-effective less side effects.

Introduction

Laryngoscopy and intubation are noxious stimuli that evoke numerous undesirable effects, such as tachycardia, hypertension, cardiac dysrhythmias, and increased plasma catecholamine levels by stimulating oropharyngeal and laryngeal structures.[1] The onset of this intubation response occurs within 5 seconds of airway manipulation, peaks at 1-3 minutes, and stabilizes by 5-10 minutes.[2] Most healthy patients tolerate this transitory phenomenon, but it can be life threatening for cardiac, neurosurgical and elderly patients who might experience myocardial ischemia during this vulnerable time.[3,4]

A variety of pharmacological methods have been utilized for attenuation of the response at intubation which include lignocaine,[5] beta blockers,[6] calcium channel blockers,[7] nitroglycerine,[8] opioids,[9] and alpha adrenergic 2 agonists like dexmedetomidine.[10-12]

Dexmedetomidine is superior to other agents because of its multiple actions, which include conscious sedation without respiratory depression, anaesthetic-sparing, analgesic, anxiolytic, anti-sialogogue, antiemetic, and antitussive effects.[13]

Obtundation of the pressor response is one of the most frequently topics in the field of anaesthesiology. Anaesthesiologists have continually sought an agent that effectively suppresses adverse cardiovascular insults while providing a maximal safety margin.

In many of the studies on dexmedetomidine for pressor-response obtundation available in the literature, the depth of anaesthesia has not been monitored, which is vital in this regard, as inadequate depth is one of the precipitating factors for intubation response.[2,10,11] The plasma adrenaline and nor-adrenaline levels, the biochemical markers of stress response, have not been studied across different doses of dexmedetomidine in this context, and researchers have cited these as limiting factors.[12,14,15]

Hence, considering the existing lacunae in the literature, the present study was designed to determine the optimal dose of dexmedetomidine to attenuate the pressor response by comparing three doses: 0.5 μg kg^{-1}, 0.75 μg kg^{-1}, and 1 μg kg^{-1} in patients scheduled for elective operative procedures under general anaesthesia (GA) with bi-spectral index (BIS) monitoring. The primary objective was to study and compare the changes in heart rate (HR) and systolic blood pressure (SBP) following endotracheal intubation. The secondary objectives were to compare changes in plasma adrenaline and nor-adrenaline levels, Modified Observer's Assessment of Alertness/Sedation Scale (MOAS) scores, the total requirement of propofol for anaesthesia induction, and the incidence of perioperative complications among the three study groups.

Methods

This prospective randomised, double-blind, controlled study was conducted in a tertiary care teaching hospital after written informed consent was obtained from the participants. It was approved by the Delhi University Faculty of Medicine, Human Research (IEC-HR) Institutional Ethics Committee, (approval no: IECHR-2023-61-12-R2, date: 02.11.2023). Registered with the Clinical Trials Registry-India (CTRI) under registration CTRI/2023/12/060514 (www.ctri.nic.in). The patients were randomly assigned to one of the three study groups (56 participants each) using a computer-generated random number table. Allocation concealment was performed using sequentially numbered opaque sealed envelopes.

A complete pre-anaesthetic checkup and appropriate investigations were conducted in accordance with hospital protocol. A minimum fasting period of 8 hours prior to surgery was ensured for all patients.

One hundred sixty-eight consenting adult patients aged 18-60 years of either sex, American Society of Anaesthesiologists Physical Status (ASA-PS) Grade I and II, undergoing elective surgical procedures under GA with endotracheal intubation were enrolled. Patients with a history suggestive of diabetes mellitus, asthma, uncontrolled hypertension morbid obesity, altered liver or kidney function, or progressive neurological disease, as well as those who were pregnant, were excluded from the study. Those with anticipated difficult airway, laryngoscopy and intubation time of more than 15 seconds, or more than one attempt at laryngoscopy and endotracheal intubation were also excluded.

Anaesthesia Technique

An 18 G intravenous (IV) cannula was inserted in the preoperative holding area, and a venous blood sample for plasma adrenaline and nor-adrenaline was drawn for

the first time. Subsequently, a Ringer's lactate drip was administered to all study participants at a rate adjusted to 5-6 mL kg^{-1} per hour.

In the operating room, all standard monitors, including non-invasive blood pressure on the upper arm, oxygen saturation (SpO_2) probe, electrocardiogram, and BIS electrodes on the forehead, were applied to the patient. The baseline parameters [Ta] including HR, SBP, diastolic blood pressure (DBP), mean blood pressure (MBP), SpO_2 and BIS were recorded. The MOAS sedation scale, which classifies alertness and sedation using a score ranging from 0 to 6 (0 denotes deep sedation and 6 denotes an agitated state), was employed for all patients in each group.[16]

The study drug was prepared by an individual who was not actively involved in the research, and both the patient and the investigator were blinded to the group allocation. The patients in Group D1, Group D2, and Group D3 were given IV dexmedetomidine as loading doses of 0.5 μg kg^{-1}, 0.75 μg kg^{-1}, and 1 μg kg^{-1}, respectively, diluted in normal saline up to 50 ml and administered over 10 minutes prior to induction. During IV infusion of the study drug, if the SpO_2 dropped below 95%, oxygen was supplemented by a simple face mask at the rate of 5-6 liters/minute, and this was noted as an episode of desaturation. On completion of the study drug infusion, all the parameters [Tb], along with the MOAS score and BIS, were noted. Anaesthesia was induced with inj. fentanyl 2 μg kg^{-1} and titrated doses of inj. propofol administered from a syringe loaded with 2 mg kg^{-1}. The failure to respond to verbal commands was considered as the end point of induction, at which all the study parameters and BIS were recorded again [Tc].

After, administration of 0.1 mg kg^{-1} of inj. vecuronium bromide and ventilating the patient for 3 minutes, just before performing laryngoscopy, all parameters [Td] were noted. A senior anaesthesiologist performed laryngoscopy and tracheal intubation with an endotracheal tube of appropriate size. The study parameters were noted at 1 minute [Te], 2 minutes [Tf], 3 minutes [Tg], 5 minutes [Th], and 7 minutes [Ti] following intubation in all three groups. Anaesthesia was maintained with sevoflurane in oxygen and nitrous oxide (50:50) at a flow of 2 liters per minute. Throughout, the BIS values were maintained between 40-60 by adjusting the dial settings of the sevoflurane vaporizer. At time Tg, the venous blood sample for plasma adrenaline and nor-adrenaline was drawn a second time. After the last recording of the study parameters, i.e., Ti, the study was completed. The total propofol requirement for induction was recorded in all study groups.

The time points: on arrival in the operating room, after study drug infusion, following anaesthesia induction, just before laryngoscopy and intubation and then at 1, 2, 3, 5 and 7 minutes after endotracheal intubation were the designated intervals where HR, SBP, DBP, MBP, SpO_2 and BIS were noted. The sample for catecholamine analysis was drawn twice: once in the preoperative area as a baseline value, and once on the operating room table 3 minutes after endotracheal intubation.

IV ondansetron was administered to patients 30 minutes prior to the end of the surgery. Upon completion of the surgical procedure, neuromuscular blockade was reversed with neostigmine 0.05 mg kg^{-1} and glycopyrrolate 0.01 mg kg^{-1}. The tracheal tube was removed after adequate spontaneous ventilation was established and protective airway reflexes had returned.

Hypotension was defined as a >30% fall in SBP from the baseline value, bradycardia as HR<60 beats/minute, and desaturation as SpO_2 <95%>. Hypotension was treated by reducing the inhalational agent concentration by 50% when the BIS value was on the lower side of the required range (40-60), and/or by administering IV mephentermine 6 mg; bradycardia was treated with IV atropine 0.6 mg. The maintenance of anaesthetic depth was always ensured by keeping BIS values between 40-60.

Outcomes

The primary outcome was to study and compare changes in HR and SBP from baseline parameters (i.e., before administration of the study drug) to those after dexmedetomidine administration in all three groups at designated time intervals, namely, 1, 2, 3, 5, and 7 minutes after intubation, while maintaining BIS values between 40-60. The secondary outcome parameters were: the change in plasma adrenaline and nor-adrenaline levels from baseline to values following administration of three different doses of dexmedetomidine, measured 3 minutes after endotracheal intubation; the change in the MOAS score, recorded at baseline and after completion of study drug infusion (10 minutes); the total requirement for propofol for anaesthesia induction; and the incidence of perioperative complications including hypotension, bradycardia, or desaturation.

Sample Size Calculation

The sample size was calculated based on the basis of the study by Sebastian et al where the authors observed that HR and SBP at 3 minutes post intubation in dexmedetomidine 0.5 μg kg^{-1} group were 83.73±4.95 beats/minute and 129.87±9.75 mmHg respectively and in dexmedetomidine 0.75 μg kg^{-1} were 80.83±5.40 beats/minute and 124.67±8.41 mmHg respectively.[17] Using these values as references, the minimum required sample size, with 80% study power and a 5% level of significance, was 168 patients, with 56 patients in each study group.

Statistical Analysis

The statistical analysis was carried out using the SPSS version 25.0. categorical data were presented as number and percentage (%) and continuous data as mean ±

standard deviation and median [interquartile range (IQR)]. The Kolmogorov-Smirnov test was used to assess the normality of the data. Non-parametric tests were employed if the assumption of normality was rejected. Paired data at two time points were compared using the paired t-test or Wilcoxon signed-rank test. Quantitative variables were compared using one-way ANOVA or Kruskal-Wallis test among the three groups, followed by a post-hoc test if a significant result was obtained. Repeated-measures ANOVA or Friedman's ANOVA was used to compare parameters assessed at multiple time points. Qualitative variables were analysed using the chi-square test or Fisher's exact test. A *P* value of <0.05 was considered statistically significant.

Results

The CONSORT flow diagram is shown in Figure 1. The demographic variables and ASA-PS distributions were comparable across the three study groups (Table 1). The most frequent surgical procedure performed was laparoscopic cholecystectomy, followed by mastectomy and thyroidectomy.

Haemodynamic HR was significantly lower compared with baseline values within each group (D1, D2, and D3) at all time intervals except at 1 minute after intubation (Table 2). Similarly, a statistically significant decrease in SBP compared with baseline levels was observed in the D1 and D3 groups at all time points except at one minute following intubation. However, a decrease in SBP compared with baseline values was observed at every designated time point in the D2 group (Table 3). On inter group comparison, HRs at the end of the study drug infusion in group D3 were significantly lower than those in groups D1 and D2 (Table 2). There were no intergroup differences in HR at any other time intervals. Intergroup comparison showed that SBP readings did not differ between the three groups at any time point (Table 3).

Catecholamines: No significant differences were observed in the values of adrenaline and nor-adrenaline among the three dexmedetomidine dose groups at baseline and 3 minutes after intubation. However, no increase was seen in adrenaline or nor-adrenaline levels; rather, nor-adrenaline values were significantly lower at 3 minutes after intubation compared with baseline values within each group, while adrenaline levels remained near baseline values (Tables 4a and 4b). In of the wide IQR, the percent change from baseline in the values of adrenaline and nor-adrenaline was calculated (Table 5). No significant differences were found between groups for these values.

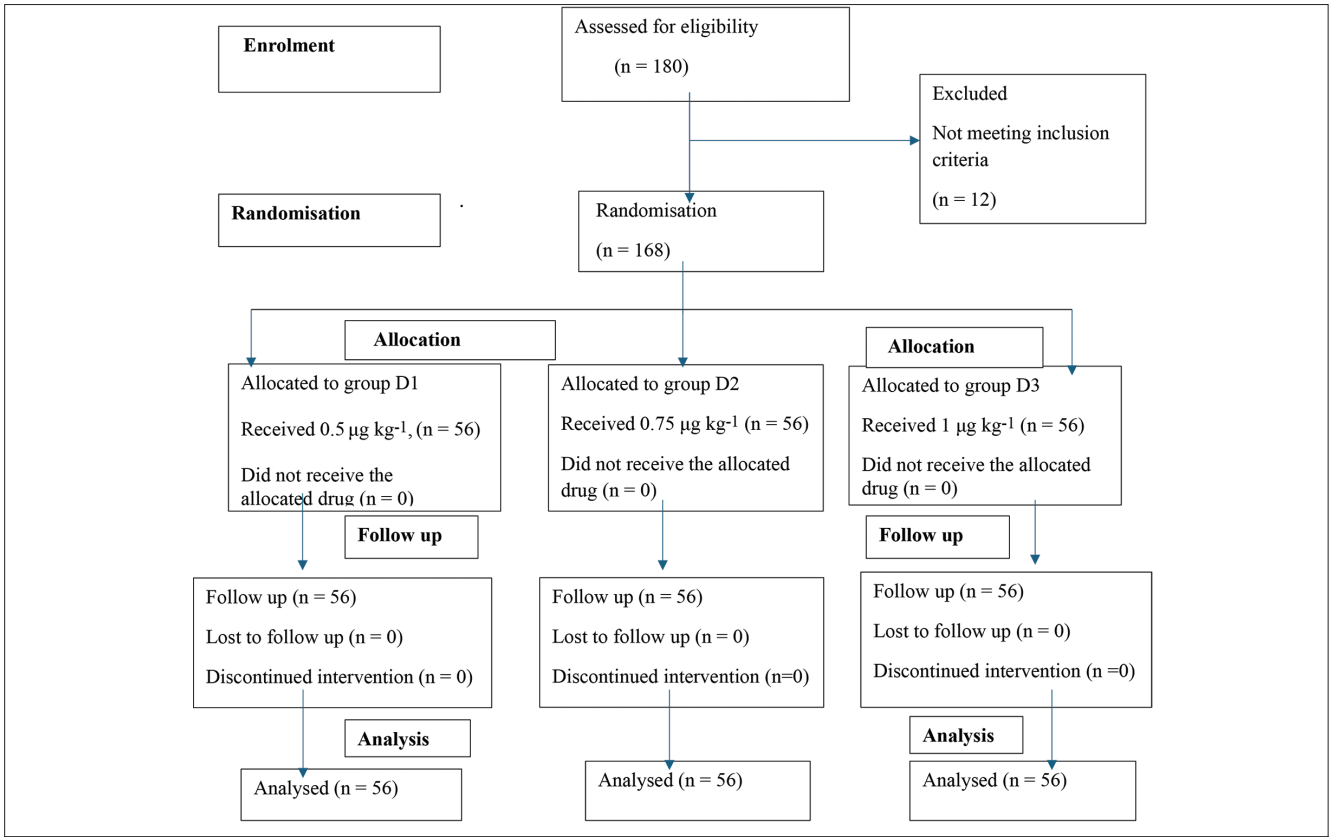


Figure 1. Consolidated standards of reporting trials (CONSORT) flow diagram.

