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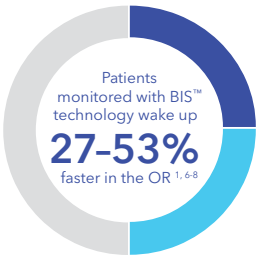

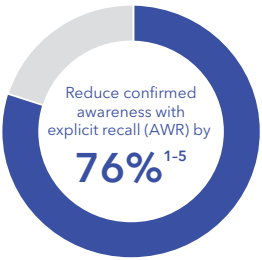

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MyJA aims to provide a platform for anaesthesiologists, clinicians, researchers, and trainees in Malaysia to publish high-quality clinical and scientific materials on all aspects of anaesthesiology, critical care, and pain medicine. It also welcomes submissions from researchers all over the world. In addition to publishing original articles (clinical trials, experimental research, meta-analysis, and systematic reviews), MyJA also features reviews, case reports and case series, and letters to the editor. The primary considerations for publication are clarity, uniqueness, scientific rigor, and advancement in design, performance, and knowledge.

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Navigating complexity: future-proofing anaesthesia for patient safety

Ina Ismiarti **Shariffuddin**

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Medical error is a well-recognised contributor to patient harm worldwide and is increasingly acknowledged as a major cause of preventable morbidity and mortality. In the United States, it is estimated to be among the leading causes of death.[1] Hogan *et al.* reported that 3.6% of in-hospital deaths were avoidable and attributed to medical error.[2] Defined as "the failure of a planned action to be completed as intended or the use of a wrong plan to achieve an aim",[3] medical error can result in a spectrum of outcomes, ranging from near misses to patient injury or death.

Anaesthesiologists practise in highly complex, time-critical environments where rapid and high-stakes decisions are frequently required. We care for patients across the entire lifespan, from neonates to the elderly, and in diverse clinical settings, including the operating theatre, labour ward, emergency department, and intensive care unit. Each anaesthetic encounter is unique, even for the same surgical procedure, because of variations in patient characteristics, comorbidities, and surgical context. For this reason, comparing the practice of anaesthesia to aviation is misleading. The unpredictability and urgency of decision-making in anaesthesia extend well beyond the protocol-driven systems typical of aviation.

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Many medical errors do not arise from ignorance or negligence. Instead, they often are the results of human and system limitations. These include fatigue, cognitive overload, skill-based mistakes, and poorly designed workflows.[3] Human factors science plays a crucial role in addressing these challenges. The discipline of human factors focuses on designing systems and environments that "make it easier for clinicians to make the right decisions and more difficult for them to make the wrong ones".[4] It recognises that clinician performance is strongly affected by the broader systems in which clinicians operate.

Healthcare can be described as a complex adaptive system composed of interdependent components functioning at multiple levels. One useful framework for understanding these levels is to consider the "micro", "meso", and "macro" dimensions of care.[4] At the micro level, individual clinical tasks, such as endotracheal intubation will depend on the clinician's skills, physical and mental condition, cognitive state, and access to appropriate equipment. At the meso level, operating theatre staff must coordinate their efforts effectively by relying on shared communication, mutual support, and aligned mental models in order to achieve common goals. At the macro level, institutional policies, workforce arrangements, and national clinical guidelines influence how care is structured and provided. All these levels are interconnected, and weaknesses in any one layer can lead to negative consequences across the entire system. Therefore, embedding human factor principles at each of these levels is critical to improving safety and performance.

Improvement efforts in patient safety should extend beyond compliance with protocols. The efforts should ensure that planned care occurs reliably. In this issue, Iskandar *et al.* explore how the use of ultrasound in central neuraxial blockade can improve success rates. They note that several barriers hinder the adoption of this technology, including financial limitations and cultural resistance to change. Addressing these challenges is essential to delivering consistent, high-quality care to all patients.

This edition of MyJA features several case reports that further illustrate the complexity and high stakes of anaesthetic practice. Mohd Najid *et al.* describe the management of a breathless pregnant patient with non-Hodgkin lymphoma who presented with symptoms of an anterior mediastinal mass, Mohd Nor *et al.* report an unexpected case of suxamethonium apnoea in a previously healthy young parturient and Zainal Abidin *et al.* report a challenging tracheal tumour resection performed under cardiopulmonary bypass. These cases highlight the physiological and technical challenges of our work, and exemplify the value of teamwork, planning, and sound judgement in delivering good outcomes to our patients.

In their review for this issue, Palari *et al.* examine the growing influence of medicolegal concerns on anaesthesia practice in Malaysia. The rising incidence of litigation has contributed to a cultural shift away from learning and root cause analysis. Increasingly, the focus has moved towards assigning blame and issuing financial compensation. While it remains essential to protect patients from preventable harm, it is equally important to support the wellbeing and professional integrity of anaesthesiologists. Achieving this balance requires a collective effort at every level of the healthcare system.

In the Letter to the Editor, Tiong, an aspiring anaesthesiologist, offers a poignant reminder of the value of mindfulness in our clinical work. His reflection serves as a timely reminder for compassion and reflection. Professor Kevin Fong, a consultant anaesthesiologist and Professor of Innovation and Engagement in Medicine at University College London, echoed a similar sentiment in his plenary lecture titled *"Risky Business"* at the recent 2025 ANZCA Annual Scientific Meeting. He reminded the audience, that: "We should be kind to those in harm's way." As we strive to improve patient safety, we must not lose sight of what anaesthesiologists are already doing right. Each day, we navigate uncertainty and manage clinical risk with care and competence. More often than not, we accept a smaller risk to prevent a much greater one.

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Ultrasound-guided central neuraxial blocks: breaking barriers to greater adoption

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Abstract

Central neuraxial blocks (CNB) remain a cornerstone of modern anaesthesia, yet traditional landmark-based techniques carry inherent limitations in accuracy and safety. Ultrasound-guided CNB has emerged as a transformative technique, offering improved first-pass success, shorter procedure times, fewer needle passes, and decreased incidence of complications such as inadvertent dural puncture and paraesthesia. Despite compelling evidence supporting these advantages, global adoption of ultrasound-guided CNB remains limited. Surveys across North America, Europe, and Asia consistently reveal underutilisation, suggesting significant barriers to implementation. This editorial explores the multifactorial impediments to wider ultrasound-guided CNB adoption, including logistical issues such as cost and equipment access, workflow disruptions in high-volume settings, the complexity of spinal sonoanatomy, and a steep learning curve requiring structured training. Cultural resistance to change and inadequate institutional support further hinder progress. Drawing from change management models, we propose strategies to overcome individual and systemic inertia. The proliferation of portable ultrasound devices and training dissemination by younger, ultrasound-proficient practitioners are expected to drive change. Ultimately, formal certification pathways and sustained advocacy will be essential to achieving mainstream adoption of ultrasound-guided CNB.

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Keywords: central neuraxial block, epidural anaesthesia, spinal anaesthesia, ultrasound guidance

Introduction

Central neuraxial blocks (CNB), encompassing spinal and epidural anaesthesia and analgesia remain a fundamental component of modern anaesthetic practice. While traditional landmark-based approaches to CNB have enjoyed long-standing acceptance, the integration of ultrasound guidance (USG) to CNB represents a paradigm shift towards greater precision and safety.[1,2] USG CNB can be performed either as a preprocedural scan (often termed ultrasound-assisted CNB, UA CNB) to preview neuraxial anatomy and outline the optimal needle insertion site, depth, and trajectory, or as real-time USG during needle insertion.[1] The use of UA CNB has been shown in randomised trials and meta-analyses to increase first-attempt success rates, decrease procedure time, and reduce the number of needle passes when compared to landmark-based approaches.[3-6] The rate of spinal- and epidural-related complications, including inadvertent dural puncture, paraesthesia, and epidural hematoma, frequently associated with a greater number of needling attempts, may also be reduced with UA CNB, underscoring its potential to significantly enhance patient safety.[4,7,8] Additionally, 2 systematic reviews, performed in a general surgical and obstetric population, respectively, have demonstrated the advantage of UA CNB in increasing first-pass success rate when a difficult CNB was anticipated compared to a landmark technique.[9,10] The latter review also revealed that UA CNB decreased the incidence of a "bloody tap" as well as postpartum back pain and headache. Furthermore, patients report greater satisfaction with UA CNB, which is expected when neuraxial procedures are completed more quickly and successfully, avoiding the need for repeated needle punctures, and ultimately leading to timely pain relief or effective anaesthesia.[5]

Real-time USG has also been shown to be a feasible approach to CNB, with some evidence indicating improved first-pass success rate compared to the landmark technique.[5,11,12] Conversely, there are also data demonstrating that real-time USG when compared to UA CNB results in a lower rate of first-attempt or first-pass success during spinal injections in the elderly.[13] The number of needle passes required is also greater, procedure time is longer, and patients report poorer satisfaction with real-time USG. Furthermore, operators rate the real-time USG CNB to be technically more difficult than the standard landmark-based approach. These findings should be interpreted with caution, since no well-defined learning curve for real-time USG CNB has been established, and the success of this advanced technique likely depends heavily on the operator's experience and training.

Nevertheless, despite the growing body of evidence supporting its clinical advantages, adoption of USG CNB has been lukewarm at best. A 2022 survey of anaesthetists on the use of ultrasound for CNB on parturients found that only 9.8% of respondents were confident in their ability to perform USG despite 93.0% acknowledging that ultrasound decreases number of attempts and improves identification of the vertebral level.[14] Moreover, surveys from various countries have consistently shown that ultrasound has not yet become routine, nor commonplace, for performance of CNB. Despite a 2008 National Institute for Health and Care Excellence (NICE) guidance supporting the role of ultrasound in epidural space catheterization, a survey performed in the same year found more than 90% of United Kingdom (UK) anaesthesiologists had never used USG CNB, while another UK survey in 2015 revealed that only 1 in 5 obstetric anaesthesia units utilized USG CNB for labour pain or caesarean sections.[15,16] In North America, findings from surveys mirror the low utilisation of USG CNB observed in Europe. A 2019 survey of anaesthesiologists in Ontario, Canada, found that although 68% used ultrasound on a "regular" basis in their general practice and 89% used ultrasound "always" or "frequently" for central venous catheterization (CVC), 85% "seldom or never" used USG CNB, and 0% reported using USG CNB on a routine basis.[17] This was despite the majority of respondents having access to ultrasound machines and being aware of its benefits in CNB. USG CNB has also seen slow, incremental uptake in Asia. Although Malaysian data remains elusive, a recent survey of anaesthesiology residents in India showed that the vast majority had yet to embrace USG CNB; when faced with a difficult spinal or epidural, 85% of respondents said they would rather proceed with general anaesthesia than re-attempt the CNB under USG.[18] This survey reveals that even among a newer generation of practitioners, reliance on landmark-based CNB remains the norm and USG is often seen as a last resort. In short, current evidence suggests that a significant proportion of anaesthesia providers worldwide appear to rarely use USG CNB or have never used it at all. This stands in stark contrast to the near-universal adoption of ultrasound for other procedures such as CVC insertion and peripheral nerve blocks (PNB).

Barriers to adoption of USG CNB

The benefits of USG CNB are clear, yet several barriers have emerged to slow its widespread adoption. Cost and resource limitations are often cited as the initial hurdle in many healthcare settings. At the very least, provision of USG CNB requires an ultrasound machine with a low-frequency curvilinear probe suitable for spinal imaging.[19] Additionally, though minor in comparison to the capital investment, there are running costs of device maintenance, ultrasound gel replenishment, and sterile ultrasound-probe covers to be factored in. Nevertheless, anaesthesiology provider access to ultrasound machines have increased significantly over the past decade, in concert with increased portability and affordability of these machines and a greater awareness on their importance among stakeholders.[20] While an ultrasound

machine dedicated for CNB alone may not seem a sound investment, the skyrocketing utility of ultrasound for other purposes related to anaesthesia and critical care, *i.e.*, PNB, vascular access, and point-of-care ultrasonography implies that a single platform suited to perform these various tasks will likely offer an expedited return of investment.[21]

An often-cited barrier to routine or greater use of USG CNB when a difficult spinal or epidural is not expected are concerns about time and workflow pressures, *i.e.*, the increased time required to perform the neuraxial procedure, especially in high-volume settings.[22] Proponents to this viewpoint argue that in a busy operating theatre environment, routine addition of USG will lead to an "unnecessary" use of precious time for extra setup and scanning. However, systematic reviews and meta-analyses comparing conventional landmark palpation and UA have found no difference in total time taken to perform the CNB.[9,10] As the individual practitioner's proficiency improves and the team gains familiarity with the technique, USG may potentially lead to a decrease in time taken to perform the block. In the interim, fears regarding a potential increase in operating room time with wider application of USG CNB can be resolved by introduction of a parallel processing "block room" model, which has been shown in a systematic review to decrease anaesthesia-controlled time, turnover time, and post-anaesthesia care unit length of stay, in addition to potentially increasing daily operating room throughput by 1.7 cases per day.[23] Performance of USG regional anaesthesia in a dedicated block room also facilitates and concentrates training opportunities in a more conducive environment without the pressures of the main operating room.[24] Cultural resistance, *i.e.*, the need to convince all stakeholders (namely surgeons, support staff, and administrators) of the benefits of adopting USG CNB represents a more intangible challenge. Nevertheless, similar obstacles were encountered and overcome with greater application of USG PNB.[25] Value-based healthcare, defined as "the equitable, sustainable and transparent use of the available resources to achieve better outcomes and experiences for every person", has become an increasingly popular subject and metric.[26] Over time, the demonstrable clinical and institutional benefits of USG PNB, such as improved pain outcomes, fewer complications, and enhanced recovery, have largely won over sceptics. With sustained advocacy, it will be a question of "when" rather than "if" a similar perception towards USG CNB develops in the future.

Another significant barrier is the steep learning curve associated with mastering spinal sonoanatomy. Due to the spine's bony structures, sonographic visualisation is more complex compared to PNB, necessitating specialised training and experience in recognising subtle anatomical details.[27] Structured educational programs have emerged as essential for overcoming these barriers. The American Society of Regional Anesthesia and Pain Medicine (ASRA) and the European Society of Regional Anaesthesia and Pain Therapy recommend standardised training curricula that integrate simulation-based training, supervised clinical practice, and competency

assessments.[26,28] Studies employing cumulative sum analyses indicate significant variability among trainees in achieving proficiency in USG CNB, underscoring the individualised nature of learning this technique and highlighting the need for tailored, comprehensive training programs with expert mentorship, simulation exercises, and repeated hands-on experience.[26] Simulation-based training has emerged as an essential component of competency-based education, mainly due to high complication rates, an increasingly litigious society, and suboptimal traditional training methods.[29] Use of a virtual spine model in teaching neuraxial anatomy and sonoanatomy has been shown to improve anaesthesia trainee test scores after just 1 hour of self-study with the model.[30]

A commonly overlooked, yet important barrier to greater adoption of USG CNB is simply individual resistance to change in practice, even in the face of compelling evidence. Introduction of change requires an understanding of how the process of change occurs, which is well-described from an organisational viewpoint by Kurt Lewin's "Change Management Model".[31] This 3-stage model, which uses a block of ice as an analogy, begins with the process of "Unfreezing", which involves challenging the status quo and preparing stakeholders to accept that a change is necessary. The next step, "Change", marks the implementation of new processes, whilst understanding that adaptation occurs at a varying pace and with different consequences across individuals. "Refreeze", the final phase of the model, describes how the change in behaviour or practice is solidified and accepted as the new norm. Rampersad *et al.* described 3 ways in which those affected by a potential major change may respond; "early adopters", who do not require much convincing and can play an important role in a team promoting the change; "safe followers", who will be initially hesitant towards change until they are certain that it is a safe thing to do; and "outliers", who either tend to resist the proposed change, remain sceptical, or are well entrenched in their old pattern of practice or behaviour.[32] Strategies to overcome resistance and outliers include gradual implementation of the change one step at a time, involvement of those affected in development and feedback, emphasising the ease and benefit of the new processes, as well as use of coaching instead of punishment as a motivational tool. Effective change management is a crucial step towards increased acceptance of USG CNB, and success hinges on leadership, inclusive team strategies, and addressing human behaviours empathetically.

The Malaysian perspective and future directions

Despite these challenges, the prospect of greater adoption of USG CNB in Malaysia appears positive. Guidelines and protocols have already been developed by the Malaysian anaesthesia community to promote and ensure the safe and effective use of ultrasound. Notably, the Malaysian Society of Anaesthesiologists (MSA) and College of Anaesthesiologists (COA) have published key documents, including the Recommendations for Peripheral Nerve Blocks (2019) and Recommendations for

Ultrasound-Guided Vascular Access (2022), which aim to guide and standardise practice in these domains.[33,34] A nationally-endorsed guideline on USG CNB will serve a similar purpose to promote the acceptance and utilisation of neuraxial ultrasound among the anaesthesia fraternity as well as the healthcare system as a whole. The importance of such a guideline cannot be understated, as full integration of ultrasonography into anaesthesia training and practice appears to be the likely trajectory when looking ahead.[35] Ultrasound has been increasingly incorporated into our anaesthesia curriculum, with many recent graduates already proficient in its use; thus, the critical mass needed for widespread adoption of USG CNB could already be present. Seeing that these younger anaesthesiologists will disseminate among the district and secondary hospitals throughout Malaysia, we can expect increased adoption of USG techniques as teaching and training diffuses, and portable ultrasound machines become more affordable and accessible. To formally recognise competency, increased access to certification in ultrasound techniques (including USG CNB) by national specialist training bodies will represent the next natural and necessary step towards greater adoption.

Conclusion

In conclusion, the use of ultrasound by anaesthesiologists has evolved remarkably over recent years: from early adoption among a small group of enthusiasts and in a handful of centres to broad utilisation of USG in PNB, vascular access, and other novel applications across public and private hospitals at present. USG CNB represents the next leap forward in terms of improved procedural success, superior analgesia, and enhanced patient safety. Barriers to greater adoption and challenges such as resource limitations, training gaps as well as individual and institutional resistance to change need to be actively addressed, which will result in steady increase in proficiency and application among practitioners as well as demand among patients and healthcare systems. As technology and training continue to advance, anaesthesiologists are well-positioned to fully harness the power of ultrasound in their practice, ultimately leading to better outcomes and experiences for the patients under their care.

Declarations

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Not required as this is an editorial.

Competing interests
Dr. Shahridan Mohd Fathil serves as Deputy Chief Editor of Malaysian Journal of Anaesthesiology. He has not been involved in any part of the publication process prior to manuscript acceptance; peer review for this journal is double blind. The remaining authors have no competing interests to declare.

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Beyond the operating theatre: mindfulness and self-care as antidotes to burnout in anaesthesiology

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A call to action: mitigating burnout and enhancing well-being in anaesthesiology

Anaesthesiology is one of the most demanding and high-stress medical specialties. Anaesthesiologists operate in a fast-paced, high-pressure environment, often working long hours for both elective and emergency procedures. The intense workload and extended shifts can contribute to excessive stress, ultimately reducing job satisfaction and negatively impacting physical and mental well-being. This persistent stress may lead to fatigue and burnout.[1] In addition to heavy workloads, other contributing factors to burnout include early-career stress, inexperience, and personal responsibilities such as having children, particularly among younger and less experienced physicians.[2] Burnout manifests as emotional exhaustion, depersonalisation, and a diminished sense of personal achievement stemming from prolonged interpersonal stressors that can compromise both patient care and physician professionalism.[3] Therefore, it is essential to find a balance to alleviate burnout and manage workload stress effectively. Maintaining work quality and professionalism without compromising patient care can be achieved through consistent mindfulness practice and self-reflection. As an undergraduate medical student aspiring to specialise in anaesthesiology, I recognise the potential of incorporating mindfulness into everyday practice beyond the operating theatre to foster well-being and combat burnout.

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Mindfulness-based stress reduction (MBSR) techniques, such as guided meditation and deep breathing exercises, can significantly help anaesthesiologists manage stress and enhance emotional resilience, even in high-pressure environments. However, implementing MBSR in an acute care setting presents challenges. Given the high-stakes and time-sensitive nature of anaesthesiology, finding even a few minutes for stress-relieving practices can be difficult. To address these barriers, institutional policies and guidelines can be revised to incorporate designated time for MBSR. If manpower allows, anaesthesiologists can take turns practicing mindfulness exercises, ensuring that patient care remains uninterrupted, and fostering a culture of well-being. Brief mindfulness sessions integrated into daily routines, such as deep breathing between procedures or reflective pauses before critical tasks, can help improve focus and reduce emotional exhaustion. A structured approach could involve allocating at least 10 minutes for mindfulness practice before each grand ward round in the intensive care unit or elective surgery. Organisations can also support MBSR implementation by incorporating mindfulness training into professional development programmes and encouraging a culture that prioritises physician well-being. While emergency procedures must remain the priority, allowing anaesthesiologists to engage in brief mindfulness exercises before non-urgent cases can help cultivate long-term stress management habits without compromising patient care. By integrating MBSR into daily practice through policy support, anaesthesiologists can experience greater well-being while maintaining efficiency and professionalism in their demanding roles.

It is equally important to address other stressors that contribute to burnout. Younger anaesthesiologists often face additional pressures from research, teaching, and clinical duties, while residency training can limit career control and create uncertainty regarding job expectations. These challenges can be mitigated through structured mentor-mentee programs and career talks that provide clarity on job expectations and subspecialisation pathways after graduation as a clinical anaesthesiologist. A systematic approach, such as assigning a senior trainee to mentor 2 to 3 junior trainees, can foster guidance and support in navigating career progression. Additionally, career talks conducted by experienced anaesthesiologists can offer valuable insights into various career pathways, helping trainees make informed decisions and manage professional expectations more effectively. Furthermore, interactive sessions or team-building activities focusing on wellness and relaxation techniques involving anaesthesiologists from different hospitals or institutions can serve as valuable platforms for stress relief, professional networking, and knowledge exchange. These sessions encourage participants to cultivate mindfulness by being fully present in the moment and acknowledging their thoughts, emotions, and physical well-being. Engaging in group discussions allows trainees and practicing anaesthesiologists to share experiences, gain diverse perspectives, and address common challenges in a supportive environment. Activities

such as yoga, meditation, and outdoor retreats such as mountain trips can further promote relaxation and mental clarity. For younger physicians, particularly women and those with children, the challenge of balancing work and family life can be mitigated through flexible work shifts. Allocating at least 1 designated day for family time can enhance overall well-being and mindfulness. Additionally, establishing peer support groups focused on family and gender-related issues can create a safe space for open discussions, allowing physicians to share strategies and experiences in managing both professional and personal responsibilities.