Table 1. Demographic Parameters

Variables	Group D1 (n = 56)	Group D2 (n = 56)	Group D3 (n = 56)	*P* value
Age (years)	36.9 (11.1)	36.1 (10.8)	37.7 (12.5)	0.762
Gender (male/female)	43/13	46/10	42/14	0.631
ASA-PS (I/II)	43/13	48/08	45/11	0.482

Values are represented in mean (standard deviation) or numbers (proportion), D1-dexmedetomidine: 0.5 μg kg^{-1}, D2-dexmedetomidine: 0.75 μg kg^{-1}, D3-dexmedetomidine: 1 μg kg^{-1}

ASA-PS, American Society of Anaesthesiologists Physical Status

Table 2. Heart Rate (Beats/Minute) Changes at Different Time Points

Time	D1	D2	D3	Inter-group *P* value
HR at baseline	89.59 (16.48)	88.21 (14.88)	85.48 (14.35)	0.352
HR after study drug completion	80.04* (15.12)	79.45* (16.29)	72.70* (12.21)	0.015# D1 versus D3 (*P*= 0.023) D2 versus D3 (*P*= 0.042) D1 versus D2 (*P*= 0.975)
HR at end point of induction	77.18* (13.41)	76.13* (14.61)	75.02* (11.93)	0.69
HR just before laryngoscopy	77.66* (13.41)	76.39* (14.56)	73.59* (11.78)	0.28
1 minute after intubation	86.05 (10.89)	84.13 (13.91)	82.86 (12.06)	0.389
2 minutes after intubation	80.64* (11.21)	80.50* (11.47)	80.29* (11.11)	0.986
3 minutes after intubation	79.89* (12.55)	78.16* (12.67)	78.02* (9.94)	0.652
5 minutes after intubation	76.52* (12.68)	74.68* (11.38)	77.23* (9.94)	0.425
7 minutes after intubation	76.86* (11.64)	75.00* (13.94)	75.23* (12.41)	0.701

Values are represented in mean (standard deviation) *: *P* value<0.05 compared to baseline: statistically significant, #: *P* value<0.05 between group: statistically significant, D1- dexmedetomidine: 0.5 μg kg^{-1}, D2-dexmedetomidine: 0.75 μg kg^{-1}, D3- dexmedetomidine: 1 μg kg^{-1}

HR, heart rate

Table 3. Systolic Blood Pressure (mmHg) Changes at Different Time Points

Time	D1	D2	D3	Inter-group *P* value
SBP at baseline	125.84 (11.6)	129.21 (13.22)	125.57 (11.41)	0.211
SBP after study drug completion	119.73* (19.22)	124.77* (12.82)	122.11* (13.19)	0.22
SBP at end point of induction	108.43* (18.12)	109.91* (14.01)	113.66* (12.31)	0.16
SBP just before laryngoscopy	103.82* (16.34)	106.95* (13.60)	102.52* (17.60)	0.32
1 minute after intubation	121.82 (15.31)	118.29* (16.86)	124.21 (48.46)	0.399
2 minutes after intubation	118.37* (16.57)	113.77* (15.34)	116.45* (13.03)	0.269
3 minutes after intubation	112.75* (17.06)	109.50* (13.77)	110.70* (11.69)	0.490
5 minutes after intubation	107.57* (14.73)	106.50* (12.56)	106.14* (12.22)	0.838
7 minutes after intubation	109.96* (16.35)	106.30* (14.32)	106.77* (14.16)	0.398

Values are represented in mean (standard deviation), *: *P* value<0.05 compared to baseline: statistically significant, D1-dexmedetomidine: 0.5 μg kg^{-1}, D2-dexmedetomidine: 0.75 μg kg^{-1}, D3-dexmedetomidine: 1 μg kg^{-1}

SBP, systolic blood pressure

Table 4a. Changes in Nor-adrenaline Levels (pg/mL)

Time	D1	D2	D3	Inter-group *P* value
Baseline	8433.6 (4302.8)	9392.0 (7698.2)	9494.1 (5749.5)	0.091
3 minutes after intubation	7685.7 (7710.9)	8207.8 (8043.3)	8448.4 (7111.5)	0.134
Within group *P* value	0.02*	<0.01*	0.02*	

Values are represented in median (inter quartile range) *: *P* value<0.05 compared to baseline. D1-dexmedetomidine: 0.5 μg kg^{-1}, D2-dexmedetomidine: 0.75 μg kg^{-1}, D3-dexmedetomidine: 1 μg kg^{-1}

Table 4b. Changes in Adrenaline (pg/mL)

Time	D1	D2	D3	*P* value
Baseline	4278.9 (6666.3)	4052.8 (3343.6)	4068.3 (3218.0)	0.362
3 minutes after intubation	4368.8 (5829.5)	3887.9 (3553.7)	3818.9 (3529.3)	0.494
P value	0.431	0.712	0.492	

Values are represented in median-inter quartile range, D1-dexmedetomidine: 0.5 μg kg^{-1}, D2-dexmedetomidine: 0.75 μg kg^{-1}, D3-dexmedetomidine 1: μg kg^{-1}

Table 5. Percent Change in Catecholamines from Baseline

Variable	D1	D2	D3	*P* value
% change adrenaline	-1.0 (-9.5, 23.4)	-5.5 (-20.0, 17.2)	-4.1 (-12.2, 5.5)	0.412
% change nor-adrenaline	-7.2 (-28.9, 7.8)	-5.2 (-24.3, 5.9)	-6.7 (-22.3, 4.8)	0.993

Values are represented in median-inter quartile range. D1-dexmedetomidine: 0.5 μg kg^{-1}, D2-dexmedetomidine: 0.75 μg kg^{-1}, D3-dexmedetomidine: 1 μg kg^{-1}

Supplementary outcomes: The MOAS scores were comparable between the groups (*P* >0.05), although a statistically significant reduction was seen in them after study drug infusion compared with baseline values within all groups. A significantly higher incidence of bradycardia was observed in the 1 μg kg^{-1} group (7 patients out of 56) compared with the other two groups (0.5 μg kg^{-1} and 0.75 μg kg^{-1}), in each of which 1 patient out of 56 was affected (*P*=0.014). A comparable incidence of hypotension (9, 12, and 8 patients in D1, D2, and D3 groups, respectively; *P*=0.581) was observed, and no desaturation event occurred in any group. A significantly lower propofol dose requirement with the 1 μg kg^{-1} dose of dexmedetomidine, compared with both other groups, was observed (*P* <0.05) (D1 vs D3 *P* <0.05, D2 vs D3 *P*=0.031). A statistically significant, steady decline in BIS values from baseline to values after completion of study drug infusion and at induction was observed in all three groups (*P* <0.05). However, no significant difference was found in BIS values between the groups.

Discussion

In the present study, all three dexmedetomidine doses, i.e., 0.5 μg kg^{-1}, 0.75μg kg^{-1}, and 1 μg kg^{-1}, successfully blunted the haemodynamic response and the catecholamine rise to endotracheal intubation. Sedation scores and BIS values were comparable between the groups, but were reduced from baseline values within each group. The dose of 1 μg kg^{-1} reduced the propofol requirement, but resulted in a higher incidence of bradycardia than the lower doses.

Dexmedetomidine has been shown to be effective in attenuating the pressor response to laryngoscopy and intubation.[18-20] It has been compared in several doses ranging from 0.5 μg kg^{-1} to 1 μg kg^{-1} with varied results. [4,5,10-12,14,15,17]

The results of the present study are in concordance with those of some earlier studies, where a comparable obtundation in intubation response was seen with two different doses of dexmedetomidine, i.e., 0.5 and 1 μg kg^{-1} and 0.5 and 0.75 μg kg^{-1}.[2,11,17] Contrary to our observations, a few researchers have found that a higher dose of dexmedetomidine (1 μg kg^{-1}) is more effective in attenuating the pressor response at intubation.[5,10,15]

However, all the above-mentioned studies were affected by one or more limitations, including a small sample size, lack of plasma catecholamine assessment, and lack of anaesthetic depth monitoring.

The only study measuring nor-adrenaline levels during dexmedetomidine infusion to attenuate the intubation response was carried out in patients undergoing coronary artery bypass grafting. Jalonen et al.[21] studied the haemodynamic effects of dexmedetomidine, which was administered as a loading dose followed by infusion (50 ng

kg^{-1} $minute^{-1}$ over 30 minutes before induction of anaesthesia and subsequently 7 ng kg^{-1} $minute^{-1}$ up to the end of surgery), versus placebo in eighty patients.

The authors concluded that, in patients in the study group, dexmedetomidine successfully blunted the intubation response, reduced the intraoperative haemodynamic variability, and decreased the noradrenaline concentration from baseline values without any change in adrenaline values. However, the authors commented that, due to the limited sample size of 40 participants per group, adverse effects such as bradycardia could not be reliably ascertained. Hypotension was more frequent in the study group (9 of 40 patients).

This study differs from the present one in multiple respects. They had administered dexmedetomidine as a higher loading dose, followed by an infusion for the entire duration of the surgery. The sample size was limited; a different patient group was studied; premedication with scopolamine was administered; pancuronium was used as the muscle relaxant; and the study lacked anaesthesia depth monitoring. However, the finding that nor-adrenaline values decreased compared with baseline values, without a change in adrenaline levels, was concordant with ours.

The present study is the only study to date in which attenuation of the haemodynamic pressor response with different doses of dexmedetomidine has been evaluated by assessment of plasma catecholamine levels while ensuring adequate depth of anaesthesia by maintaining BIS between 40 and 60 throughout the study period. Samples for baseline adrenaline and nor-adrenaline levels in all patients were drawn in the pre-operative area because anxiety levels typically rise after transfer to the operating room table, potentially increasing catecholamine concentrations. As the pressor response peaks at around 1-3 minutes of airway manipulation, a second sample was taken at three minutes after endotracheal intubation.

Laryngoscopy and intubation are expected to result in an increase in catecholamine levels.[1,2] However, in the present study, there was no rise in the levels of adrenaline or noradrenaline in any of the groups; rather, noradrenaline levels were significantly lower in all three groups three minutes after securing the airway compared with baseline values, while adrenaline levels remained near baseline. In the inter-group comparison, no significant differences were found in the values of adrenaline and noradrenaline. This possibly suggests that all three doses of dexmedetomidine were equally effective in attenuating the catecholamine rise following intubation at an adequate depth of anaesthesia.

In some earlier studies, the increase in adrenaline levels after intubation was observed to be much greater than the increase in nor-adrenaline levels, in some cases up to four times.[22,23] Thus, attenuating the increase in the former may be more difficult, which might explain our finding of adrenaline values remaining around baseline, in contrast to the noradrenaline levels observed following intubation with all three doses of dexmedetomidine.

Dexmedetomidine, despite a multitude of benefits, has been associated with adverse effects such as bradycardia and hypotension, especially at doses between 1-2 μg kg^{-1}, as reported in the literature.[11,14,24-29] The observations of the present study are also consistent with regard to the incidence of bradycardia, which was higher in the 1 μg kg^{-1} group than in the other two dose groups. In two patients belonging to the 1 μg kg^{-1} group, IV atropine 0.6 mg was administered twice to manage bradycardia; this occurred at the end of the study drug infusion, when the reduction in HR was significantly greater than in the other two groups (0.5 μg kg^{-1} and 0.75 μg kg^{-1}).

We found a comparable incidence of hypotension among the three study groups, which was treated by reducing the inhalational agent concentration by 50% when the BIS value was on the lower side of the required range (40-60), and/or by administering IV mephentermine 6 mg. Only 6 patients required administration of IV mephentermine 6 mg as a one-time dose (one, three, and two patients in groups D1, D2, and D3, respectively). The most common time point at which hypotension occurred was 5 minutes post-intubation, possibly because the intubation response had abated, surgery had not yet commenced, and adequate depth of anaesthesia was being maintained.