As a medical student, stress is inevitable, especially when balancing clinical duties, studies, and personal interests. One of the most effective approaches I have adopted for managing burnout is structured task organisation. I begin by listing all my tasks, prioritising them based on urgency and importance, and systematically addressing them. Procrastination often leads to a buildup of last-minute work, increasing stress and anxiety. To prevent this, I break tasks into smaller, manageable steps, set achievable deadlines, minimise distractions, and reward myself for progress. Additionally, I find relief in sharing my thoughts with family and close friends, as expressing my feelings helps alleviate stress. Practicing self-affirmation and recognising even minor accomplishments have kept me motivated. Like many others, I have struggled with imposter syndrome, often feeling inadequate compared to my peers. However, I have realised that constant comparison is unproductive. Instead, I focus on self-improvement by incorporating daily mindfulness and wellness practices. Every day, I write in a journal and reflect on my progress, noting at least 5 things I am grateful for, no matter how small, such as getting sufficient rest. This habit has significantly reduced my imposter syndrome, shifting my mindset from self-doubt to personal growth. By implementing these strategies, I have achieved a better balance between academics, clinical duties, and personal well-being while maintaining a healthier and more focused outlook.

Regardless of the form of mindfulness practice or reflection, what truly matters is finding a method that effectively alleviates stress and enhances well-being. As much as career progression and clinical duties are essential for a practicing physician, maintaining both mental and physical health is equally important. A healthy physician is better equipped to provide high-quality, professional care to patients. Prioritising self-care is not a sign of weakness but a necessity to sustain long-term success and fulfilment in the medical profession.

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Development and validation of creatinine-based estimates of the glomerular filtration rate equation from chromium EDTA imaging in the multiracial Malaysian population

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Abstract

Introduction: The glomerular filtration rate (GFR) is a reliable parameter for assessing kidney function. It is estimated from equations such as Cockcroft–Gault (CG), Modification of Diet in Renal Disease (MDRD), and Chronic Kidney Disease- Epidemiology Collaboration (CKD-EPI). However, these equations were derived using Western population demographic data and had different performances when applied to other ethnicities and populations.
Objective: We developed a new equation (NE) based on the ^{51}Cr-EDTA-measured GFR, that can be used explicitly in the Malaysian multiracial population.
Methods: A cross-sectional study was conducted using electronic medical records of patients who underwent 51Cr-EDTA imaging between 2013 and 2021. Ethical approval was obtained.

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Results: A total of 209 patients were recruited, of which 105 patients were randomised to the development cohort and 104 patients to the validation cohort. The NE was developed using the development cohort data, and its performance was subsequently tested in the validation cohort. The result showed that CKD-EPI had the highest precision and accuracy in estimating GFR. CG had the lowest bias, while the NE performed second best. CKD-EPI had the highest correlation to ^{51}Cr-EDTA imaging-measured GFR, followed by the NE.
Conclusion: CKD-EPI demonstrated the best performance among the estimated GFR equations. However, NE showed comparable performance, exhibiting low bias, high precision, and good accuracy.

Keywords: ^{51}Cr EDTA-measured glomerular filtration rate, glomerular filtration rate equations, Malaysia, multiracial population

Introduction

Chronic kidney disease (CKD) is a global health concern, causing significant socioeconomic and healthcare challenges. It is not only a progressive disease, but also a significant risk factor for coronary events and mortality. Fortunately, CKD is treatable and preventable. Early detection of kidney dysfunction and appropriate management can prevent deterioration of kidney function and thus reduce the risk of dialysis.[1] Serum creatinine is commonly used in clinical practice as a marker of kidney function. However, interpretation based on serum creatinine alone is not accurate, as its levels are influenced by factors such as muscle mass, age, and dietary lifestyle.[2]

A more reliable indicator of kidney function is the glomerular filtration rate (GFR). Accurate estimation of GFR is essential in daily clinical practices, where it affects drug dosing, nutrition in critically ill patients, fluid requirement, and staging of kidney disease.[1] GFR can be measured directly using inulin, ^{51}chromium ethylenediamine tetra-acetic acid (^{51}Cr-EDTA), technetium-99m diethylene-triaminepenta-acetic acid (99mTC-DTPA), and iohexol. However, these direct measurement methods are expensive, complex, time-consuming, and not widely available. Therefore, it is essential to have a reliable, convenient, and precise method to estimate GFR in the clinical setting.[3]

Several equations are used to estimate GFR, including Chronic Kidney Disease-Epidemiology Collaboration (CKD-EPI),[4] Modification of Diet in Renal Disease (MDRD),[5] and Cockcroft–Gault (CG).[6] However, these equations were derived using Western population demographic data and perform differently when applied to

other ethnicities and populations.[7-9] Countries such as China, Korea, Japan, and Thailand have recognised this issue, and have modified these equations by incorporating ethnic-specific coefficients to enhance accuracy for their populations.[10-13]

There have been a few studies conducted in Malaysia to evaluate the performance of existing estimating GFR equations in the Malaysian population by comparing the calculated GFR with the GFR value measured by ^{51}Cr-EDTA,[3,14.15] and the performance of the equations varied. The study conducted by Ralib *et al.* aimed to develop an estimated GFR (eGFR) equation that tailored to the Malaysian population. However, this study primarily examined patients from East Coast of Malaysia, who were predominantly of Malay ethnicity, thereby lacking representation from other major ethnic groups in Malaysia, such as the Chinese and Indian populations.[9] Therefore, the findings may not be fully generalisable to the broader Malaysian demographic.

Our study aimed to develop a new equation (NE) based on measured GFR obtained from ^{51}Cr-EDTA imaging that can be explicitly used in our population. All equations were evaluated in the validation cohort, comparing the bias, precision, and accuracy.

Methods and materials

This was a cross-sectional study conducted at the University Malaya Medical Centre (UMMC). Ethical approval was obtained from the Medical Research Ethics Committee, UMMC (MREC ID NO:2021105-10644). This study involved the electronic medical records (EMR) of patients who underwent 51Cr-EDTA imaging at the Nuclear Medicine Centre, UMMC. Patients aged 16-year-old and above who underwent ^{51}Cr-EDTA imaging at the Nuclear Medicine Centre, UMMC from the year 2013 to 2021 were included in this study. We excluded patients of races other than Malay, Chinese, and Indian, as well as inadequate or missing data in the EMR.

A name list of patients who underwent ^{51}Cr-EDTA imaging was obtained from the Department of Radiology, and the records of the patients were traced via the EMR. Demographic data and renal function of the patients were collected, including age, gender, height, weight, ethnicity, and urea and creatinine level. In patients with multiple measurements of scans, the latest ^{51}Cr-EDTA imaging result was taken. The renal function test had to be within 3 months from the date of ^{51}Cr-EDTA imaging.

Patients were randomised into a development and validation cohort using a random number generated in Microsoft Excel. The data were then analysed using SPSS 26 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were performed on

demographic data and clinical variables. Parametric data were presented as mean ± SD, whereas skewed data sets were shown in the median (interquartile range). Independent t-test was used to compare 2 parametric variables, and Mann-Whitney U test was used for non-parametric variables. Analysis of categorical variables was done using the Chi-square test. Linear regression was performed to evaluate the relationship between estimated and measured GFR. We considered statistical significance at $P < 0.05$.

A new eGFR equation (NE) was developed using a non-linear regression model and a generalised least squares algorithm in the development cohort. Internal validation was performed in the validation cohort by comparing accuracy, bias, precision, and Pearson correlation between all the formulas (NE, CG, MDRD, and CKR-EPI) and the measured GFR.

The accuracy of equations was denoted as the proportion of eGFR values that lay within 30% and 50% of measured GFR, mean absolute value (MAE), and root mean square error (RMSE) of difference between measured and estimated values. Bland-Altman plot was performed in the validation cohort to test the agreement between estimated and measured GFR by looking at mean bias and precision. Mean bias was defined as the average differences between measured GFR and estimated GFR in the dataset. Precision was defined by the standard deviation of the differences between estimated and measured GFR

Results

A total of 486 qualified patients were identified from the EMR. However, a total of 277 patients were excluded from this study; of these, 149 of them were less than 16 years old, 127 of the patient's data were missing, and 1 of the patients was a foreigner. Thus, a total of 209 patients were successfully recruited into the study (Fig. 1). The included patients were then randomised into 2 cohorts: the developmental cohort (105 patients) and the validation cohort (104 patients).

Table 1 shows the demographic and renal function of the patients in the study. No statistical differences were found in demographic and renal function between the development and the validation groups. The mean of CG (105.03 ml/min) is nearest to the mean measured GFR (107.52 ml/min), followed by the mean of the NE.

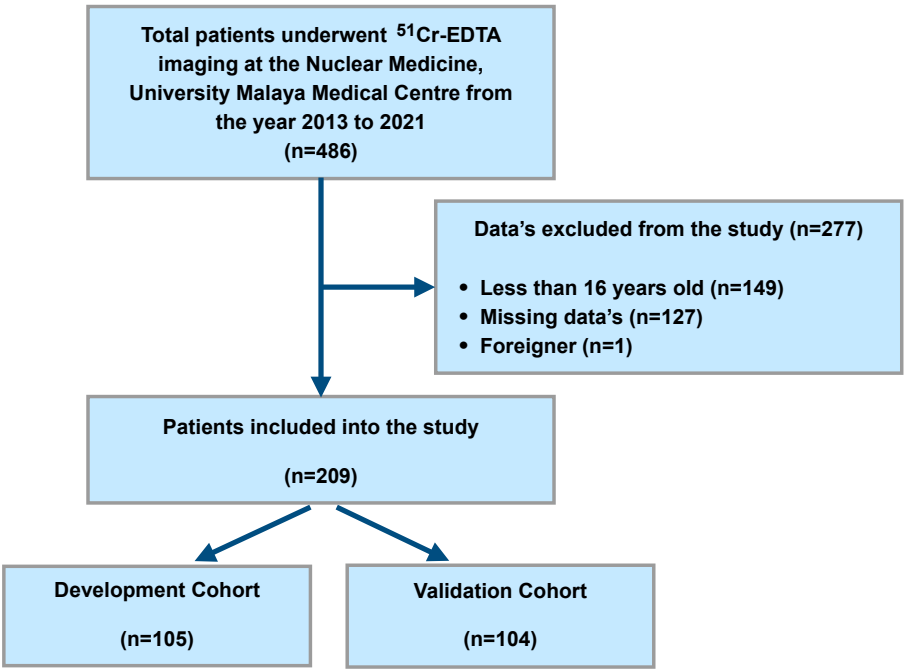


Fig. 1. Process of patient recruitment.

Development of a new equation of eGFR from the development cohort

A total of 105 patients was randomised into the development cohort. We used generalised least square algorithm to the NE (Fig. 2). The GFR was regressed against the patients' serum creatinine in the development cohort. The R^2 value for equation ethnicity 1 (Malay) was 0.525, with an adjusted value of 0.498; for equation ethnicity 2 (Chinese) was 0.305, with an adjusted value of 0.275; and for ethnicity 3 (Indian) was 0.31 with an adjusted value of 0.218 (Fig. 3).