Contrary to our observations, Silpa et al.,[12] while comparing 0.5 μg kg^{-1} and 1 μg kg^{-1} of dexmedetomidine for pressor response attenuation, in patients scheduled for elective cardiac surgery found no adverse effects of hypotension or bradycardia with the 1 μg kg^{-1} dose. Possible reasons for this include the different patient population and a longer duration of dexmedetomidine loading-dose infusion (15 minutes) compared with that in the present study (10 minutes). A few other studies did not observe any adverse effects at the 0.5 μg kg^{-1}, 0.75 μg kg^{-1}, or 1 μg kg^{-1} doses of dexmedetomidine.[5,10,12,15,17]

The possible reasons of differences from the observations of the present study could be the choice of induction agent,[5] the absence of anaesthesia depth monitoring,[5,10,12] glycopyrrolate premedication[15] and the patient population being studied.[12,17]

Dexmedetomidine produces a dose-dependent sedative effect and mimics that of natural sleep, with easy arousability.[13,17] All doses of dexmedetomidine in the present study showed a decrease in sedation scores and BIS values from baseline compared with values obtained immediately after study drug infusion; however no episode of desaturation (SpO_2 <95%) was seen in any patient. In contrast, Zhan-Ying et al.[27] and Sulhyan et al.[30] observed that a dose of 1 μg kg^{-1}

caused desaturation in their studies. In the present study, the induction dose requirement for propofol was reduced with 1 μg kg^{-1} of dexmedetomidine compared with 0.5 μg kg^{-1} and 0.75 μg kg^{-1}. This finding differed from that reported by Sharma and Mehta[11] who concluded that both doses (0.5 and 1 μg kg^{-1}) were similar in reducing the propofol dose requirement.

There is an ongoing quest to obtain an optimal dose of dexmedetomidine that results in the desired obtundation of the pressor response, is biochemically confirmed by catecholamine levels, and ensures an adequate depth of anaesthesia. Hence, in the present study, we found that a dose of dexmedetomidine, 0.5 μg kg^{-1}, is beneficial, optimal, and cost-effective, with fewer side effects.

Strengths

The strength of this study lies in its novelty. This is the first study in the literature to assess the optimal dose of dexmedetomidine for obtundation of the haemodynamic pressor response to laryngoscopy and intubation, while maintaining an adequate depth of anaesthesia and including biochemical confirmation by catecholamine level analysis.

Study Limitations

The possible limitations of the study were, firstly, that it was a single-center study involving patients of Indian origin. Secondly, invasive blood pressure was not monitored, which could probably have provided a more accurate real-time reading. Lastly, since there was no previous study on catecholamine assessment, the sample size was not calculated based on catecholamine levels; this could be addressed in future research on this subject.

Conclusion

There were no differences among the three doses of dexmedetomidine in attenuating the pressor response to laryngoscopy and intubation, as measured by haemodynamic parameters and catecholamine levels, when adequate anaesthetic depth was maintained. Nevertheless, bradycardia occurred more frequently with the 1 μg kg^{-1} dose, and the 0.75 μg kg^{-1} dose had no added advantage over the 0.5 μg kg^{-1} dose. Hence, 0.5 μg kg^{-1} appears to be the optimum dose of dexmedetomidine for attenuation of the pressor response.

Using catecholamine levels as the primary outcome for sample size calculation would provide greater clarity regarding the optimal dexmedetomidine dose for complete suppression of the stress response.

Ethics

Ethics Committee Approval: It was approved by the Delhi University Faculty of Medicine, Human Research (IEC-HR) Institutional Ethics Committee, (approval no: IECHR-2023-61-12-R2, date: 02.11.2023).

Informed Consent: Participants provided written informed consent for this prospective, randomized, double-blind, controlled study.

Footnotes

Author Contributions: Surgical and Medical Practices - M.G.; Concept - M.G., M.M.; Design - M.G., M.M., N.K., D.C., S.G.; Data Collection or Processing - M.G., M.M., N.K., D.C., S.G., A.S.C.; Analysis or Interpretation - M.G., M.M., S.T.; Literature Search - M.G., M.M., N.K.; Writing - M.G., M.M.

Declaration of Interests: The authors declare no conflicts of interest.

Funding: This study was supported through funds provided by the Department of Health Research. MH and FW Government of India, New Delhi under the Multidisciplinary Research Unit (MRU) scheme.

References

1. Megalla SA, Abdou KA, Mohamed AI. Bispectral index guided attenuation of hemodynamic and arousal response to endotracheal intubation using magnesium sulfate and fentanyl. Randomized, controlled trial. *Egypt J Anaesth*. 2019;35(1):43-48. [CrossRef]
2. Jarineshin H, Abdolahzade Baghaei A, Fekrat F, et al. Comparison of two different doses of dexmedetomidine in attenuating cardiovascular responses during laryngoscopy and endotracheal intubation: a double blind, randomized, clinical trial study. *J Med Life*. 2015;8(Spec Iss 4):45-51. [CrossRef]
3. Mahajan L, Kaur M, Gupta R, Aujla KS, Singh A, Kaur A. Attenuation of the pressor responses to laryngoscopy and endotracheal intubation with intravenous dexmedetomidine versus magnesium sulphate under bispectral index-controlled anaesthesia: a placebo-controlled prospective randomised trial. *Indian J Anaesth*. 2018;62(5):337-343. [CrossRef]
4. Shukla S, Kadni RR, Chakravarthy JJ, Zachariah KV. A comparative study of intravenous low doses of dexmedetomidine, fentanyl, and magnesium sulfate for attenuation of hemodynamic response to endotracheal intubation. *Indian J Pharmacol*. 2022;54(5):314-320. [CrossRef]
5. Gulabani M, Gurha P, Dass P, Kulshreshtha N. Comparative analysis of efficacy of lignocaine 1.5 mg/kg and two different doses of dexmedetomidine (0.5 μg/kg and 1 μg/kg) in attenuating the hemodynamic pressure response to laryngoscopy and intubation. *Anesth Essays Res*. 2015;9(1):5-14. [CrossRef]
6. Mhatre A, Chitnis S. Comparative study of intravenous 2% lignocaine versus metoprolol to attenuate the pressor response to laryngoscopy. *Int J Current Research*. 2018;10:73013-73019. [CrossRef]
7. Mikawa K, Nishina K, Takao Y, Shiga M, Maekawa N, Obara H. Attenuation of cardiovascular responses to tracheal extubation: comparison of verapamil, lidocaine, and verapamil-lidocaine combination. *Anesth Analg*. 1997;85(5):1005-1010. [CrossRef]
8. Kamra S, Wig J, Sapru RP. Topical nitroglycerin. A safeguard against pressor responses to tracheal intubation. *Anaesthesia*. 1986;41(11):1087-1091. [CrossRef]
9. Aouad MT, Al-Alami AA, Nasr VG, Souki FG, Zbeidy RA, Siddik-Sayyid SM. The effect of low-dose remifentanil on responses to the endotracheal tube during emergence from general anesthesia. *Anesth Analg*. 2009;108(4):1157-1160. [CrossRef]
10. Smitha KS, Shukla D, Sathesha M, Rao R, Nethra SS, Sudheesh K. Comparison of two different doses of dexmedetomidine in attenuating hemodynamic changes during laryngoscopy. *J Evol Med Dent Sci*. 2014;3(61):13501-13509. [CrossRef]
11. Sharma N, Mehta N. Therapeutic efficacy of two different doses of dexmedetomidine on the hemodynamic response to intubation, the intubating conditions, and the effect on the induction dose of propofol: a randomized, double-blind, placebo-controlled study. *Anesth Essays Res*. 2018;12(2):566-571. [CrossRef]

12. Silpa AR, Koshy KA, Subramanian A, Pradeep KK. Comparison of the efficacy of two doses of dexmedetomidine in attenuating the hemodynamic response to intubation in patients undergoing elective cardiac surgery: a randomized double-blinded study. *J Anaesthesiol Clin Pharmacol.* 2020;36(1):83-87. [CrossRef]
13. Lee S. Dexmedetomidine: present and future directions. *Korean J Anesthesiol.* 2019;72(4):323-330. [CrossRef]
14. Keshri RK, Prasad MK, Choudhary AK, Jheetay GS, Singh Y, Kapoor K. Comparative evaluation of different doses of intravenous dexmedetomidine on hemodynamic response during laryngoscopy and endotracheal intubation in geriatric patients undergoing spine surgeries: a prospective, double-blind study. *Anesth Essays Res.* 2018;12(4):897-902. [CrossRef]
15. Gupta K, Bansal M, Gupta PK, Singh M, Agarwal S, Tiwari V. Dexmedetomidine premedication with three different dosages to attenuate the adverse hemodynamic responses of direct laryngoscopy and intubation: a comparative evaluation. *ASJA.* 2016;9(1):66. [CrossRef]
16. Nonaka T, Inamori M, Miyashita T, et al. Can sedation using a combination of propofol and dexmedetomidine enhance the satisfaction of the endoscopist in endoscopic submucosal dissection? *Endosc Int Open.* 2018;6(1):E3-E10. [CrossRef]
17. Sebastian B, Talikoti AT, Krishnamurthy D. Attenuation of haemodynamic responses to laryngoscopy and endotracheal intubation with intravenous dexmedetomidine: a comparison between two doses. *Indian J Anaesth.* 2017;61(1):48-54. [CrossRef]
18. Piao G, Wu J. Systematic assessment of dexmedetomidine as an anesthetic agent: a meta-analysis of randomized controlled trials. *Arch Med Sci.* 2014;10(1):19-24. [CrossRef]
19. Bajwa SJ, Kaur J, Singh A, et al. Attenuation of pressor response and dose sparing of opioids and anaesthetics with pre-operative dexmedetomidine. *Indian J Anaesth.* 2012;56(2):123-128. [CrossRef]
20. Sudheesh K, Harsoor S. Dexmedetomidine in anaesthesia practice: a wonder drug? *Indian J Anaesth.* 2011;55(4):323-324. [CrossRef]
21. Jalonen J, Hynynen M, Kuitunen A, et al. Dexmedetomidine as an anesthetic adjunct in coronary artery bypass grafting. *Anesthesiology.* 1997;86(2):331-345. [CrossRef]
22. Kayhan Z, Aldemir D, Mutlu H, Oğüş E. Which is responsible for the haemodynamic response due to laryngoscopy and endotracheal intubation? Catecholamines, vasopressin or angiotensin? *Eur J Anaesthesiol.* 2005;22(10):780-785. [CrossRef]
23. Patro S, Ramani Y, Dhaarani R, Deshmukh H. Laryngoscopy and intubation induced stress response - dexemedetomidine a safer alternative. *SJAMS.* 2015;3(9A):3203-3210. [CrossRef]
24. Djalali Motlagh S, Rokhtabnak F, Ghodraty MR, Maleki Delarestaghi M, Saadat S, Araghi Z. Effect of different loading doses of dexmedetomidine on controlled hypotension and the ıncidence of bradycardia during rhinoplasty: a clinical trial. *Anesth Pain Med.* 2021;11(4):e118857. [CrossRef]
25. Gerlach AT, Murphy CV. Dexmedetomidine-associated bradycardia progressing to pulseless electrical activity: case report and review of the literature. *Pharmacotherapy.* 2009;29(12):1492. [CrossRef]
26. De Cassai A, Boscolo A, Geraldini F, et al. Effect of dexmedetomidine on hemodynamic responses to tracheal intubation: a meta-analysis with meta-regression and trial sequential analysis. *J Clin Anesth.* 2021;72:110287. [CrossRef]
27. Zhan-Ying G, Chang-Ming W, Shuai T, Lin-Lin T, Yu-Feng H. Comparison of effects of different doses dexmedetomidine on inhibiting tracheal intubation-evoked haemodynamic response in the elderly patients. *J Clin Diagn Res.* 2015;9(9):UC10-UC13. [CrossRef]
28. Kateel K, Verma I, Mahajan M. Comparison of dexmedetomidine, lidocaine and fentanyl in attenuation of haemodynamic response to laryngoscopy and intubation in cardiac surgery patients. *Journal of Applied Pharmaceutical Research.* 2023;11(1):33-40. [CrossRef]
29. Kharwar RK, Kumar M, Tiwary PK, Suwalka U, Prakash S. A comparison of intravenous dexmedetomidine V/S inj. fentanyl for attenuation of hemodynamic responses during laryngoscopy and intubation after propofol induction. *NJIRM.* 2014;5(3):59-63. [CrossRef]
30. Sulhyan SR, Vagarali AT, Patil SS, Dixit MD. A comparative clinical study of dexmedetomidine versus placebo to attenuate hemodynamic response to endotracheal intubation in patients undergoing off pump coronary arterial bypass grafting. *Journal of the Scientific Society.* 2014;41(3):151-155. [CrossRef]

Case Report
Cardiovascular and Thoracic Anaesthesia

DOI: 10.4274/TJAR.2026.252260
Turk J Anaesthesiol Reanim 2026;54(2):134-137

Turkish Journal of Anaesthesiology & Reanimation

Role of Intraoperative Bronchoscopy in Diagnosing Bronchus Related Complications Following VATS

Sathish K[1], Senthilkumar Sukumar[2], Raja Siddhartha K S[2]

[1]MGM Cancer Institute, Consultant, Department of Anaesthesiology & SICU, Chennai, India
[2]MGM Cancer Institute, Department of Anaesthesiology & SICU, Chennai, India

Abstract

We report the case of a 60-year-old female with adenocarcinoma of the right upper lobe who underwent a video-assisted thoracoscopic surgery (VATS) upper lobectomy and subsequently presented with complete right lung collapse in the immediate postoperative period. Urgent bronchoscopy revealed complete stapling of the right mainstem bronchus. Hence, emergency re-exploration and bronchoplasty of the right mainstem bronchus and the right lower-lobe bronchus were done. While bronchoscopy following VATS lobectomy for lung cancer poses technical challenges and represents an independent risk factor for postoperative pulmonary complications, it remains a valuable tool for the early detection of complications such as lung collapse, which may result from thick mucus, a foreign body, iatrogenic injury, or the tumour itself.

Keywords: Diagnosis, lung neoplasms, adverse effects, bronchoscopy, video-assisted thoracic surgery

Main Points

- In this case, despite the risk of postoperative pulmonary complications, bronchoscopy after video-assisted thoracoscopic surgery facilitated early detection of surgical complication.
- In this case, postoperative bronchoscopy revealed a completely stapled right mainstem bronchus.
- Re-exploration and bronchoplasty of the right mainstem bronchus and of the lower lobe bronchus were performed as corrective surgery.
- Perioperative bronchoscopy is a valuable tool for the early detection of complications, in this case detecting a lung collapse related to a surgical staple.

Introduction

Evidence-based studies show that airway complications after lobectomy are associated with significant morbidity and mortality.[1] Pulmonary lobar torsion, bronchovascular fistula, bronchopleural fistula, and atelectasis[2] present a significant clinical challenge, warranting early diagnosis and prompt intervention to improve patient outcomes.

Bronchoscopy facilitates earlier detection of such complications[3] compared with imaging, which is time-consuming and requires careful review of reports. The present case report emphasizes the importance of intraoperative bronchoscopy following any lung isolation procedure, enabling the early recognition and effective management of complications.

Case Report

The informed consent was duly acquired from the patient. A 60-year-old female patient with a known history of asthma and hypertension was diagnosed with adenocarcinoma of the right lung and was scheduled for a video-assisted thoracoscopic surgery (VATS) right upper lobectomy. Computed tomography (CT) revealed a nodule of 3×2 cm in the posterior segment of the right upper lobe. After a comprehensive assessment and optimisation with steroids and bronchodilator coverage for asthma, a VATS-assisted right upper lobectomy was planned. After routine induction of anaesthesia, lung separation was achieved using a 35-F left-sided double-lumen tube (DLT) guided by fibreoptic bronchoscopy, and surgery proceeded.

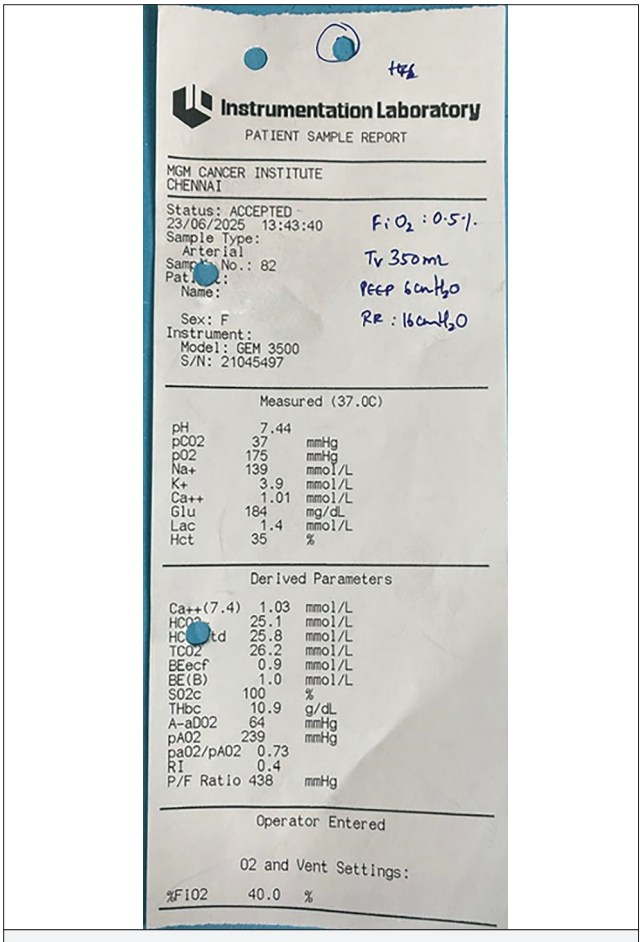
Corresponding author: Sathish K MD **E-mail:** drsathishkalyan@gmail.com
Received: November 10, 2025 **Accepted:** January 02, 2026 **Epub:** January 20, 2026 **Published date:** April 15, 2026
Cite this article as: K S, Sukumar S, KS SR. Role of intraoperative bronchoscopy in diagnosing bronchus related complications following VATS. *Turk J Anaesthesiol Reanim*. 2026;54(2):134-137

A uniportal VATS right upper lobectomy was successfully performed, and a functional intercostal drain was placed. The DLT was subsequently replaced with a single-lumen tube,[4] and adequate lung recruitment was achieved. Arterial blood gas analysis showed a satisfactory $PaCO_2$ of 37 mmHg and a P/F ratio of 430 (Figure 1).

Following adequate analgesia, neuromuscular blockade was reversed, and the trachea was extubated. Post-extubation, the patient complained of pain and difficulty in breathing ; during this episode, oxygen saturation dropped from 100% to 92% despite administration of 100% oxygen. After additional analgesic supplementation, auscultation revealed decreased, coarse breath sounds with rhonchi over the right hemithorax. Bronchospasm was suspected, and treatment with bronchodilators and steroids was initiated. Oxygen saturation subsequently improved to 96-98% with an FiO_2 of 1.0. Given the diagnosis of bronchospasm and established hypoxic pulmonary vasoconstriction (HPV), the patient was transferred to the post-surgical intensive care unit (ICU) for oxygen therapy via high-flow nasal oxygen (HFNO) and bronchodilator therapy. After 30 minutes of HFNO with an FiO_2 of 0.8, the arterial PCO_2 was 60 mmHg, the arterial PO_2 was 67 mmHg, and the P/F ratio was 134 (Figure 2). A postoperative chest radiograph displayed total collapse of the right hemithorax (Figure 3).

Furthermore, bronchoscopy was performed immediately, revealing a complete obstruction of the right main bronchus (Figure 4). A diagnosis of accidental stapling of the right main bronchus was established (Supplementary Video 1), and the patient was immediately taken back to the operating room for re-exploration. Complete occlusion of the right main bronchus with collapse of the middle and lower lobes was noted. Bronchoplasty of the right main bronchus and the lower lobe bronchus was performed, along with middle lobectomy, because of a narrowed bronchial opening. Bronchial patency was confirmed using a paediatric bronchoscope (Ambu Slim, 3.8 mm) before extubation.

The patient was transferred to the postoperative ICU for elective ventilation via a single-lumen tube and was extubated 12 hours later after a postoperative X-ray (Figure 5) confirmed expansion of the right lower lobe.


Instrumentation Laboratory
PATIENT SAMPLE REPORT
MGM CANCER INSTITUTE
CHENNAI
Status: ACCEPTED
23/06/2025 13:43:40
Sample Type:
Arterial
Sample No.: 82
Name:
Sex: F
Instrument:
Model: GEM 3500
S/N: 21045497
F_iO_2 : 0.5/.
Tv 350mL
PEEP 6cmH_2O
RR : 16cmH_2O
Measured (37.0C)

pH	7.44	
pCO2	37	mmHg
pO2	175	mmHg
Na+	139	mmol/L
K+	3.9	mmol/L
Ca++	1.01	mmol/L
Glu	184	mg/dL
Lac	1.4	mmol/L
Hct	35	%

Derived Parameters

Ca++(7.4)	1.03	mmol/L
HCO3	25.1	mmol/L
HCO3 std	25.8	mmol/L
TCO2	26.2	mmol/L
BEecf	0.9	mmol/L
BE(B)	1.0	mmol/L
SO2c	100	%
THbc	10.9	g/dL
A-aDO2	64	mmHg
pAO2	239	mmHg
paO2/pAO2	0.73	
RI	0.4	
P/F Ratio	438	mmHg

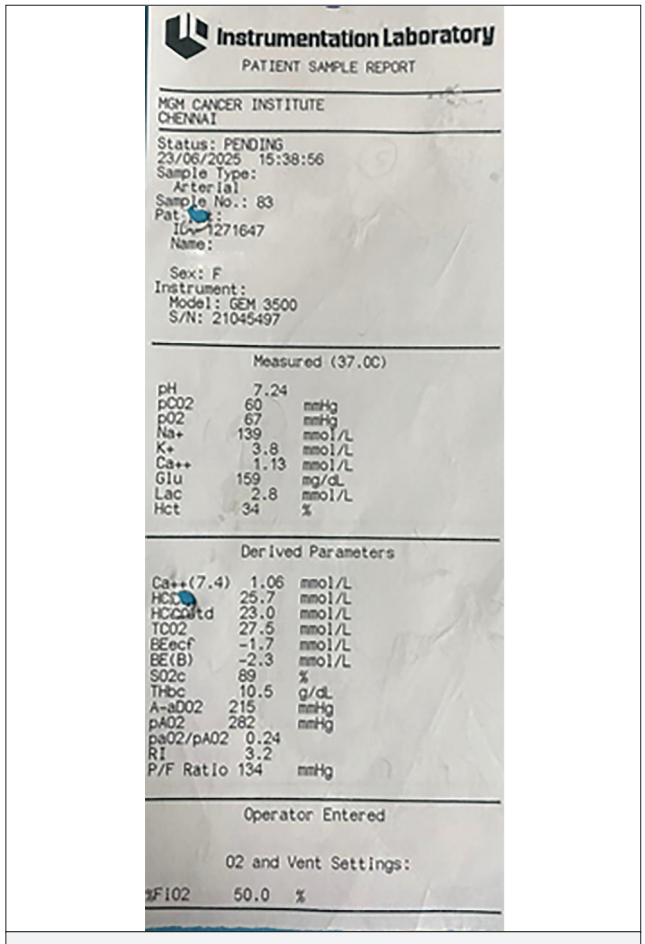
Operator Entered

02 and Vent Settings:

%FiO2	40.0	%

Figure 1. ABG prior to extubation.

ABG, arterial blood gas.


Instrumentation Laboratory
PATIENT SAMPLE REPORT
MGM CANCER INSTITUTE
CHENNAI
Status: PENDING
23/06/2025 15:38:56
Sample Type:
Arterial
Sample No.: 83
Pat[illegible]:
IC[illegible]1271647
Name:
Sex: F
Instrument:
Model: GEM 3500
S/N: 21045497
Measured (37.0C)

pH	7.24	
pCO2	60	mmHg
pO2	67	mmHg
Na+	139	mmol/L
K+	3.8	mmol/L
Ca++	1.13	mmol/L
Glu	159	mg/dL
Lac	2.8	mmol/L
Hct	34	%

Derived Parameters

Ca++(7.4)	1.06	mmol/L
HCO3	25.7	mmol/L
HCO3 std	23.0	mmol/L
TCO2	27.5	mmol/L
BEecf	-1.7	mmol/L
BE(B)	-2.3	mmol/L
SO2c	89	%
THbc	10.5	g/dL
A-aDO2	215	mmHg
pAO2	282	mmHg
paO2/pAO2	0.24	
RI	3.2	
P/F Ratio	134	mmHg

Operator Entered

02 and Vent Settings:

%FiO2	50.0	%

Figure 2. Postoperative ABG in ICU.

ABG, arterial blood gas; ICU, intensive care unit.

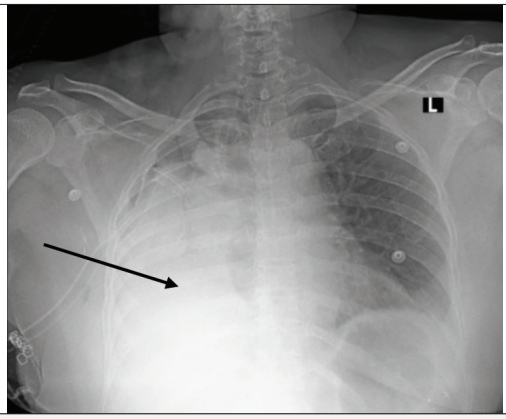


Figure 3. Postoperative chest radiograph showing total collapse of the right hemithorax.

L: left.

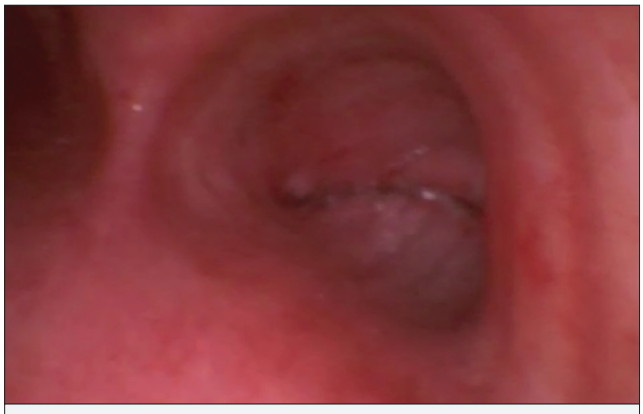


Figure 4. Bronchoscopy view demonstrating complete stapling of the right main bronchus.

Discussion

VATS is a minimally invasive surgical technique that offers several advantages over traditional open surgery. However, as with any surgical procedure, it is associated with potential risks and complications, including bleeding, infection, pneumonia, pneumothorax, and prolonged air leak. Among these, bronchial injuries account for approximately 0.1-1.5% of cases[5,6] and are typically caused by surgical intervention or stapler closure of the bronchial stump.[7] Early diagnosis, guided by a high index of clinical suspicion, is crucial for reducing morbidity and mortality.[2,7] Bedside lung point-of-care ultrasound can be used, but only as an adjunct to radiography for diagnosing early respiratory complications.[8] In such clinical scenarios, CT imaging and bronchoscopy play a pivotal role in confirming the diagnosis.

Intraoperative diagnostic bronchoscopy is not routinely performed unless there is a clear indication, because it is associated with an increased risk of postoperative pulmonary

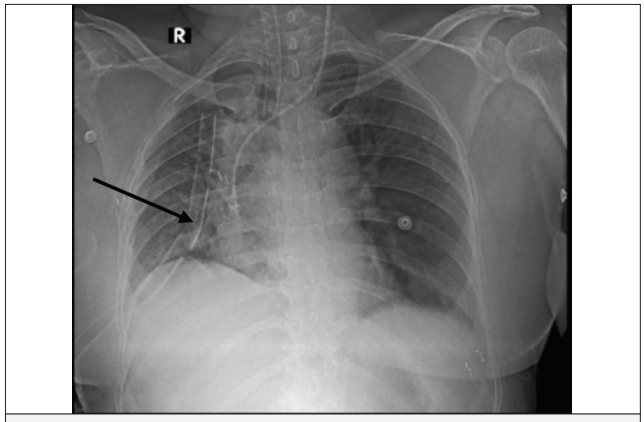


Figure 5. Postoperative chest X-ray after re-exploration, showing re-inflation of the right lower lobe.