Internal validation from the validation cohort

We validated the newly developed equation in 104 patients in the validation cohort. The mean eGFR value obtained from the NE was 111.04 ml/min, higher than the measured GFR in the validation cohort, which was 107.52 (Table 1). The CKD-EPI equation had estimated the lowest mean of eGFR among all the equations.

Table 1. Demographic and renal function of the patients.

Variables	All patients (*n* = 209)	Development cohort (*n* = 105)	Validation cohort (*n* = 104)	*P* value
Age (years)	49.95 ± 15.26	49.78 ± 15.89	50.10 ± 14.66	0.87
Gender				
Male	88 (42.11)	51 (48.6)	37 (35.58)	0.06
Female	121 (57.89)	54 (51.4)	67 (64.42)	
Weight (kg)	67.81 ± 15.7	68.30 ± 14.65	67.3 ± 16.75	0.65
Height (cm)	160.33 ± 8.90	160.85 ± 8.81	159.80 ± 9	0.4
Body mass index (kg/m2)	26.26 ± 5.10	26.30 ± 4.82	26.22 ± 5.39	0.92
Ethnicity				
Malay	68 (32.54)	38 (36.2)	30 (28.85)	0.4
Chinese	107 (51.20)	49 (46.7)	58 (55.77)	
Indian	34 (16.26)	18 (17.1)	16 (15.38)	
99mTc-DTPA-measured GFR (ml/min)	107.03 ± 38.01	106.54 ± 38.27	107.52 ± 37.92	0.85
Plasma creatinine (µmol/L)	63 (52-84.5)	59 (54-91.5)	60(51.25-80.5)	0.06
Estimated GFR by CG (ml/min)	102.79 ± 43.28	100.56 ± 42.44	105.03 ± 44.21	0.46
Estimated GFR by MDRD (ml/min)	100.6 ± 38.62	98.39 ± 40.35	102.83 ± 36.84	0.41
Estimated GFR by CKD-EPI (ml/min)	93.82 ± 28.71	92.60 ± 28.53	95.05 ± 28.98	0.49
Estimated GFR by NE (ml/min)	108.83 ± 25.42	106.64 ± 25.92	111.04 ± 24.82	0.21

GFR: glomerular filtration rate; CG: Cockcroft–Gault; CKD-EPI: Chronic Kidney Disease-Epidemiology Collaboration; MDRD: Modification of Diet in Renal Disease; NE: new equation
Qualitative data are expressed as number (%).
Parametric data are expressed as the mean ± SD.
Non-parametric data are expressed as median (interquartile range).

$$GFR = \begin{cases} 28.219(0.9925)^{Age}\left(\frac{S_{Cr}}{15.779}\right)^{-0.5780} & if\ Ethnicity = 1 \\ 34.099(0.9967)^{Age}\left(\frac{S_{Cr}}{26.266}\right)^{-0.3849} & if\ Ethnicity = 2 \\ 54.628(0.9869)^{Age}\left(\frac{S_{Cr}}{976480}\right)^{-0.08464} & if\ Ethnicity = 3 \end{cases}$$

Fig. 2. A new equation was developed to estimate GFR.

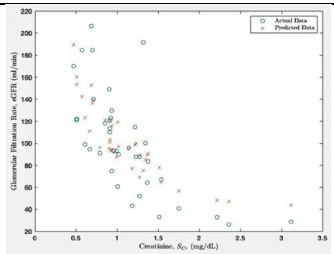
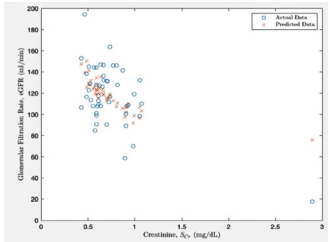
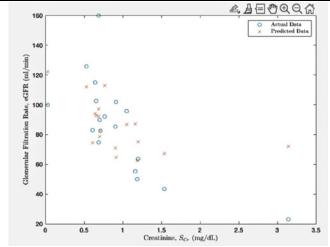
Ethnicity		
1 **MALAY**		Nonlinear regression model: y ~ (b1*((x1/b2)^ - b3)*(b4^x2)) Estimated Coefficients: Estimate SE tStat pValue b1 28.219 7.0676 3.9927 0.00031887 b2 15.779 7.3069 2.1594 0.037756 b3 0.57801 0.15028 3.8461 0.00048603 b4 0.9925 0.0033998 291.93 7.2514e-61 Number of observations: 38, Error degrees of freedom: 35 Root Mean Squared Error: 33.1 R-Squared: 0.525, Adjusted R-Squared 0.498 F-statistic vs. zero model: 131, p-value = 4.24e-19
2 **CHINESE**		Nonlinear regression model: y ~ (b1*((x1/b2)^ - b3)*(b4^x2)) Estimated Coefficients: Estimate SE tStat pValue b1 34.099 11.28 3.023 0.0040826 b2 26.266 5.6389 4.6581 2.7417e-05 b3 0.38493 0.1064 3.6178 0.00073589 b4 0.99674 0.0020279 491.52 3.1545e-87 Number of observations: 49, Error degrees of freedom: 46 Root Mean Squared Error: 24.1 R-Squared: 0.305, Adjusted R-Squared 0.275 F-statistic vs. zero model: 401, p-value = 5.67e-33
3 **INDIAN**		Nonlinear regression model: y ~ (b1*((x1/b2)^ - b3)*(b4^x2)) Estimated Coefficients: Estimate SE tStat pValue b1 54.618 63.926 0.8544 0.40632 b2 9.7648e+05 0.00030283 3.2245e+09 3.1657e-135 b3 0.08464 0.071311 1.1869 0.25372 b4 0.98685 0.0068664 143.72 5.7839e-25 Number of observations: 18, Error degrees of freedom: 15 Root Mean Squared Error: 28.3 R-Squared: 0.31, Adjusted R-Squared 0.218 F-statistic vs. zero model: 57.3, p-value = 1.91e-08

Fig. 3. Linear regression model of GFR and serum creatinine of patients in the development cohort.

Table 2 shows the correlation analysis between eGFR and measured GFR. CKD-EPI had the highest positive correlation ($R = 0.82$), followed by the NE ($R = 0.76$). CKD-EPI also had the highest ability to predict the actual GFR, with an R^2 value of 0.67, followed by the NE with an R^2 value of 0.58.

Table 3 highlights the performance of various eGFR equations in terms of accuracy. Among the equations, the CKD-EPI demonstrated the highest accuracy, achieving 85.58% in P30 and 100% in P50 for estimating GFR, outperforming all other equations. Furthermore, CKD-EPI exhibited both low MAE and low RMSE. Notably, the NE equation recorded the lowest RMSE among all eGFR equations,

Bland-Altman analyses were performed to measure the agreement between all eGFR equations and measured GFR (Fig. 4). CG and NE had the least bias of 2.46 ml/min and 3.52ml/min, respectively. On the other hand, CKD-EPI had the most precision to estimate GFR, with the lowest SD of 22.04 ml/min, followed by NE with an SD value of 25.05 ml/min.

Table 2. Correlation analysis between eGFR and measured GFR

	Equations	***R***	**95% CI**	***R²***	***p***
^{51}Cr-EDTA measured-GFR	CG	0.66	0.52 to 0.71	0.44	< 0.001
	MDRD	0.73	0.60 to 0.86	0.53	< 0.001
	CKD-EPI	0.82	0.70 to 0.93	0.67	< 0.001
	NE	0.76	0.63 to 0.89	0.58	< 0.001

GFR: glomerular filtration rate; CG: Cockcroft–Gault; CKD-EPI: Chronic Kidney Disease-Epidemiology Collaboration; MDRD: Modification of Diet in Renal Disease; NE: new equation

Table 3. Accuracy of eGFR equations

	P_{30} (%)	**P_{50} (%)**	**MAE (ml/min)**	**RMSE (ml/min)**
CG	72.12	91.35	25.11	34.03
MDRD	81.73	96.15	20.76	27.8
CKD-EPI	85.58	100	18.5	25.24
NE	77.88	84.62	19.37	25.19

CG: Cockcroft–Gault; CKD-EPI: Chronic Kidney Disease-Epidemiology Collaboration; MDRD: Modification of Diet in Renal Disease; NE: new equation; MAE: mean absolute value; RMSE: root mean square error

Table 4. Bland-Altman analyses between eGFR and measured GFR

Equation	Mean bias ± SD (ml/min)	Differences (IQR)	Percent differences (IQR)
CG	2.49 ± 3.41	-7.08 (-21.22–13.99)	-8.45 (-19.94–12.84)
MDRD	4.69 ± 27.54	-5.2 (20.41–9.94)	-4.4 (-21.51–11.08)
CKD-EPI	12.47 ± 22.04	-9.45 (-24.83–1.56)	-9.6 (-21.49–1.82)
NE	3.52 ± 25.05	3.76 (-10.83–21.73)	3.77 (-8.96–21.09)

IQR: interquartile range; CG: Cockcroft–Gault; CKD-EPI: Chronic Kidney Disease-Epidemiology Collaboration; MDRD: Modification of Diet in Renal Disease; NE: new equation
Parametric data are expressed as the mean ± SD.
Non-parametric data are expressed as median (interquartile range).

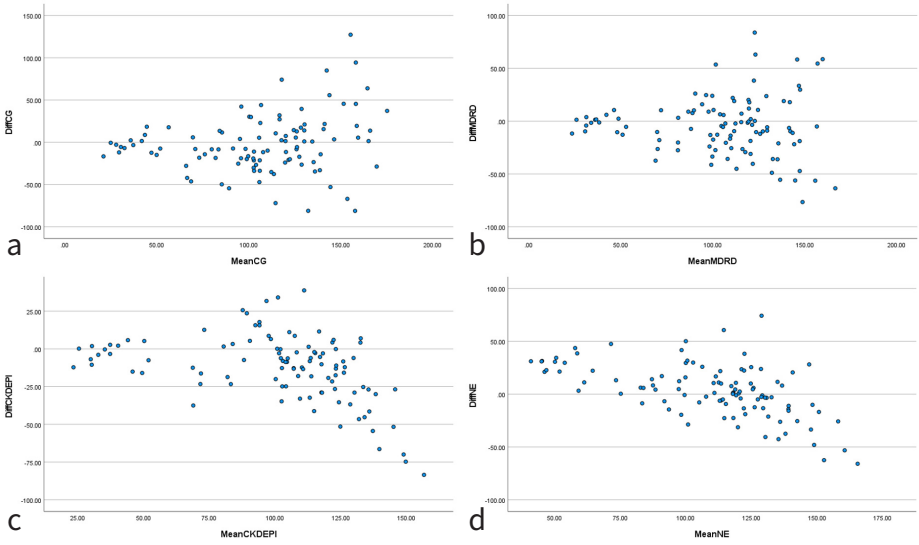


Fig. 4. Bland-Altman plots of eGFRs and measured GFRs for *(a)* CG, *(b)* MDRD, *(c)* CKD-EPI, and *(d)* NE. The dotted line shows the mean of bias, and the bold line shows the 1.96 SD of the mean bias.

Discussion

This study aimed to develop an NE to estimate the GFR for the Malaysian multiracial population, addressing limitations of widely used equations such as CG, MDRD, and CKD-EPI.