R: right.

complications and prolonged hospital stay among patients undergoing lobe resection for lung cancer.[9]

In the current case, no significant hypoxia or abnormally elevated airway pressures were observed intraoperatively after initiation of dual-lung ventilation that would suggest complete bronchial obstruction.

Following extubation patient was shifted to ICU where the patient developed marked hypoxia requiring HFNO. A chest radiograph revealed total collapse of the right hemithorax; bronchoscopy was immediately undertaken to evaluate a presumptive diagnosis of mucus plugging or inadequate recruitment. However, bronchoscopy revealed that the right main bronchus had been inadvertently stapled. Although perioperative bronchoscopy remains technically challenging due to blood and secretions in the airway, which compromise visibility and increase infection risk, it may be used as a valuable bedside tool for detecting early complications.[10,11] Based on the clinical presentation, poor recruitment, mucus plugging, and HPV were considered differential diagnoses until bronchoscopy was performed. Intraoperative bronchoscopy plays a crucial role in identifying an off-target bronchial transection in the remnant neighbouring lobes, including the visualisation of ipsilateral adjacent airway and the localisation of surgical ligation clips. In such cases, bronchoscopy serves as an essential tool to prevent diagnostic delay. Hence, we began performing post-procedure bronchoscopy and lung ultrasound to assess bronchial patency and lung expansion, respectively, prior to extubation in all such cases.

Conclusion

To sum up, although complications following the VATS procedure are rare, they can be fatal. In such instances,

intraoperative bronchoscopy, despite its technical difficulty, serves as a valuable bedside tool for the diagnosis of immediate postoperative complications.

Ethics

Informed Consent: The informed consent was duly acquired from the patient.

Footnotes

Author Contributions: Surgical and Medical Practices - S.K., S.S., R.S.K.S.; Concept - S.K., S.S., R.S.K.S.; Design - S.K., S.S., R.S.K.S.; Data Collection and/or/Processing - S.K., S.S., R.S.K.S.; Analysis or Interpretation - S.K., S.S., R.S.K.S.; Literature Search - S.K., S.S., R.S.K.S.; Writing - S.K., S.S., R.S.K.S.

Declaration of Interests: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding: The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

1. Flores RM, Ihekweazu U, Dycoco J, et al. Video-assisted thoracoscopic surgery (VATS) lobectomy: catastrophic intraoperative complications. *J Thorac Cardiovasc Surg.* 2011;142(6):1412-1417. [CrossRef]
2. Wallwork K, Belcher E. Post-lobectomy airways complications. *Shanghai Chest.* 2021;5:18. [CrossRef]
3. Borah A, Cocciardi S, Boujaoude Z, Abouzgheib W. Erroneous bronchial transection after video assisted thoracoscopic surgery (VATS) pulmonary resection diagnosed with bronchoscopy: case report. *Medicine (Baltimore).* 2019;98(50):e18377. [CrossRef]
4. Tanoubi I, Sun JN, Drolet P, Fortier LP, Donati F. Replacing a double-lumen tube with a single-lumen tube or a laryngeal mask airway device to reduce coughing at emergence after thoracic surgery: a randomized controlled single-blind trial. *Can J Anaesth.* 2015;62(9):988-995. [CrossRef]
5. Decaluwe H, Petersen RH, Hansen H, et al. Major intraoperative complications during video-assisted thoracoscopic anatomical lung resections: an intention-to-treat analysis. *Eur J Cardiothorac Surg.* 2015;48(4):588-598; discussion 599. [CrossRef]
6. Łochowski MP, Kozak J. Video-assisted thoracic surgery complications. *Wideochir Inne Tech Maloinwazyjne.* 2014;9(4):495-500. [CrossRef]
7. Tanaka H, Aoki T, Oda M, Inoue Y. Stapling of an endobronchial suction tube with the bronchus during robot-assisted right lower lobectomy: a case report. *Surg Case Rep.* 2021;7(1):191. [CrossRef]
8. Bosch L, Mathe O, Robin JJ, et al. Assessment of lung ultrasound for early detection of respiratory complications in thoracic surgery. *Braz J Anesthesiol.* 2022;72(1):128-134. [CrossRef]
9. Falcoz PE, Puyraveau M, Thomas PA, et al. Video-assisted thoracoscopic surgery versus open lobectomy for primary non-small-cell lung cancer: a propensity-matched analysis of outcome from the European Society of Thoracic Surgeon database. *Eur J Cardiothorac Surg.* 2016;49(2):602-609. [CrossRef]
10. Xu Z, Liu C, Zhang C, et al. Bronchoscopy increased the risk of postoperative pulmonary complications in patients undergoing lobectomy for lung cancer: a retrospective cohort study. *J Thorac Dis.* 2025;17(6):3840-3852. [CrossRef]
11. Pápai-Székely Z, Grmela G, Sárosi V. Novel diagnostic processes and challenges in bronchoscopy. *Pathol Oncol Res.* 2024;30:1611774. [CrossRef]

Click for Supplementary Video 1 link:

https://youtu.be/H4NOP3i_F-Y

Case Report
Cardiovascular and Thoracic Anaesthesia

DOI: 10.4274/TJAR.2026.262398
Turk J Anaesthesiol Reanim 2026;54(2):138-142

Turkish Journal of Anaesthesiology & Reanimation

Flow-controlled One-lung Ventilation During Carinal Sleeve Reconstruction: Anaesthetic Management and Technical Feasibility

Cansu Kılınç Berktaş[1] Emine Şeyda Teloğlu[1] Funda Gümüş Özcan[1], Ece Yasemin Demirkol[2]

[1]University of Health Sciences Türkiye, Başakşehir Çam and Sakura City Hospital, Clinic of Anaesthesiology and Reanimation, İstanbul, Türkiye
[2]University of Health Sciences Türkiye, Başakşehir Çam and Sakura City Hospital, Clinic of Thoracic Surgery, İstanbul, Türkiye

Abstract

Carinal sleeve resection with reconstruction represents one of the most challenging thoracic surgical procedures and requires meticulous anaesthetic management to maintain adequate gas exchange within a shared and surgically interrupted airway while preserving an unobstructed surgical field. Conventional ventilation strategies, including cross-field ventilation and high-frequency jet ventilation, may interfere with surgical exposure or result in unstable ventilation. We describe the anaesthetic management of a 64-year-old male patient in whom flow-controlled ventilation- one-lung ventilation (FCV-OLV) was employed during carinal sleeve lobectomy with reconstruction. Following initial double-lumen tube ventilation, FCV was established using a Tritube® connected to an Evone® ventilator and maintained throughout airway reconstruction. Ventilation was achieved without interruptions, apneic periods, or cross-field ventilation. Oxygenation and carbon dioxide elimination remained stable during 180 minutes of FCV, while the small-lumen tube provided optimal surgical exposure. The patient was extubated uneventfully at the end of surgery and experienced an uncomplicated postoperative course. This case highlights the feasibility of flow-controlled OLV as an anaesthetic strategy during complex airway reconstruction. FCV-OLV enabled uninterrupted ventilation, stable gas exchange, and excellent surgical conditions without the need for extracorporeal support or alternative ventilation techniques

Keywords: Airway management/methods, anaesthesia, thoracic, flow-controlled ventilation, positive-pressure respiration, tracheal neoplasms/surgery, ventilation, one-lung

Main Points

- Flow-controlled ventilation (FCV) can provide uninterrupted gas exchange during complex airway reconstruction.
- FCV- one-lung ventilation may improve surgical exposure by allowing the use of a small-lumen ventilation tube.
- This technique can be applied as a rescue strategy when unexpected carinal involvement occurs.
- FCV may reduce the need for cross-field ventilation or extracorporeal support in selected cases.

Introduction

Involvement of the carina by lung or tracheal tumors is uncommon and remains one of the most challenging scenarios in thoracic surgery. Despite advances in bronchial sleeve lobectomy and tracheal surgery, tumors invading the carina are rarely amenable to resection and require highly specialized surgical and anaesthetic management.[1,2] From an anaesthetic perspective, the principal challenge lies in maintaining adequate oxygenation and carbon dioxide elimination while preserving an unobstructed surgical field within a shared and surgically interrupted airway.

Several ventilation strategies have been described during carinal reconstruction, including cross-field ventilation, high-frequency jet ventilation (HFJV), and extracorporeal membrane oxygenation (ECMO).[2,3] However, each technique has important limitations. Cross-field ventilation may interfere with surgical exposure and workflow, HFJV has been associated

Corresponding author: Cansu Kılınç Berktaş MD **E-mail:** cansukilinc87@gmail.com
Received: January 29, 2026 **Accepted:** March 07, 2026 **Published date:** April 15, 2026
Cite this article as: Kılınç Berktaş C, Teloğlu EŞ, Gümüş Özcan F, Demirkol EY. Flow-controlled one-lung ventilation during carinal sleeve reconstruction: anaesthetic management and technical feasibility. *Turk J Anaesthesiol Reanim*. 2026;54(2):138-142

with inadequate carbon dioxide clearance, air trapping, and aerosol generation, and ECMO introduces additional complexity, cost, and anticoagulation-related risks.[1,3]

Flow-controlled ventilation (FCV) is a relatively novel ventilation technique that delivers a constant and controlled gas flow during both inspiration and active expiration. When applied through small-lumen tubes such as the Tritube®, FCV enables continuous ventilation while minimizing airway obstruction. Experimental and clinical studies have demonstrated that FCV may improve oxygenation, reduce peak airway pressures, and decrease mechanical power compared with conventional ventilation modes.[4-7] More recent investigations have suggested that FCV may be particularly advantageous during one-lung ventilation and airway surgery by providing stable gas exchange and improved surgical conditions.[5,6]

In this report, we describe the anaesthetic management of a patient undergoing carinal sleeve lobectomy with reconstruction using FCV-OLV. The purpose of this case is to highlight the feasibility of FCV-OLV as an alternative airway management strategy in complex airway reconstruction, focusing on anaesthetic considerations rather than surgical or oncologic outcomes.

Case Report

A 64-year-old male patient (American Society of Anesthesiologist Physical Status II) with a predicted body weight (PBW) of 81.5 kg (calculated according to standard formulas for males) was scheduled for right upper lobectomy via thoracotomy due to suspected lung malignancy. Preoperative evaluation revealed adequate cardiopulmonary reserve, with pulmonary function testing showing an forced expiratory volume in 1 second/forced vital capacity ratio of 85%. Standard monitoring was applied, including electrocardiography, pulse oximetry, invasive arterial blood pressure monitoring via a left radial arterial line, and end-tidal carbon dioxide monitoring. An 8F central venous catheter was placed in the right internal jugular vein. Written informed consent was obtained from the patient for publication of this case report and accompanying images.

General anaesthesia was induced with propofol (2 mg kg^{-1}), fentanyl (2 µg kg^{-1}), and rocuronium (0.6 mg kg^{-1}). The trachea was intubated with a 37F left-sided double-lumen tube (DLT), and mechanical ventilation was initiated in pressure-controlled mode. Initial intraoperative conditions were stable.

During surgical exploration, frozen-section analysis revealed tumor involvement of the carina, so the initially planned right upper lobectomy was converted to a carinal sleeve lobectomy with reconstruction. Following this unexpected intraoperative finding, conventional ventilation strategies were no longer feasible without compromising the surgical field. Therefore, FCV was introduced intraoperatively as a rescue strategy to maintain adequate ventilation while optimizing surgical exposure.

At this stage, the DLT was withdrawn to the tracheal level, and temporary ventilation was achieved via a 7.0 mm standard endotracheal tube surgically inserted into the left main bronchus. Subsequently, a Tritube® was introduced retrogradely through the surgical field, retrieved orally, and connected to an Evone® ventilator. The cuff of the Tritube® was positioned in the left main bronchus and remained in place throughout airway reconstruction, allowing continuous ventilation without interruption or apneic periods.

From the initiation of FCV until the end of the procedure, anaesthesia was maintained with total intravenous anaesthesia (TIVA), administered as continuous infusions of propofol and remifentanil. The depth of anaesthesia was titrated to maintain a SedLine® patient state index between 25 and 50. Propofol infusion rates ranged between 6-10 mg kg^{-1} h^{-1} and remifentanil infusion rates between 0.05-0.1 µg kg^{-1} min^{-1}, adjusted according to hemodynamic and electroencephalographic parameters. TIVA was preferred because FCV was delivered via a separate ventilator system without connection to a conventional anaesthesia machine vaporizer. No ventilatory complications occurred during FCV, and hemodynamic parameters remained stable without the need for vasoactive support.

Ventilation was maintained using FCV with an inspired oxygen fraction of 1.0, a constant flow of 12 L min^{-1}, an inspiratory-to-expiratory ratio of 1:1, and an end-expiratory pressure of 8 mbar. Peak inspiratory pressure was approximately 19 mbar, with an average tidal volume of 310 mL (corresponding to 3.8 mL kg^{-1} PBW) and a respiratory rate of 20 breaths per minute. End-tidal carbon dioxide values remained at approximately 31 mmHg. Arterial blood gas analyses were performed intermittently during FCV, and the results remained within acceptable limits, with no episodes of significant hypercapnia or respiratory acidosis.