Among the formulas, the CKD-EPI demonstrated the strongest performance. showcasing the highest accuracy, with 85.58% of estimates falling within 30% (P30) of the measured GFR and 100% within 50% (P50). It also recorded low MAE and low RMSE, indicating its reliability. The precision of CKD-EPI was good, with a low standard deviation of 22.04 ml/min, reflecting its low variability and consistent performance in estimating GFR. It exhibited the highest positive correlation with the measured GFR (R = 0.82), indicating its ability to produces value closely aligned with the actual GFR values. However, CKD-EPI exhibited the highest mean bias among the formulas, which reflected its tendency to overestimate the GFR value. Overall, CKD-EPI is the most accurate and reliable formula for estimating GFR in the Malaysian multiracial population.

The newly developed NE was able to provide a fairly accurate GFR value with 77.88% in P30 and 84.62% in P50. Notably, it had the lowest RMSE among the equations. The NE had a lower mean bias (3.52 ml/min), meaning its estimates were generally closer to the measured values, and less prone to overestimation of GFR. Despite a slightly higher standard deviation (25.05 ml/min), suggesting more variability, the NE was strongly correlated with the measured GFR (R = 0.76), although slightly lower than that of the CKD-EPI. These results indicate that NE offered comparable performance to existing equations, but it required refinement with larger sample size.

The MDRD had higher P30 and P50 than NE, but it also showed a higher error tendency with MAE 20.76 ml/min and RMSE 27.8 ml/min. It tends to overestimate the GFR more than NE, and showed less consistency as evidenced by the highest standard deviation (27.54 ml/min) among all equations. It had a good correlation with the measured GFR with r value of 0.73, slightly weaker than NE and CKD-EPI. These findings suggested that MDRD estimated GFR fairly well, but less reliably compared to CKD-EPI.

While CG demonstrated high precision in estimating GFR, its accuracy was relatively low compared to other equations. CG had the weakest correlation with the measured GFR, but it had the lowest mean bias (2.49 ml/min), consistent with findings from a previous local study.14 [14] These results indicate that CG has weaker overall performance compared to the other equations.

Our study found that CKD-EPI demonstrated the best overall performance in our sample multiracial population, which is consistent with findings from previous studies.15,16 [15,16] Interestingly, when applied specifically to the Malay population, MDRD appeared to outperform CKD-EPI, as reported in earlier research. This highlights the significance of ethnicity in influencing the performance of GFR equations and the need for a robust equation that explicitly applies to the Malaysian multiracial population.

Limitations

NE was developed using local data, which theoretically should capture the population-specific characteristics. However, the relatively small sample size in the development cohort (105 patients) limited the equation's robustness, potentially affecting its precision and accuracy. Nevertheless, NE performed reasonably well and showed its potential for estimating GFR in the Malaysian multiracial population.

Moreover, this study was conducted at a single centre, and the ethnic distribution of the sampling population was unequal (51.2% were Chinese, 32.54% were Malay, and 16.26% were Indian). This racial distribution did not fully reflect Malaysia's overall demographic composition, where Malays constitute the majority. Therefore, the results from the current study were unlikely to represent Malaysia's general population.

Conclusion

Based on the findings of this study, we concluded that CKD-EPI demonstrated the best performance among the eGFR equations, offering the highest precision and accuracy for estimating GFR in the Malaysia population. However, the newly developed NE showed comparable performance, exhibiting low bias, high precision, and good accuracy.

Future research with large sample size is needed to produce a robust equation that can be explicitly applied to the Malaysian population in order to improve CKD diagnosis and management in Malaysia.

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Medical Research Ethics Committee, Universiti Malay Medical Centre (MREC ID NO:2021105-10644).

Competing interests

AMR, SHC and IIS are the members of the Editorial Board of Malaysian Journal of Anaesthesiology; they were not involved in any part of the editorial process prior to article acceptance. The other authors declare that they have no competing interests.

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Baxter

In the latest edition of the **Recommendations for Safety Standards and Monitoring during Anaesthesia and Recovery**, the following statement was made:[1]

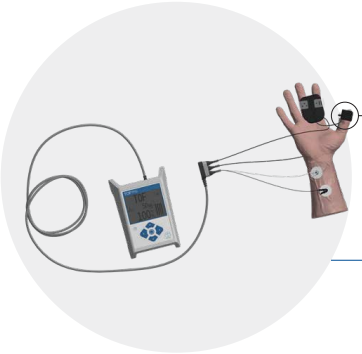
3.7 Neuromuscular function

3.7.1 A peripheral nerve stimulator should be available when muscle relaxants are used to monitor neuromuscular function.

- **Various stimulation modes**
  - TOF, PTC, TC, DBS, Single Twitch
- **Adjustable continuous measurement**

- **3D AMG available to measure muscle movement more precisely**

- **Portable to be used at various locations**



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This effect can be used to adjust the signal strength.

Testimonial

"TOF3D is a standalone device for the measurement of Nueromuscular Transmission (NMT). I have used the device to **rule out residual neuromuscular blockade** for postoperative patients in the PACU. It is **portable** and **reliable**. NMT monitoring device is **essential** in the provision of **safe** and **high-quality** neuromuscular blockade."

Dr Shahridan Mohd Fathil
Consultant Anaesthesiologist
Gleneagles Hospital Johor

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Reference :
1 Recommendations for Safety Standards and Minimal Monitoring Standards during Anaesthesia and Recovery (5th Edition) 2022: College of Anaesthesiologists, Academy of Medicine Malaysia and Malaysian Society of Anaesthesiologists [cited 2023 May 20]. Available from: https://www.msa.net.my/view_file.cfm?fileid=230

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Medicolegal issues affecting anaesthesiologists in Malaysia: an overview

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Abstract

Medicolegal issues have a significant impact on the practice of anaesthesiologists worldwide. Current trends indicates that although anaesthesiologists are less likely to be sued compared to other specialities, the payouts by anaesthesiologists are huge due to the high cost associated with the long-term management of patients with cerebral palsy and hypoxic ischaemic encephalopathy. The impact on anaesthesiologists is acknowledged, with many societies worldwide taking various steps to address them, such as the Second Victim Programme by the Malaysian Society of Anaesthesiologists. This aims to address some of the potential mental health issues affecting anaesthesiologists facing the aftermath of a poor clinical outcome and subsequently having to deal with the process of litigation. Various solutions have been addressed to acknowledge medicolegal issues in Malaysia, such as mediation as a way forward for dispute resolution. However, solutions such as this will take time for widespread adoption, and as such, the impact will not be immediately felt. It is far better for anaesthesiologists to be proactive in having increased awareness of the challenges associated with litigation via comprehensive medicolegal education.

Keywords: anaesthesiology, legal medicine, Malaysia, medicolegal education, Second Victim Programme

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Introduction

The practice of anaesthesiology and critical care medicine has greatly evolved in Malaysia. From what used to be a basic level of anaesthesia care using a combination of ether and air as anaesthesia with a simple improvised vaporiser in March 1847 in Malacca,[1] anaesthesiologists in Malaysia are now delivering state-of-the-art care at almost 400 hospitals and medical centres nationwide. With the widespread availability of anaesthesia services, complex surgical procedures are being performed.

With this evolution, patients have come to expect high standards of care with good clinical outcomes rather than just routine, adequate clinical care. There are challenging discussions, especially when dealing with unexpected poor outcomes after surgery. The conversation following poor postoperative outcomes breaks down or is misinterpreted, and patients and/or their families tend to express their displeasure toward both the surgical and anaesthesia team taking care of their loved ones.

Most of these disputes are settled within the hospital by virtue of the internal grievance mechanisms. However, there are a few who pursue litigation in the courts. These are the kind of cases that end up causing significant distress to the anaesthesiologists. The impact includes both mental and physical effects to the practitioner, loss of confidence, and potential loss of employment and income.

This paper aims to discuss the trends in medicolegal issues faced by anaesthesiologists in some countries and their similarities to Malaysia. The paper will also look into some of the legal guidelines of medical practice applicable in Malaysia and potential solutions to help anaesthesiologists mitigate risks.

Global trends in litigation against anaesthesiologists

The impact of litigation against anaesthesiologists in Malaysia has been hard to study due to the paucity of data surrounding the subject. Unfortunately, Malaysia does not have a central database of medicolegal cases whereby cases involving anaesthesiologists as well as their specifics can be traced.[2] The problem is further compounded by the dual healthcare system practiced in Malaysia, where public and private anaesthesiologists render their services with different contractual obligations. This has also been highlighted by the late Dato Dr Radha Krishnan in 1991, where he mentioned that statistics or other relevant information of anaesthetic mishaps are often difficult to obtain. Even the limited data available are incomplete, as data collection and methods of reporting such incidents has been scant, especially in the private sector.[3]

Most of the information are available in Malaysia is found in court judgement documents and confidential hospital reports only accessible to Ministry of Health officials. The data that are freely available are currently from a few countries where it is systematically collected, analysed, and published to ensure that anaesthesiologists can learn from the issues and take steps to mitigate risks.

In a comprehensive study on claims involving anaesthesiologists working with NHS England between 2008 and 2018, it was found that, although the specialty of anaesthesia was at low risk of litigation, claims relating to airway management, central venous catheterisation, and cardiac arrest remained severe and costly.[4] This is consistent with what we are seeing in Malaysia as well, with the sum of payouts determined by the courts for these type of cases running into millions of ringgits.

In another study on 222 medicolegal claims involving 160 anaesthetist members of Victoria, Australia's largest medical indemnity organization between 1980 and 1999, 35% of anaesthetists had a claim, with 84 relating to dental injury and the rest relating to claims for awareness, complications of epidural anaesthesia, coronial enquiries, nerve palsies, postoperative complications, and circulatory arrest.[5] The Canadian Medical Protective Association analysed closed civil legal cases between 2007 and 2016 involving specialist anaesthesiologists where airway management was the central concern. The analysis concluded that severe patient harm is common when airway management is the focus of the claim. Patients were otherwise typically low-risk cases presenting for elective surgery. Failure to assess or change management based on the airway exam or encountered difficulty were the most common errors.[6]

There have been attempts to improve the financial impact brought upon by litigation to both the injured party and the doctors involved. The Malaysia Medical Council required all its registered doctors to have a Professional Indemnity cover as a requisite to obtain their Annual Practising Certificate for the year 2020.[7] However, due to the different insurance providers and medical defence organizations providing medicolegal coverage, each had their own data that was not released to outside parties. As such, the number of cases as well as the payouts made specifically for cases involving anaesthesiologists are not clearly known.

The Ministry of Health (MOH) Malaysia publishes in its annual reports all medicolegal awards paid out for malpractice allegations against MOH facilities and its staff. In 2023 alone, MOH awarded a total of RM 6,891,879.28 (USD 1,629,863.84) in compensation for 61 ex gratia settlements RM 2,073,591.70 (USD 490,384.70) and 12 litigation cases RM 4,818,287.58 (USD 1,139,479.15). However, no breakdown of the type of cases and the speciality involved were disclosed in the report.[8]

In Malaysia, obstetric cases that end up with complications to the child, such as cerebral palsy or spinal cord injuries, typically include anaesthesiologists who are named as part of the defendants in the medicolegal suit. As expected, the payouts for this type of injuries run into the millions.[9,10] In 2024 alone, there were at least 3 significant judgments released by the courts that had anaesthesiologists determined to be partly or wholly negligent in causing harm to the patients.[11-13] All 3 cases required the anaesthesiologists to respond to patients presenting in an emergency situation. Unfortunately, the outcome of the resuscitation was that the patients suffered from hypoxic ischaemic encephalopathy. This led to a million-ringgit payout in view of the nature of the awards given by the courts, which included cost of care, loss of income, and aggravated damages, amongst others.