FCV was maintained for 180 minutes during tracheal, left main bronchial, and intermediate bronchial anastomoses. The tube position was continuously monitored throughout airway reconstruction, and no displacement or loss of the airway occurred. Hemodynamic parameters remained stable, and no episodes of desaturation were observed.

The total surgical duration was 270 minutes. After completion of reconstruction and confirmation of airway integrity, the Tritube® was withdrawn, and the patient was extubated uneventfully at the end of surgery. He was transferred to the intensive care unit for postoperative observation, remained stable during a 16-hour stay, and was subsequently transferred to the ward. The patient was discharged on postoperative day 8 without complications.

Follow-up fiberoptic bronchoscopy performed one month later demonstrated a well-healed anastomosis without evidence of stenosis or leakage.

Discussion

Carinal sleeve resection with reconstruction is one of the most demanding scenarios in thoracic anaesthesia because the airway is shared and surgically interrupted, and continuous ventilation is required without compromising surgical exposure. Despite advances in surgical techniques, tumors involving the carina remain rare and technically challenging, requiring close coordination between the surgical and anaesthetic teams.[1,2] From an anaesthetic perspective, maintaining adequate oxygenation and carbon dioxide elimination while preserving an unobstructed operative field is the principal challenge.

Several ventilation strategies have been described during carinal surgery, including cross-field ventilation, HFJV, and ECMO.[2,3] However, each approach has inherent limitations. Cross-field ventilation may interfere with surgical workflow and visualization, HFJV has been associated with inadequate carbon dioxide elimination, air trapping, and aerosol generation, and ECMO introduces additional complexity, cost, and risks related to anticoagulation and cannulation.[1,3] These limitations emphasize the need for alternative ventilation strategies that allow uninterrupted ventilation while maintaining optimal surgical conditions.

FCV was not planned preoperatively but was introduced intraoperatively as a rescue strategy after frozen-section analysis confirmed carinal involvement, and the procedure was converted to carinal sleeve reconstruction. This scenario highlights an important clinical advantage of FCV: its feasibility in unexpected intraoperative situations requiring rapid adaptation of airway management. FCV enabled uninterrupted one-lung ventilation throughout airway reconstruction without the need for cross-field ventilation, apneic periods, or extracorporeal support, thereby maintaining stable gas exchange and optimal surgical exposure. In addition, when FCV is delivered via a standalone ventilator system, TIVA may be preferable, as it avoids fluctuations in anaesthetic concentration and allows a stable anaesthetic depth independent of the anaesthesia workstation.

From a physiological standpoint, FCV differs fundamentally from conventional ventilation modes. It delivers a constant and controlled gas flow during both inspiration and active expiration, allowing more precise regulation of airway pressures and gas exchange.[4,7] In FCV, tidal volume is not set as a predefined target but results from the interaction between applied flow, pressure limits, and patient-specific respiratory mechanics.[8-10] Experimental and clinical studies have demonstrated that FCV may improve oxygenation, reduce peak airway pressures, and decrease mechanical power compared with pressure- or volume-controlled ventilation, particularly during one-lung ventilation.[5,6,8,10-12] In our case, the selected end-expiratory pressure facilitated maintenance of alveolar recruitment during prolonged one-lung ventilation without excessive airway pressures, resulting in stable oxygenation and normocapnia.

Beyond gas exchange, surgical exposure is a critical determinant of success during carinal reconstruction. Using a small-lumen tube, such as the Tritube®, in combination with FCV provided excellent visualization of the operative field and eliminated the need for repeated tube manipulation. The Tritube® is a small-lumen endotracheal tube designed for use with dedicated FCV systems, and its small outer diameter facilitates surgical access during airway reconstruction. Although small-lumen tubes carry a potential risk of obstruction by blood or secretions, careful monitoring and the ability to flush and suction through the tube may facilitate management if needed. Previous clinical studies have reported similar advantages of FCV in airway and upper thoracic surgery, including improved surgical comfort, reduced aerosolization, and uninterrupted ventilation.[4,7,11,13] Our experience is consistent with these findings and extends them by demonstrating the feasibility of FCV as a rescue strategy during complex carinal reconstruction. From a surgical perspective, various techniques for carinal reconstruction have been described, each associated with specific technical challenges and potential complications.[14,15] The surgical reconstruction technique used in this case is illustrated in Figure 1.[15] Although surgical outcomes depend primarily on meticulous technique and preservation of vascular supply, anaesthetic strategies that ensure stable ventilation and optimal exposure play a crucial supportive role in achieving successful reconstruction.[1,14] The present case underscores the importance of adaptable anaesthetic management in facilitating complex airway surgery.

Ventilatory and hemodynamic parameters during FCV are summarized in Table 1, together with commonly reported clinical ranges for FCV, to facilitate interpretation.

Study Limitations

This report describes a single case and therefore cannot be generalized. The absence of comparative data precludes conclusions regarding superiority over other ventilation strategies. Additionally, outcomes may be influenced by institutional experience with FCV and close interdisciplinary collaboration. Accordingly, the observations presented here should be considered hypothesis-generating.

Clinical Implications

This case suggests that flow-controlled one-lung ventilation may be considered when unexpected intraoperative findings necessitate uninterrupted ventilation and optimal surgical

exposure during complex airway reconstruction. FCV may serve as a valuable addition to the anaesthesiologis's armamentarium in selected high-risk thoracic procedures.

Conclusion

Flow-controlled one-lung ventilation enabled stable oxygenation, effective carbon dioxide elimination, and uninterrupted ventilation during carinal sleeve resection with reconstruction in the present case. Introduced intraoperatively as a rescue strategy following unexpected carinal involvement, FCV provided optimal surgical exposure without the need for cross-field ventilation or extracorporeal support. This case highlights the feasibility of FCV as an adaptable airway management option in complex thoracic surgery when conventional ventilation techniques are insufficient. Further clinical experience and comparative studies are needed to better define its role in airway reconstruction.

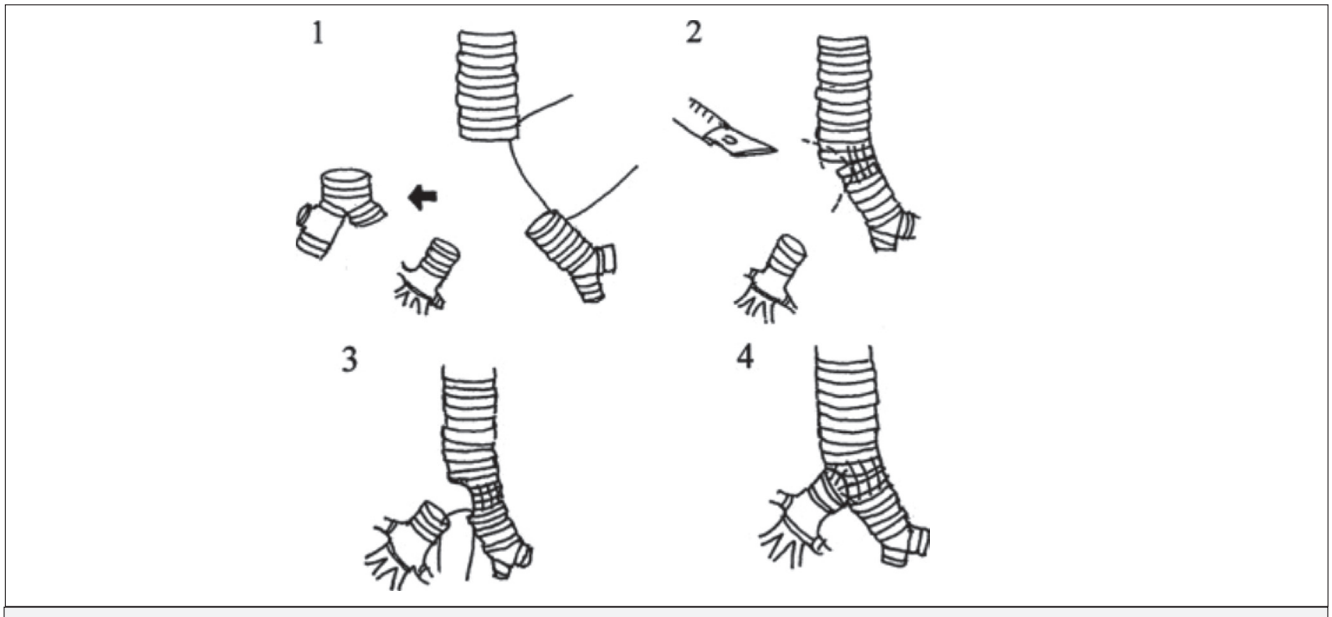


Figure 1. Carinal reconstruction technique used in this case. Adapted from Yamamoto et al. [15]

A novel carinal reconstruction technique. (1) After the tracheal carina is resected, two thirds of the circumference of the trachea and the left main bronchus are anastomosed. (2) The remaining one third of the circumference is trimmed to create an oval-shape orifice to which the right bronchus is anastomosed. (3) The right bronchus is anastomosed to this trimmed orifice in end-to-side fashion.

Table 1. Ventilatory and Hemodynamic Parameters During 180 Minutes of Flow-controlled One-lung Ventilation

Parameter	Observed value	Typical clinical range in FCV*
FiO_2	1.0	As clinically indicated
Constant flow	12 L min^{-1}	~8-16 L min^{-1}
I:E ratio	1:1	1:1 commonly applied
End-expiratory pressure	8 mbar	5-10 mbar (adjusted individually)
Peak inspiratory pressure	~19 mbar	Adjusted to lung mechanics
Respiratory rate	20 breaths/min	Titrated for CO_2 control
Tidal volume	310 mL (3.8 mL kg^{-1} PBW)	Not preset; depends on flow and pressure settings
End-tidal CO_2	~31 mmHg	30-45 mmHg targeted range
Duration of FCV	180 min	-
Hemodynamic stability	Stable; no vasoactive support required	-

*: Typical ranges reflect values commonly reported in clinical studies of flow-controlled ventilation and are not fixed manufacturer-recommended settings
FiO_2, fraction of inspired oxygen; CO_2, carbon dioxid; PBW, predicted body weight; FCV, flow-controlled ventilation

Ethics

Informed Consent: Written informed consent was obtained from the patient for publication of this case report and accompanying images.

Footnotes

Author Contributions: Surgical and Medical Practices - C.K.B., F.G.Ö.; Concept - C.K.B., E.Ş.T.; Design - C.K.B., E.Ş.T., F.G.Ö.; Data Collection and/or/Processing - T C.K.B., E.Ş.T., E.Y.D.; Analysis and/or/Interpretation - C.K.B., F.G.Ö., E.Y.D.; Literature Review - C.K.B., E.Y.D.; Writing - C.K.B.

Declaration of Interests: The authors declare no conflicts of interest.

Funding: No funding was received for conducting this study.

References

1. Regnard JF, Perrotin C, Giovannetti R, et al. Resection for tumors with carinal involvement: technical aspects, results, and prognostic factors. *Ann Thorac Surg.* 2005;80(5):1841-1846. [CrossRef]
2. D'Andrilli A, Trabalza Marinucci B, et al. Carinal reconstruction for lung cancer and airway tumors: long-term results. *Ann Thorac Surg.* 2025;120(2):271-281. [CrossRef]
3. Voltolini L, Salvicchi A, Gonfiotti A, et al. Veno-venous ECMO in complex airway surgery. *J Thorac Dis.* 2024;16(3):1452-1460. [CrossRef]
4. Filauro M, Mora F, Vallin A, et al. Evone® flow controlled ventilation: a new device for laryngotracheal surgery. *Acta Otorhinolaryngol Ital.* 2022;42(2):189-193. [CrossRef]
5. Abram J, Spraider P, Martini J, et al. Flow-controlled versus pressure-controlled ventilation in thoracic surgery with one-lung ventilation - a randomized controlled trial. *J Clin Anesth.* 2025;103:111785. [CrossRef]
6. Spraider P, Martini J, Abram J, et al. Individualised flow-controlled ventilation versus pressure-controlled ventilation in a porcine model of thoracic surgery requiring one-lung ventilation: a laboratory study. *Eur J Anaesthesiol.* 2022;39(11):885-894. [CrossRef]
7. Sebrechts T, Morrison SG, Schepens T, Saldien V. Flow-controlled ventilation with the evone ventilator and tritube versus volume-controlled ventilation: a clinical cross-over pilot study describing oxygenation, ventilation and haemodynamic variables. *Eur J Anaesthesiol.* 2021;38(2):209-211. [CrossRef]
8. Bialka S, Palaczynski P, Szuldrzynski K, et al. Flow-controlled ventilation - a new and promising method of ventilation presented with a review of the literature. *Anaesthesiol Intensive Ther.* 2022;54(1):62-70. [CrossRef]
9. Schmidt J, Wenzel C, Spassov S, et al. Flow-controlled ventilation attenuates lung ınjury in a porcine model of acute respiratory distress syndrome: a preclinical randomized controlled study. *Crit Care Med.* 2020;48(3):e241-e248. [CrossRef]
10. Weber J, Straka L, Borgmann S, Schmidt J, Wirth S, Schumann S. Flow-controlled ventilation (FCV) improves regional ventilation in obese patients - a randomized controlled crossover trial. *BMC Anesthesiol.* 2020;20(1):24. [CrossRef]
11. Meulemans J, Jans A, Vermeulen K, Vandommele J, Delaere P, Vander Poorten V. Evone® flow-controlled ventilation during upper airway surgery: a clinical feasibility study and safety assessment. *Front Surg.* 2020;7:6. [CrossRef]
12. Wittenstein J, Scharffenberg M, Ran X, et al. Comparative effects of flow vs. volume-controlled one-lung ventilation on gas exchange and respiratory system mechanics in pigs. *Intensive Care Med Exp.* 2020;8(Suppl 1):24. [CrossRef]
13. Schmidt J, Günther F, Weber J, et al. Flow-controlled ventilation during ear, nose and throat surgery: a prospective observational study. *Eur J Anaesthesiol.* 2019;36(5):327-334. [CrossRef]
14. Sarper A, Aydoğdu Titiz T, Öz N, Arslan G, Bozcuk H, Demircan A. Results of carinal sleeve lobectomy and sleeve pneumonectomy in lung cancer. *Turkish J Thorac Cardiovasc Surg.* 2010;18(4):293-299. [CrossRef]
15. Yamamoto K, Miyamoto Y, Ohsumi A, Imanishi N, Kojima F. Surgical results of carinal reconstruction: an alterative technique for tumors involving the tracheal carina. *Ann Thorac Surg.* 2007;84(1):216-220. [CrossRef]

Letter to the Editor

DOI: 10.4274/TJAR.2026.252351
Turk J Anaesthesiol Reanim 2026;54(2):143-145

Turkish Journal of Anaesthesiology & Reanimation

The Motor-sparing Paradigm in Knee Analgesia: Advancing Multi-block Strategies with the BiFeS Block as A New Player

Tayfun Et[1], İlke Dolğun[2], Muhammet Korkusuz[1], İbrahim Tülüce[3]

[1]Karamanoğlu Mehmetbey University Faculty of Medicine, Department of Anaesthesiology and Intensive Care Medicine, Karaman, Türkiye
[2]University of Health Sciences Türkiye, İstanbul Haseki Training and Research Hospital, Clinic of Anaesthesiology and Reanimation, İstanbul, Türkiye
[3]Karamanoğlu Mehmetbey University Faculty of Medicine, Department of Orthopedics and Traumatology, Karaman, Türkiye

Keywords

Adductor canal block, biceps femoris short head block, motor-sparing, orthopaedic anaesthesia, regional anaesthesia

Dear Editor,

Advances in anatomical understanding and enhanced recovery pathways have reshaped regional anaesthesia strategies for total knee arthroplasty (TKA). Motor-sparing techniques have gained increasing importance, reflecting modern priorities such as early mobilisation, reduced fall risk, and optimised functional recovery. This evolution extends beyond the practice patterns described in the review published in the Turkish Journal of Anaesthesiology and Reanimation.[1] Recent systematic evaluations have further highlighted the growing role of selective, function-preserving regional techniques in contemporary perioperative care.[2]

Despite progress with anterior-based approaches such as the adductor canal block (ACB), posterolateral knee pain remains a frequently under-addressed component of postoperative discomfort. Anatomical studies have clarified the sensory innervation of the posterior knee capsule,[3] demonstrating contributions from superolateral genicular branches that are not consistently covered by traditional anterior or periarticular techniques. This understanding has stimulated the development of more selective posterior interventions aligned with current motor-sparing goals.

Among these innovations, the biceps femoris short head (BiFeS) block represents a recent anatomically targeted addition. First described by Kilicaslan et al.,[4] the BiFeS block was designed to target the articular branches that innervate the posterolateral aspect of the knee joint by promoting local anaesthetic spread along the facies poplitea toward the superior lateral genicular nerve and adjacent articular branches, while largely sparing the main motor nerves.[4,5] This anatomical selectivity has been proposed as an explanation for its posterolateral analgesic effect without clinically relevant motor impairment.

The combined use of ACB and BiFeS blocks has recently been incorporated into our clinical practice. We present a representative case to illustrate the technique and its potential functional profile.

A sixty-two-year-old male patient (American Society of Anesthesiologists physical status II) underwent unilateral TKA. Informed consent was obtained from the patient for both the procedure and the publication of this case. With the patient in the supine position, baseline isometric strength of the foot muscles was assessed using a handheld dynamometer. Plantar flexion measured 13.1 kilogram-force (kgf) and dorsiflexion measured 9.4 kgf. After mild sedation (midazolam 1 mg, fentanyl 25 µg, and dexamethasone 8 mg , administered intravenously), an ACB was performed with 15 mL of 0.25% bupivacaine.

Corresponding author: Prof. Tayfun Et, **E-mail:** drtayfunet@gmail.com
Received: December 17, 2025 **Accepted:** February 02, 2026 **Epub:** February 09, 2026 **Published date:** April 15, 2026
Cite this article as: Et T, Dolğun İ, Korkusuz M, Tülüce İ. The motor-sparing paradigm in knee analgesia: advancing multi-block strategies with the BiFeS block as a new player. Turk J Anaesthesiol 2026;54(2):143-145

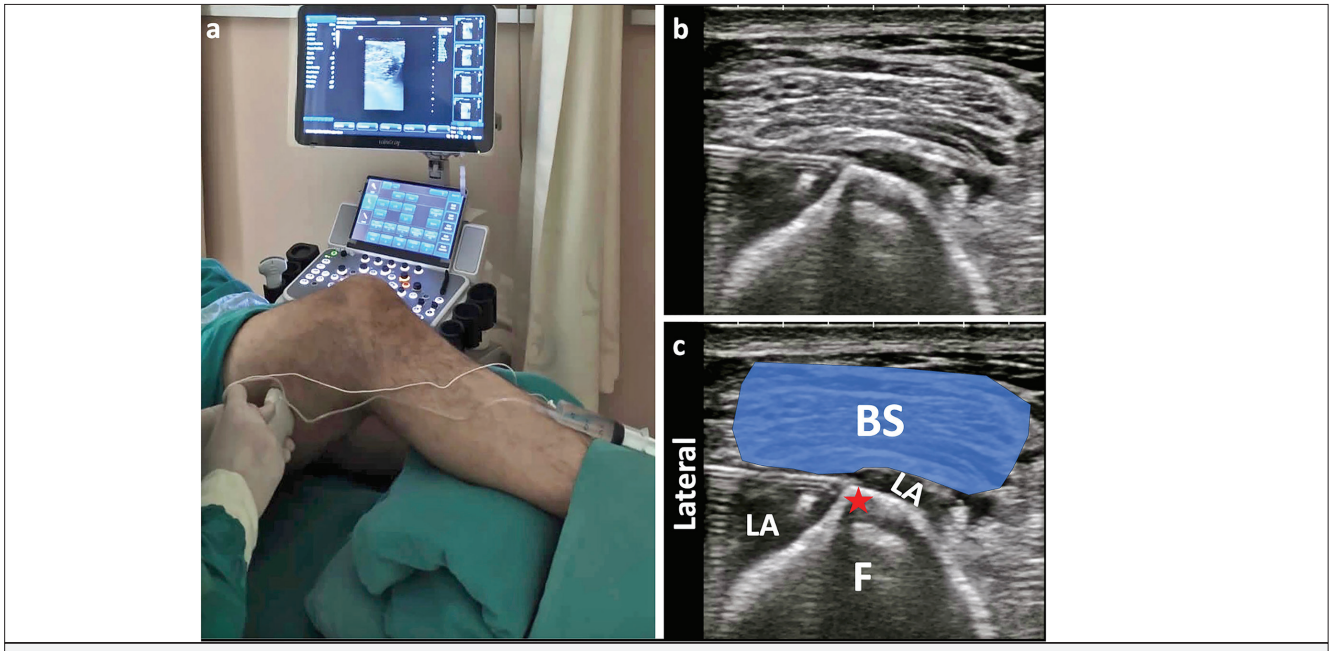


Figure 1. The biceps femoris short head block procedure: a. Patient and ultrasound probe positioning, b. Corresponding ultrasound image of the target area, c. Schematic illustration of the relevant anatomy, depicting the short head of the biceps femoris muscle (BS), the spread of local anaesthetic (LA), and the femoral shaft (F). The red star marks the lateral supracondylar line of the femur, the key anatomical landmark for needle guidance.

Ultrasound examination for the BiFeS block was performed using a high-frequency linear transducer (5-18 MHz), with the patient supine and a bolster placed under the leg to be blocked, facilitating access to the posterolateral thigh (Figure 1a). The probe was initially placed in a posterolateral orientation, approximately 20 cm proximal to the lateral femoral epicondyle. It was then slid distally until the short head of the biceps femoris appeared as a narrow, elongated structure. The probe was further moved distally, where the muscle assumed a more quadrilateral configuration, allowing differentiation from the long head of the biceps femoris (Figure 1b). The needle insertion point was selected just distal to the attachment of the adductor magnus to the linea aspera, approximately 8-10 cm proximal to the tip of the lateral femoral epicondyle along the lateral supracondylar line of the femur. Using an in-plane lateral-to-medial approach, the needle was advanced to the interface between the femur and the BiFeS muscle. A total of 20 mL of 0.25% bupivacaine was injected. Correct needle placement was confirmed by observing the linear spread of the local anaesthetic along the femoral surface and the elevation of the muscle (Figure 1c).

One hour after the block, repeat dynamometry showed minimal change in strength (plantar flexion: 12.8 kgf; dorsiflexion: 9.3 kgf). Spinal anaesthesia was then administered in the sitting position using 2.5 mL of 0.5% hyperbaric bupivacaine without intrathecal opioids.

Postoperative multimodal analgesia consisted of paracetamol (1 g three times daily) and dexketoprofen (50 mg twice daily), with oral oxycodone (5 mg) reserved for numerical rating scale pain score ≥4. Resting pain scores at 2, 4, 6, 8, 12, and 24 hours postoperatively were 1, 2, 2, 2, 4, and 4, respectively. No opioids were required during the first 8 hours, and total oxycodone consumption over 24 hours was 15 mg. The modified Bromage score was 4 at 5 hours postoperatively, and the patient was mobilised at 8 hours postoperatively.

In this single case, we observed a reduction in posterolateral knee pain, preservation of quadriceps and peroneal motor function, and early mobilisation. These preliminary findings suggest that the combined ACB and BiFeS approach may be feasible and function-preserving when performed in the supine position; however, further systematic investigation is required before drawing conclusions regarding reproducibility, comparative effectiveness, or routine clinical applicability.

Overall, developments in knee analgesia increasingly reflect a shift toward selective, anatomy-guided, motor-sparing strategies. Within this evolving landscape, particularly in the context of multimodal peripheral block combinations, the BiFeS block represents a potentially useful addition to address the persistent posterolateral analgesic gap. Its integration with established anterior approaches, such as the ACB, may offer a rational pathway for exploration in future clinical studies.

Footnotes

Declaration of Interests: The authors declare no conflicts of interest.

Funding: The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

1. Güler G, Atıcı Ş, Kurt E, Karaca S, Yılmazlar A. Current approaches in hip and knee arthroplasty anaesthesia. *Turk J Anaesthesiol Reanim.* 2015;43(3):188-195. [CrossRef]
2. White L, Kerr M, Thang C, Pawa A. Motor-sparing regional anaesthesia for total knee arthroplasty: a narrative and systematic literature review. *Br J Anaesth.* 2025;134(2):510-522. [CrossRef]
3. Tran J, Peng PWH, Gofeld M, Chan V, Agur AMR. Anatomical study of the innervation of posterior knee joint capsule: implication for image-guided intervention. *Reg Anesth Pain Med.* 2019;44(2):234-238. [CrossRef]
4. Kilicaslan A, Tulgar S, Ahiskalioglu A, et al. Ultrasound-guided biceps femoris short head block: a novel regional anesthesia technique for the posterolateral knee. *Pain Med.* 2025;26(11):726-732. [CrossRef]
5. Sarikaya Ozel E, Taflan MG. Ultrasound-guided biceps femoris short head block for posterolateral knee analgesia after total knee arthroplasty: a case report. *A A Pract.* 2025;19(9):e02060. [CrossRef]

Letter to the Editor

DOI: 10.4274/TJAR.2026.262383
Turk J Anaesthesiol Reanim 2026;54(2):146-147

Turkish Journal of Anaesthesiology & Reanimation

Reflection on the Integration of Artificial Intelligence in Anaesthesiology: Beyond Algorithmic Performance

Hamza Najout, Mustapha Bensghir

Mohammed V University, Mohammed V Military Teaching Hospital, Faculty of Medicine and Pharmacy, Department of Anaesthesiology and Intensive Care, Rabat, Morocco

Keywords

Airway management, intensive care, perioperative care, pharmacology, regional anaesthesia

Dear Editor,

We read with great interest the review by Dost et al.[1], "Artificial Intelligence in Anaesthesiology: Current Applications, Challenges, and Future Directions." The authors provide a comprehensive and forward-looking synthesis of how artificial intelligence is reshaping the perioperative continuum, from preoperative assessment to intensive care, education, and research. In particular, their discussion of decision-support systems and predictive analytics raises important questions about how algorithmic outputs should be interpreted and integrated into routine anaesthetic care. Their conclusions are consistent with recent literature describing the rapid expansion of data-driven technologies in modern anaesthetic practice.[2]

While the technical progress described is impressive, several unresolved issues warrant closer attention if innovation is to genuinely improve patient safety. A central concern remains the gap between algorithmic performance and true bedside utility. Many tools achieve excellent technical metrics under controlled conditions, yet their translation into meaningful patient-centred outcomes is far less certain, as highlighted by recent methodological evaluations.[3] This distinction, clearly acknowledged by Dost et al.[1], formed the primary motivation for our correspondence.