The challenges shown above demonstrate the importance of having a central database of national statistics to provide a definitive idea on how exactly anaesthesiologists are impacted. In pushing for more anaesthesiologists to be educated on the ever-increasing medicolegal issues in Malaysia, we cannot rely on international studies or courts highlighting significant judgements alone. The national societies and special interest groups representing anaesthesiologists should do more in ensuring all legal cases are recorded efficiently and available for a detailed analysis so that any shortcomings in anaesthetic management can be identified and managed accordingly.

Legal governance of medical practice in Malaysia

In Malaysia, the legal framework concerning the governance of medical practice falls under a few ambits of legislation. The main legislation is the Medical Act 1971 ("Act 50") and its subsidiary legislation, Medical Regulations 2017 ("2017 Regulations"). Under this act, the role and composition of the Malaysian Medical Council is well established. The Council is given the powers to not only regulate the standards of practice of registered medical practitioners but also to regulate the professional conduct and ethics of registered medical practitioners.[14]

To this end, the Malaysian Medical Council has published various guidelines pertaining to codes of ethical professional conduct, duties of doctors, good medical practice, confidentiality, consent taking, conflicting interests, and many others. These guidelines provide some framework for doctors in conducting themselves ethically and upholding professionalism. Any infringement of the above guidelines may potentially lead the doctors to be investigated by the Malaysian Medical Council or used in the court of law.[15] Moreover, guidelines established by local and foreign societies representing the clinical specialities may also be used by lawyers during court proceedings in addition to the role played by the expert witnesses representing both the plaintiff and the defence when determining whether defendant doctors practised to the acceptable standard of care.[16]

Doctors are also bound by legal principles and precedence determined by the judiciary for medicolegal cases. These judgements are handed down not only by courts in Malaysian jurisdiction, but also from UK and Australia. The Civil Law Act of 1956 formally received the common law of England, rules of equity, and certain English statutes, and applies English law in matters such as tort law subject to local circumstances and necessary qualifications where permitted.[17] As the legal principles are constantly evolving with the times, it is important that doctors keep abreast of the latest developments happening in these jurisdictions.[18]

Impact on anaesthesiologists

It is important to note that the overall increase in the trend of litigation does not represent a deterioration of anaesthetic standard but rather an increase in the number of high-risk cases being performed as well as the improvement in resuscitation skills. However, this has also inadvertently led to patients suffering from complications such as hypoxic ischaemic injuries while in the process of being resuscitated. There is also increased public awareness on the options of pursuing litigation. The media also plays a significant role in highlighting medical negligence cases that are successful in suing negligent doctors or hospitals. The high cost in the care of injured patients suffering from hypoxic brain injury or cerebral palsy also pushes the next of kin to seek compensation via the courts when out-of-court settlements fail to achieve a successful resolution.

As such, it is not surprising to see that anaesthesiologists are inevitably exposed to the threats of litigation. It is thus of paramount importance that an attempt should be made to further reduce the incidence of errors by the improvement in techniques and monitoring as well as adopting best practices. All these factors will influence the courts to take a more balanced view that anaesthesiologists have met the standard of care.

Second Victim Programme

Dr. Albert Wu coined the term “second victim” to highlight the impact of unanticipated adverse events, medical errors, or patient-related injury on healthcare providers who suffer alongside the primary victims, who are the patients and their families.[19] Many of the anaesthesiologists who are already facing mental anguish as a result of an adverse clinical event describe worsening feelings when faced with a legal situation. The fear is not only about the prospect of facing a lengthy battle in court where their clinical acumen, judgments, and decision-making comes into question, but also the potential financial catastrophe in the event the court awards are beyond what they are insured for.

Recognising this, a Task Force from the Malaysian Society of Anaesthesiologists and College of Anaesthesiologists, Academy of Medicine Malaysia in collaboration

with the Malaysian Society of Clinical Psychology produced a guide called A-SHIELD Peer Support After Adverse Events: Guide to Establish Second Victim Programme.[20] Although there is no data on the prevalence of second victims in Malaysia, international studies suggest that almost half of all healthcare providers involved in an adverse event will become second victims.[21]

Although the programme has just been launched, it will be interesting to see whether a structured response and support mechanism put in place will potentially help anaesthesiologists involved in medicolegal lawsuits to be better prepared to face them. However, the onus will be on the anaesthesiologist to not only seek support from their trusted peers but to also look at other potential solutions to equip themselves to navigate the complex world of medicolegal lawsuits.

Potential solutions

Among the proposed solutions are increased awareness by providing better medicolegal education for doctors at undergraduate or postgraduate levels. Despite recognising the potential pitfalls faced by the doctors, many programmes do not currently provide adequate medicolegal modules. Although it is well known that understanding health law plays a crucial role in the field of medicine as it dictates appropriate practices, regulations, and rights and responsibilities for healthcare professionals and patients, many do not realise the importance of actually paying attention to this area.[22] In a research article, Professor Puteri Nemie concluded: "Educating future medical professionals with the fundamentals of law and ethics would ensure greater accountability, knowledge and personal commitment in providing medical services to the society. The ideals of professionalism not only require them to have the necessary expertise, dedication, respect, compassion, empathy, honesty, altruism, responsibility, integrity, self-improvement and accountability but also adherence to the demands of law and highest ethical standards."[23]

Another proposal that is currently being explored is to investigate mediation instead of court litigation as a way forward for dispute resolution. On February 6, 2025, the Legal Affairs Division of the Prime Minister's Department announced the proposed implementation of the Madani Mediation Centre that will look into strengthening the country's mediation landscape while at the same time achieving fair, effective, and harmonious conflict resolution for the greater good.[24] This is a welcome announcement by the majority of healthcare professionals, as it is well recognised that mediation provides a more effective, compassionate, and lasting resolution that benefits healthcare institutions, practitioners, and patients.[25] Mediation would offer patients and their families a path toward quicker conflict resolution and allow them to focus on the recovery of their loved ones rather than fighting a protracted battle in the courts where the outcome may not be satisfactory to all parties involved.

Conclusion

The rising incidence of litigation against anaesthesiologists in Malaysia is of serious concern to the fraternity. There is no doubt that clinical governance plays a crucial role in ensuring patient safety as well as upholding professional accountability and fair outcomes in medicolegal lawsuits. However, the impact of litigation on anaesthesiologists, who face both professional and emotional stress, cannot be denied. As such, support mechanisms such as the Second Victim Programme are vital to mitigate the effects of litigation and encourage resilience amongst practitioners. Finally, Malaysia's anaesthesiology leaders should focus on finding the right balance between safeguarding patients from harmful negligent practices and protecting the wellbeing of anaesthesiologists. Given that the practice of anaesthesiology requires safeguarding, a monumental effort involving all stakeholders will be required sooner rather than later.

Declarations

Ethics approval and informed consent
Not required.

Competing interests
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A breathless journey: airway management in a pregnant patient with non-Hodgkin lymphoma

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Abstract

Airway compromise due to malignancy in pregnancy is rare but presents significant challenges. Physiological changes during pregnancy may further exacerbate airway obstruction from mediastinal masses, complicating management. We report a case requiring early tracheostomy for airway stabilisation and chemotherapy initiation. A 32-year-old at 17 weeks' gestation presented with non-Hodgkin lymphoma and a large anterior mediastinal mass causing severe airway compression. Multidisciplinary planning prioritised early airway stabilisation to avoid emergent interventions. Awake fibreoptic intubation allowed controlled tracheostomy placement, securing the airway for chemotherapy. Following the third cycle of treatment, the patient showed a good clinical response with significant mass reduction, improved symptoms, and better tolerance of oral intake. Plans were made for elective Caesarean section at 32–34 weeks, with tracheostomy maintained for airway security during delivery. This case underscores the importance of proactive airway management and collaborative planning in pregnancy complicated by mediastinal mass and airway compromise. Early airway stabilisation and multidisciplinary collaboration are critical in managing pregnant patients with compromised airways, thus optimising maternal and foetal outcomes. Future cases with similar risks may benefit from planned airway stabilisation and multidisciplinary collaboration.

Keywords: difficult airway, non-Hodgkin lymphoma, pregnancy, tracheostomy

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Introduction

Airway compromise due to malignancy in pregnancy poses significant risks to both maternal and foetal outcomes. Large anterior mediastinal masses, such as those seen in lymphomas, can progressively obstruct the airway, a condition that may worsened by pregnancy-related physiological changes.[1,2] This case highlights the successful stabilisation of a pregnant patient with non-Hodgkin lymphoma through early tracheostomy, enabling safe chemotherapy initiation. It underscores the critical role of multidisciplinary collaboration, meticulous procedural planning, and clear inter-specialty communication in managing complex airway scenarios during pregnancy.[2]

Case presentation

A 32-year-old Malay woman at 17 weeks and 5 days of gestation presented with newly diagnosed diffuse large B-cell non-Hodgkin lymphoma. The patient presented with progressive enlargement of an anterior chest swelling and increasing dyspnoea, as well as additional symptoms including hoarseness of voice and an inability to tolerate solid food, leading to significant weight loss. She was unable to lie flat due to the compressive effects of a large chest mass. There was no stridor or distended neck vein. Her medical history included no prior surgeries or significant illnesses, except for a seafood allergy. Functional assessment indicated NYHA Class III, with limited activity due to dyspnoea. Physical examination showed a large anterior chest mass (Fig. 1), Mallampati Class II airway good mouth opening, adequate neck extension, and absence of Pemberton's sign absent. Computed tomography revealed a 9.6 × 14.1 × 15.5 cm mediastinal mass (Fig. 1). At the thoracic inlet, the mass compressed the trachea with narrowing of its anterior-posterior diameter measuring 3.7 mm at its narrowest.

An urgent multidisciplinary team (MDT) discussion was held involving the anaesthesia, obstetrics, haematology, and otorhinolaryngology (ORL) teams. Key concerns included the need for high-dose steroids alongside chemotherapy to reduce the mass, the risk of perilesional oedema from initial treatment potentially worsening airway compromise, and the significant concern of neutropenic sepsis and tumour lysis syndrome. Given these factors, early tracheostomy was deemed critical for airway stabilisation and safe chemotherapy initiation.

Nevertheless, due to the severity of the airway narrowing, the MDT decided that if securing the airway was difficult or impossible, the procedure would be abandoned, and she would be referred to a cardiothoracic centre in another state

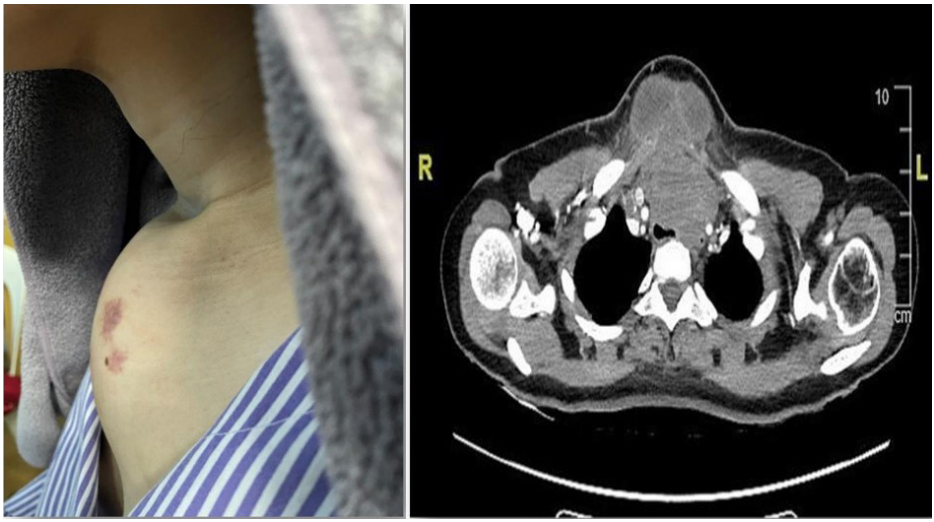

Fig. 1. (Left) A huge, solid mass over the chest area. *(Right)* Computed tomography showed that the mass originated from the mediastinum with extrathoracic extension.

for extracorporeal membrane oxygenation (ECMO) support before further intervention. To maximise the patient's chances of success, no sedation was given during awake fibreoptic intubation (AFOI) to maintain spontaneous breathing and avoid airway collapse. The patient and her family were thoroughly counselled regarding these risks, and consent was obtained for tracheostomy.

Standard monitoring included continuous pulse oximetry, end-tidal carbon dioxide ($ETCO_2$), and an arterial line inserted in the right radial artery for continuous blood pressure monitoring. An injection of intravenous (IV) glycopyrrolate 0.2 mg was administered. Preparations included the presence of the ORL team, who was ready for an emergent airway situation. A consultant anaesthetist performed the procedure in sitting position as the patient turned and became breathless at a lower inclination. A size 6.5 mm nasopharyngeal airway was soaked with 2% lidocaine gel and applied on the larger left nares. The initial scope was advanced through the nasal airway to topicalize the nasopharynx, larynx, supraglottic area, vocal cords, subglottic area, and over at the visualised site of narrowest tracheal compression and beyond distal to the compression above the carina. A total of 9 ml of 2% lidocaine (1 ml solution in 10 ml of air) was given. Continuous verbal communication with the patient was provided while waiting for the onset of the local anaesthetic. A size 5.0 microlaryngeal tube (MLT) was successfully advanced over the fibreoptic scope and through the compressed trachea.

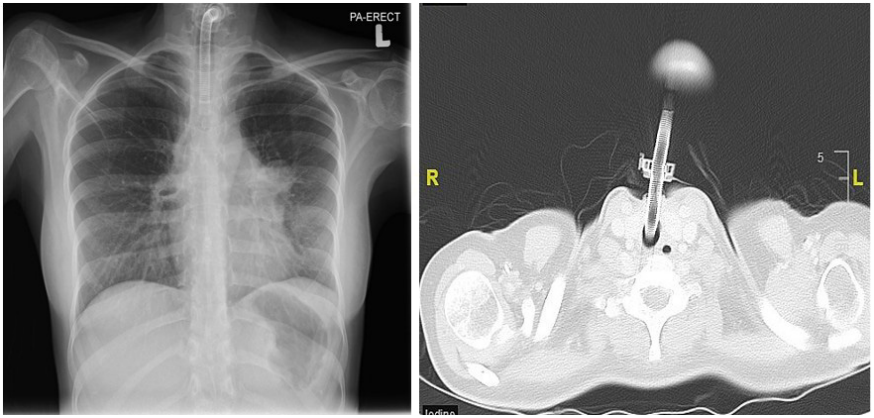

Fig. 2. (Left) Chest X-ray post tracheostomy in ICU. *(Right)* Repeat computed tomography after third cycle of chemotherapy showed significant mass reduction.

The patient was placed in a supine position and anaesthesia was induced with a combination of sevoflurane with 100% oxygen, IV propofol 50 mg, and target-controlled infusion of remifentanil. MLT placement was further confirmed with sustained $ETCO_2$. There was no increase in airway pressure, ventilation was well established, and oxygen saturation remained above 96%.

The ORL team performed the tracheostomy using a flexible tracheostomy tube size 7.0 (Shiley™, Medtronic, Minneapolis, MN, USA). The tube position was reconfirmed via flexible scope, with the tip seen to lie just above the carina and bypassing the external compression. Atracurium 25 mg was administered for muscle relaxation, with no significant impact on ventilation or oxygen saturation. Anaesthesia was maintained with oxygen, air, and sevoflurane. The patient remained haemodynamically stable without any inotropes or vasopressor support.

She was sent to the intensive care unit for further stabilisation and close monitoring. A chest X-ray confirmed tracheostomy placement with no acute complications (Fig 2). Chemotherapy commenced 10 days post-tracheostomy. After the third cycle, there was a significant reduction in the mediastinal mass size, allowing the patient to tolerate semi-solid food and sleep with one pillow (Fig. 2). A follow-up MDT discussion determined that the tracheostomy should remain in place to provide secure airway access for Caesarean delivery. Given the ongoing maternal condition and the need for coordinated care, early delivery via elective Caesarean section at 32 to 34 weeks' gestation was planned.

However, due to severe intrauterine growth restriction, early delivery was planned at 28 weeks' gestation. General anaesthesia was induced via the tracheostomy for Caesarean delivery. The procedure was uneventful, and the patient was weaned to a tracheostomy mask by the end of the surgery. Her baby was admitted to the neonatal intensive care unit for prematurity. She was successfully decannulated 2 weeks post-delivery. Despite an initial good response to chemotherapy, the disease later became resistant to treatment, and the patient ultimately succumbed 18 months after diagnosis.

Discussion

There is limited guidance in the literature on the optimal management of pregnant patients with an anterior mediastinal mass, with most available evidence derived from a small number of case reports documenting successful outcomes.[1,3,4]

In cases such as this, well-planned airway management is crucial, as documented by Boyne *et al.*, who highlighted the successful use of AFOI in a 35-week pregnant patient with airway compression for Caesarean delivery.[5] In our case, a proactive approach prevented rapid deterioration, while collaboration via MDT provided continuous risk assessment. In pregnant patients, reduced functional residual capacity, combined with increased blood volume and tissue swelling, can markedly decrease respiratory reserve.[5]

In contrast, Rocha *et al.* described a pregnant patient with significant airway obstruction managed successfully with high-dose corticosteroids alone,[3] thereby avoiding invasive airway intervention. Their report highlighted the potential for steroids to reduce airway compression. However, our patient presented with severe tracheal narrowing (3.7 mm anteroposterior diameter) and potential perilesional oedema following steroid therapy, making airway intervention essential. This highlights the importance of individualised management strategies.

Although successful intubation was achieved in our case, we remained vigilant for potential ventilation difficulties after administering neuromuscular blockade. Our patient did not exhibit any signs of worsening ventilation or airway collapse following muscle relaxant administration, likely due to the bypassing of the compression site via the tracheostomy. Boyne *et al.* reported worsening airway compression despite successful intubation upon loss of spontaneous breathing in a patient with a mediastinal mass, leading to increased airway pressures and ventilation difficulties.[4]

In a situation where intubation using AFOI is unsuccessful, ECMO can serve as a vital bridge for oxygenation while addressing the airway issue.[4] Some recommend femoral vessel cannulation before anaesthesia induction in patients with > 50% lower airway obstruction to facilitate ECMO if oxygenation fails.[6]

A case reported a 23-week pregnant patient with malignant thymoma and superior vena cava syndrome requiring sternotomy and one-lung ventilation. The airway was secured under general anaesthesia with spontaneous breathing, and positive pressure ventilation was initiated only after sternotomy. ECMO cannulas were not placed, as the surgical plan involved tumour elevation if ventilatory failure occurred.[3] In our case, in situations where intubation or tracheostomy is anticipated to be difficult or impossible, the patient will then be referred to a centre equipped with ECMO expertise to ensure optimal management of the airway and oxygenation.

Conclusion

Early airway stabilisation and multidisciplinary collaboration are critical in managing pregnant patients with compromised airways, thus optimising maternal and foetal outcomes. Future cases with similar risks may benefit from planned airway stabilisation and multidisciplinary collaboration.

Declarations

Informed consent for publication
This case report was presented and published with the patient's informed written consent.

Competing interests
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Suxamethonium apnoea in a pregnant patient undergoing emergency lower segment Caesarean section under general anaesthesia

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Abstract

We report a well-described but rare occurrence of suxamethonium apnoea, also known as Phase II block. A 16-year-old Burmese primigravida at 38 weeks and 4 days' gestation was scheduled for an emergency lower segment Caesarean section due to poor progress in labour. Her antenatal course had been uneventful, and she had no significant medical history, allergies, or history of prior surgery. General anaesthesia was chosen due to her age and clinical circumstances. Rapid sequence induction was performed using intravenous propofol and suxamethonium. Muscle relaxation was subsequently maintained with atracurium. At the end of an uneventful surgery, reversal with neostigmine and atropine was administered upon observing spontaneous breathing effort. However, 30 minutes later, the patient still exhibited poor respiratory effort with persistent hypercapnia and poor motor strength. The patient was subsequently sedated with propofol and transferred to the Intensive Care Unit for ventilatory support and neuromuscular monitoring. She was extubated and transferred to the general ward the following morning.

Keywords: apnoea, Caesarean section, neuromuscular blockade, pseudocholinesterase deficiency, suxamethonium

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Introduction

Suxamethonium is a depolarizing neuromuscular blocking agent used for rapid sequence induction of general anaesthesia. Its short duration of action of 9 to 13 minutes is due to rapid metabolism by circulating plasma pseudocholinesterase (PChE).[1] Suxamethonium apnoea is a condition in which there is delayed recovery of muscle power after administration of suxamethonium due to PChE deficiency. PChE deficiency can be congenital or acquired due to conditions such as pregnancy, renal and liver disease, hypothyroidism, or concurrent use of drugs such as anticholinesterases or monoamine oxidase inhibitors.[2] The incidence of PChE deficiency is approximately 1 in 5000.[3] Plasma PChE activity in pregnancy is reduced by approximately 30% at 20 to 24 weeks' gestation and may persist up to 1 week postpartum.[4] While this reduction is rarely clinically significant on its own, it may unmask a latent congenital PChE deficiency, resulting in a dramatically prolonged neuromuscular blockade following suxamethonium administration.

In this case report, we describe a teenage primigravida who developed prolonged neuromuscular weakness after receiving a standard dose of suxamethonium during general anaesthesia for an emergency Caesarean section. This case aims to highlight the importance of considering PChE deficiency in young, otherwise healthy patients undergoing general anaesthesia, and emphasises the value of vigilant neuromuscular monitoring to guide safe extubation and recovery, especially in obstetric emergencies.

Case presentation

A 16-year-old Burmese teenager, primigravida at 38 weeks and 4 days of gestation, was referred to our hospital for suspected foetal macrosomia. She had no significant medical history, allergies, or history of prior surgeries. She also denied any family history of adverse reactions to anaesthesia or neuromuscular disorders. Her antenatal course had been uneventful, with routine follow-ups at a private clinic. Her body mass index was 21.9 kg/m^2, with a weight of 54 kg and height of 157 cm.