This tension is particularly evident in the discussion of the hypotension prediction index, which Dost et al.[1] cite as a prominent example of predictive analytics in perioperative medicine. Although this technology demonstrates strong discriminative ability, its real-world clinical interpretation remains complex. The validation study by Davies et al.[3] illustrates important methodological considerations in assessing such tools but does not report a definitive positive predictive value in the main text, nor does it demonstrate that false alerts resulted in clinically inappropriate fluid or vasopressor administration. Nonetheless, in theory, frequent alerts with limited immediate clinical relevance may contribute to alarm fatigue or increased cognitive load, a phenomenon well described in the broader literature on physiologic monitoring and patient safety,[4] underscoring the need for cautious, context-aware integration rather than automated action based solely on algorithmic signals. These considerations should therefore be interpreted as hypothesis-generating rather than as evidence of demonstrated clinical harm or inappropriate intervention.

Equally important are the educational and professional implications of this technological transition. If automated systems routinely identify sonoanatomical structures in regional anaesthesia or anticipate haemodynamic events, there is a legitimate concern that over-reliance could erode independent clinical reasoning. In the absence of robust outcome focused data, these considerations remain perspective-based reflections; however, they are consistent with the well-described concept of automation bias, whereby users may defer excessively to automated recommendations at the expense of independent judgement.[5,6]

Corresponding author: Hamza Najout Phd, MD **E-mail:** hamza.najout@gmail.com
Received: January 02, 2026 **Accepted:** February 18, 2026 **Epub:** 10, March 2026 **Published date:** April 15, 2026
Cite this article as: Najout H, Bensghir M. Reflection on the integration of artificial intelligence in anaesthesiology: beyond algorithmic performance. *Turk J Anaesthesiol Reanim*. 2026;54(2):146-147

To mitigate this risk, artificial intelligence systems should be deliberately positioned as adjunctive tools that support supervised learning, promote reflective decision-making, and preserve the acquisition of foundational skills, rather than replacing core clinical judgement.[2]

Beyond individual tools, Dost et al.[1] appropriately highlight broader challenges related to governance and responsibility. Medico-legal accountability remains insufficiently defined when clinical decisions are influenced by algorithmic recommendations. Clear attribution of responsibility among clinicians, institutions, and technology providers is essential to ensure that patient safety and professional liability are not diluted as decision-support systems become more prevalent.

To move beyond descriptive concerns and facilitate safe clinical adoption, we propose a pragmatic, stepwise framework for integrating predictive and assistive algorithms into anaesthetic practice: contextual validation, ensuring local performance assessment in the target patient population; human-in-the-loop decision-making, whereby algorithmic outputs inform but do not dictate clinical actions; educational integration, using these tools explicitly as teaching aids within structured supervision; and shared accountability structures, clarifying medico-legal responsibility and documentation when algorithmic advice contributes to clinical decisions. Such an approach may help bridge the gap between technical capability and meaningful clinical benefit.

Concerns regarding equity and generalisability further complicate adoption. Most current models are trained on datasets derived predominantly from high-income settings. When applied to patients with distinct physiological profiles or in resource-limited systems, performance may degrade, risking the emergence of a two-tier standard of care. Recent reviews emphasise that such imbalance may limit the universal value of these technologies unless broader and more diverse validation strategies are adopted.[7] Importantly, these limitations should not be extrapolated indiscriminately to all forms of artificial intelligence in anaesthesiology; rather, the hypotension prediction index serves as an illustrative, context-specific example within a wider, heterogeneous field. Accordingly, the concerns discussed here should not be extrapolated to artificial intelligence in anaesthesiology as a whole, but rather be understood within the specific context of predictive decision-support tools.

The intent of this correspondence is not to challenge the conclusions of Dost et al.[1], but to complement their review by proposing a practical framework to support the safe, educational, and accountable clinical integration of such technologies. The next phase of research should prioritise clinical trials focused on patient-centred outcomes rather than surrogate technical metrics, alongside robust external validation, educational safeguards, and clearly defined accountability pathways. Only through such balanced and critically informed integration can technological innovation fulfil its promise as a genuine partner in safe, equitable anaesthetic care.

Footnotes

Authorship Contributions

Concept - H.N., M.P.; Design - H.N., M.P.; Data Collection and/or Processing - H.N., M.P.; Analysis or Interpretation: H.N., M.P.; Literature Search - H.N., M.P.; Writing - H.N., M.P.

Declaration of Interests: The author(s) declare no conflicts of interest.

Funding: The author(s) received no financial support for the research, authorship, and/or publication of this article.

Declaration Regarding the Use of AI and AI-Assisted Technologies: During the preparation of this manuscript, the authors used OpenAI's ChatGPT for language refinement and structural editing. All content was reviewed, verified, and approved by the authors, who take full responsibility for the integrity and accuracy of the final manuscript.

References

1. Dost B, Turan EI, Aydın ME, et al. Artificial intelligence in anaesthesiology: current applications, challenges, and future directions. *Turk J Anaesthesiol Reanim.* 2025;53(6):282-292. [CrossRef]
2. Schroeder KM, Nanda M, Mariano ER, Gupta RK, Maniker RB, Elkassabany NM. Artificial intelligence for regional anesthesiology and acute pain medicine in the 21st century. *Anesthesiol Clin.* 2025;43(4):831-842. [CrossRef]
3. Davies SJ, Sessler DI, Jian Z, et al. Comparison of differences in cohort (forward) and case-control (backward) methodologic approaches for validation of the hypotension prediction index. *Anesthesiology.* 2024;141(3):443-452. [CrossRef]
4. Drew BJ, Harris P, Zègre-Hemsey JK, et al. Insights into the problem of alarm fatigue with physiologic monitor devices: a comprehensive observational study of consecutive intensive care unit patients. *PLoS One.* 2014;9(10):e110274. [CrossRef]
5. Lyell D, Coiera E. Automation bias and health information systems: a systematic review. *J Am Med Inform Assoc.* 2017;24(2):e1-e10. [CrossRef]
6. Bainbridge L. Ironies of automation. *Automatica.* 1983;19(6):775-779. [CrossRef]
7. Lopes S, Rocha G, Guimarães-Pereira L. Artificial intelligence and its clinical application in anesthesiology: a systematic review. *J Clin Monit Comput.* 2024;38(2):247-259. [CrossRef]

Letter to the Editor

DOI: 10.4274/TJAR.2026.262502
Turk J Anaesthesiol Reanim 2026;54(2):148-149

Turkish Journal of Anaesthesiology & Reanimation

Response to "Reflection on the Integration of Artificial Intelligence in Anaesthesiology: Beyond Algorithmic Performance"

Burhan Dost[1], Engin İhsan Turan[2], Muhammed Enes Aydın[3], Ali Ahıskalıoğlu[3], Madan Narayanan[4], Resul Yılmaz[5], Alessandro De Cassai[6,7]

[1]Ondokuz Mayıs University Faculty of Medicine, Department of Anaesthesiology and Reanimation, Samsun, Türkiye
[2]University of Health Sciences Türkiye, İstanbul Kanuni Sultan Süleyman Training and Education Hospital, Clinic of Anaesthesiology and Reanimation, İstanbul, Türkiye
[3]Atatürk University Faculty of Medicine, Department of Anaesthesiology and Reanimation, Erzurum, Türkiye
[4]Frimley Park Hospital, NHS Frimley Health Foundation Trust, Camberley, UK
[5]Necmettin Erbakan University Faculty of Medicine Hospital, Department of Anaesthesiology and Reanimation, Konya, Türkiye
[6]University of Padua (DIMED), Department of Medicine, Padua, Italy
[7]University Hospital of Padua, Institute of Anaesthesia and Intensive Care Unit, Padua, Italy

Keywords

Artificial intelligence, hypotension prediction index, perioperative care

Dear Editor,

We sincerely thank the authors for their thoughtful and insightful letter[1] regarding our review.[2] We appreciate their careful reading of our work and constructive reflections on the evolving role of artificial intelligence (AI) in anaesthesiology.

We fully agree that a critical challenge lies in bridging the gap between the algorithmic performance and real-world clinical benefits. As highlighted in both our review and the authors' letter, high discriminative accuracy does not necessarily translate to improved patient-centred outcomes. The example of the hypotension prediction index (HPI) is particularly illustrative: despite promising predictive metrics, the relatively low positive predictive value in clinical settings raises valid concerns regarding alarm fatigue, cognitive overload, and the potential for inappropriate therapeutic interventions.[3] We concur that future investigations must increasingly prioritise outcome-driven, pragmatic clinical trials rather than surrogate technical endpoints alone. Despite these concerns, the evidentiary landscape surrounding HPI continues to evolve and extend beyond early validation cohorts. The recently published randomised controlled trial protocol by Mulder et al.[4], which compared a conventional mean arterial pressure alarm strategy with HPI-guided management in moderate- to high-risk non-cardiac surgical patients within a non-inferiority framework, directly examined whether predictive waveform analytics provide incremental clinical value beyond traditional threshold-based monitoring. In parallel, emerging data from critically ill populations, such as the prospective study by Khwannimit et al.[5] evaluating HPI performance in patients with septic shock in the intensive care unit, demonstrate both the potential and present limitations of the algorithm in high-risk settings. Taken together, these investigations highlight a broader physiological reality: haemodynamic instability is complex and dynamic and is shaped by multiple interacting variables. No single measurement can fully represent this complexity of the disease. Therefore, HPI should not be interpreted as a replacement for conventional monitoring but rather as a contributory element within an evolving multimodal decision-support framework that integrates pressure trends, waveform characteristics, clinical context, and physician judgment.

We also strongly support the authors' emphasis on the educational implications of their findings. The integration of AI into regional anaesthesia, airway management, and haemodynamic monitoring should not replace fundamental clinical reasoning

Corresponding author: Burhan Dost MD **E-mail:** burhandost@hotmail.com
Received: February 27, 2026 **Accepted:** March 07, 2026 **Epub:** 10.03.2026 **Published date:** April 15, 2026
Cite this article as: Dost B, Turan Eİ, Aydın ME, et al. Response to "reflection on the integration of artificial intelligence in anaesthesiology: beyond algorithmic performance". *Turk J Anaesthesiol Reanim*. 2026;54(2):148-149

or anatomical expertise. In contrast, we believe that these systems should be designed to function as supervised educational tools that reinforce decision-making, pattern recognition, and situational awareness. Safeguarding against clinical deskilling must remain a core objective as AI becomes increasingly embedded in anaesthesia training programs.

Furthermore, we appreciate the important points raised regarding equity, generalisability, and dataset bias. The predominance of training data from high-income healthcare systems may limit the external validity of many AI models. Broader, multicentre, and internationally diverse validation studies are essential to prevent the emergence of unequal standards of care and ensure that AI-based tools remain reliable across heterogeneous patient populations and clinical environments.

In addition, the integration of large language models into clinical practice requires evaluation beyond technical performance, incorporating considerations of safety, clinical relevance, and responsible implementation.[6] The authors highlight that high accuracy alone does not guarantee clinical benefit and that AI-generated outputs must be interpreted within the clinical context, under human supervision, and through structured evaluation processes. They further stressed that these systems may play an important role as supportive tools in medical education but should not replace fundamental clinical reasoning or expertise. This perspective closely aligns with the principles highlighted in our review, namely that AI in anaesthesiology should be positioned as an adjunct that strengthens patient safety, educational quality, and clinical decision-making, rather than as a substitute for clinical judgment.

In conclusion, we are grateful to the authors for expanding the discussion beyond technical capability to clinical responsibility. We fully agree that the next phase of AI research in anaesthesiology must focus on patient-centred outcomes, external validation, educational safeguards, and transparent accountability frameworks.

Footnotes

Author Contributions: Concept - B.D., E.İ.T., M.E.A., A.A., M.N., R.Y., A.D.C.; Design - B.D., E.İ.T., M.E.A., A.A., M.N., R.Y., A.D.C.; Literature Review - B.D., E.İ.T., M.E.A., A.A., M.N., R.Y., A.D.C.; Writing - B.D., E.İ.T., M.E.A., A.A., M.N., R.Y., A.D.C.

Declaration of Interests: One authors of this article, Burhan Dost, are a members of the Editorial Board of the Turkish Journal of Anaesthesiology and Reanimation. However, they did not involved in any stage of the editorial decision of the manuscript. The other authors declared no conflict of interest.

Funding: The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

1. Najout H, Bensghir M. Reflection on the integration of artificial intelligence in anaesthesiology: beyond algorithmic performance. *Turk J Anaesthesiol Reanim.* 2026;54(2):146-147. [CrossRef]
2. Dost B, Turan Eİ, Aydın ME, et al. Artificial intelligence in anaesthesiology: current applications, challenges, and future directions. *Turk J Anaesthesiol Reanim.* 2025;53(6):282-292. [CrossRef]
3. Davies SJ, Vistisen ST, Jian Z, Hatib F, Scheeren TWL. Ability of an arterial waveform analysis-derived hypotension prediction index to predict future hypotensive events in surgical patients. *Anesth Analg* 2020;130(2):352-359. Erratum in: *Anesth Analg* 2023;137(3):e33. [CrossRef]
4. Mulder MP, Florax AA, Harmannij-Markusse M, Fresiello L, Donker DW, Potters JW. Comparison of a mean arterial pressure alarm to the hypotension prediction index in preventing intraoperative hypotension in elective moderate- to high-risk non-cardiac surgical patients: a study protocol for a blinded, parallel, randomized controlled trial with a non-inferiority framework. *Trials.* 2026;27(1):104. [CrossRef]
5. Khwannimit B, Sathaporn N, Vattanavanit V. Ability of the hypotension prediction index to predict hypotension in patients with septic shock in the intensive care unit. *Sci Rep.* 2025;15(1):40478. [CrossRef]
6. De Cassai A, Dost B, Augoustides J, et al. Responsible use of large language models in manuscript authorship, peer review and editorial processes: a delphi consensus among editors-in-chief of Anesthesia and Pain Medicine journals (RULE-AP). *Br J Anaesth.* 2026. [CrossRef]