The patient was subsequently admitted for induction of labour due to oligohydramnios, with an amniotic fluid index of 5 cm and an estimated foetal weight of 3.0 to 3.2 kg. Labour was induced using 2 doses of intravaginal dinoprostone 3 mg, administered 6 hours apart. However, cervical dilation progressed poorly after 10 hours, with inadequate contractions and cervical dilatation of only 5 cm. A decision was made by the obstetrician to proceed with an emergency Caesarean section due to failed induction of labour.

Informed consent was obtained from the patient and her guardian following a detailed discussion of the risks and benefits of the available anaesthetic options. Given the urgency of delivery, her young age, and concerns about cooperation and tolerability during spinal anaesthesia, general anaesthesia was selected.

Following preoxygenation with 100% oxygen, rapid sequence induction was performed using intravenous (IV) propofol 100 mg and suxamethonium 100 mg. Endotracheal intubation was achieved without complications. IV atracurium 25 mg was administered approximately 5 minutes after the suxamethonium, once initial intubation and airway security were confirmed. Anaesthesia was maintained with sevoflurane in a 50:50 oxygen-nitrous oxide mixture to achieve a minimum alveolar concentration of more than 0.8. After delivery of the neonate, the mother was administered IV fentanyl 100 mcg, paracetamol 1 g, and morphine 3 mg for analgesia. Uterotonic support was provided with IV carbetocin 100 mcg. IV dexamethasone 4 mg was also given for postoperative nausea and vomiting prophylaxis. The estimated blood loss during the surgery was 300 ml.

At the end of surgery, which lasted 1 hour and 10 minutes, a bilateral transversus abdominis plane block was performed under ultrasound guidance with ropivacaine 0.375%, 15 mL on each side. Sevoflurane was discontinued, and non-depolarising neuromuscular blockade reversal with IV neostigmine 2.5 mg and atropine 1 mg was administered upon observing spontaneous breathing efforts. However, 30 minutes later, the patient still exhibited poor respiratory effort, with tidal volumes of 60 to 100 mL and persistent hypercapnia with $ETCO_2$ of 51 mmHg. Neurological examination revealed reactive pupils (2 mm bilaterally). Motor strength was assessed by observing spontaneous limb movement, ability to lift head, and response to verbal commands such as hand-squeezing and purposeful lower limb movements. Clinically, strength was graded as 2/5 in all four limbs using the Medical Research Council scale.

Given the unexpected, prolonged weakness and delayed emergence, neuromuscular monitoring using a peripheral nerve stimulator (PNS) was initiated in the operating room following administration of reversal agents. This reflects common practice in our setting, where PNS is generally utilised postoperatively unless intraoperative concerns arise. Train- of-four (TOF) monitoring revealed 4 twitches with a TOF ratio of 1.0; however, the absolute twitch height was notably reduced (Fig. 1a). These findings were suggestive of a prolonged depolarising neuromuscular block, despite apparent recovery from atracurium.

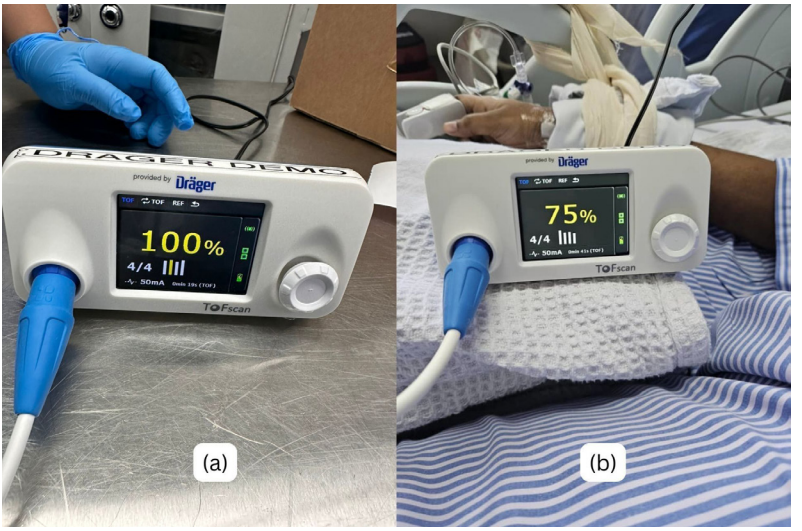

Fig. 1 (a) TOF count of 4 with a TOF ratio of 1.0 at 1-hour post-reversal of non- depolarising neuromuscular blockade. *(b)* TOF count of 4 with a TOF ratio of 0.75 at 4-hour post-suxamethonium administration.

An arterial blood gas analysis performed within an hour postoperatively revealed metabolic acidosis (pH 7.25, pO_2 351 mmHg, pCO_2 37 mmHg, HCO_3 -16 mmol/l, base excess -6 mmol/l). However, the degree of acidosis was not severe enough to explain the profound muscle weakness.

Considering the prolonged weakness and TOF findings indicative of a depolarising block, suxamethonium apnoea was strongly suspected. The patient remained in the operating theatre for approximately 1 hour under close observation, during which sedation with a propofol infusion was maintained. She was subsequently transferred to the ICU for continued mechanical ventilation, sedation, and close monitoring.

In the ICU, TOF monitoring was performed at 30-minute intervals. Sedation was gradually tapered as a Phase II block became more likely, with TOF trends showing progressive improvement. Routine postoperative investigations, including serum electrolytes—magnesium (0.91 mmol/l), potassium (4.1 mmol/l), and sodium (136 mmol/l)—were all within normal limits. A plain computerised tomography of the brain was also unremarkable, effectively excluding intracranial pathology as a cause of delayed recovery.

Approximately 4 hours after suxamethonium was administered, TOF monitoring showed a count of 4 with a ratio of 0.75 (Fig. 1b), which improved to 0.95 over the

Fig. 2. Anaesthetic alert card for patient.

following hour. With these reassuring findings and concurrent improvement in respiratory effort and tidal volumes, the patient was successfully extubated around 5 hours after the initial dose of suxamethonium. She remained stable overnight in the ICU and was transferred to the general ward the following morning after an uneventful stay.

A PChE sent on postoperative day 2 revealed a severely deficient level of < 1000 U/L. Unfortunately, she could not be further investigated as the dibucaine number test is not offered in Malaysia, and the cost of outsourcing to the United States was beyond the patient's financial means.

The patient was issued a laminated alert card detailing her diagnosis (Fig. 2), advising avoidance of suxamethonium and mivacurium in future procedures, and recommending the use of regional anaesthesia or non-depolarising agents when appropriate. She was also advised to inform first-degree relatives of the potential hereditary nature of the condition and the importance of screening prior to undergoing anaesthesia.

Discussion

Inherited PChE deficiency is caused by abnormalities in the BCHE gene, which encodes the PChE enzyme located on chromosome 3. The most common variants include the atypical, K-variant, fluoride-resistant, and silent types. In addition to inherited forms, several patient- and drug-related factors can contribute to an acquired PChE deficiency, as summarised in Table 1.[5]

Table 1. Factors causing acquired PChE deficiency

Disease states	Drugs
Hypothyroidism Kidney disease Liver disease Major burns Malignancy Malnutrition Pregnancy Prolonged infections	Cyclophosphamide glucocorticoids Metoclopramide Monoamine oxidase inhibitors Neostigmine Oral contraceptives Pancuronium terbutaline

The duration of action of suxamethonium depends on the individual's PChE activity and genotype. In homozygous atypical individuals (E1aE1a), a single dose may result in paralysis lasting 2 hours or more. In those with the silent type (E1s), recovery may be delayed for up to 3 hours. Heterozygous individuals typically recover within approximately 30 minutes. In contrast, acquired PChE deficiency usually prolongs suxamethonium action only by a few minutes.[6]

Suxamethonium typically induces a Phase I block, characterised by rapid onset, short duration, and no fade on TOF stimulation. However, with prolonged exposure or in patients with PChE deficiency, a Phase II block may develop. This mimics a non-depolarising neuromuscular blockade and is associated with fade on TOF stimulation, reduced twitch height, post-tetanic facilitation, and potential resistance to neostigmine reversal.[2,3]

In our patient, initial TOF monitoring after administration of reversal agents showed a count of 4 with a TOF ratio of 1.0, but with significantly diminished twitch height. Subsequent readings demonstrated a transient drop in TOF ratio to 0.75 before gradually increasing to 0.95 over the next hour. This evolving pattern, combined with the persistently reduced twitch response, was suggestive of a transition from Phase I to Phase II block—a phenomenon described in individuals with significant PChE deficiency, even after a single dose of suxamethonium.[7]

During pregnancy, PChE activity can decrease by up to 30%, a physiological change that may unmask an underlying congenital deficiency.[4] In this case, the patient's young age, lack of prior anaesthetic exposure, and prolonged weakness following a standard dose of suxamethonium raise suspicion of a homozygous silent genotype (E1sE1s). Although confirmatory dibucaine number testing was unavailable, the markedly low PChE level (< 1000 U/L) and absence of organophosphate exposure support a diagnosis of inherited PChE deficiency. The prolonged recovery time of approximately 6 hours further aligns with the clinical phenotype of

suxamethonium apnoea due to a homozygous silent genotype.

Routine intraoperative neuromuscular monitoring is strongly recommended by international anaesthesia societies, including the Association of Anaesthetists of Great Britain and Ireland and American Society of Anesthesiologists, especially when neuromuscular blocking agents are used. In our setting, PNS monitoring was only initiated after delayed emergence was noted, which reflects common practice in many centres. Earlier intraoperative use of TOF monitoring might facilitate earlier recognition of abnormal neuromuscular responses, particularly in high-risk groups such as obstetric patients, those with no prior anaesthetic history, or individuals with genetic predispositions. However, it is important to note that TOF monitoring alone is not fully reliable—TOF ratios of 1.0 can coexist with clinical weakness and reduced twitch height in cases of Phase I block. Thus, clinical assessment remains critical in guiding management.

The postoperative management strategy in this case was supportive: sedation and mechanical ventilation until spontaneous recovery of neuromuscular function occurred. This remains the safest approach in managing suxamethonium apnoea. Although exogenous sources of PChE, such as fresh frozen plasma transfusion, are available, the risks associated with transfusion were deemed to outweigh the potential benefits in this case. Notably, stored plasma retains 87% of initial PChE activity after 21 days at 4°C, without loss of enzymatic function.[8]

Experimental treatments, including plant-derived recombinant PChE[9] and large-scale purification of PChE from serum,[10] are currently under development. However, due to limited availability and insufficient supporting evidence, these are not yet recommended for routine use in the management of suxamethonium apnoea.

Conclusion

Suxamethonium apnoea is a rare but potentially life-threatening condition, especially if unrecognised. It highlights the importance of safe emergence and extubation practices to prevent harmful adverse events. A key aspect of safe practice is ensuring spontaneous recovery from suxamethonium before administering non-depolarising muscle relaxants, which helps mitigate the risk of further complications in cases of delayed neuromuscular recovery. The hallmark of treatment is supportive, with precautionary measures such as a warning card in addition to patient education, family screening, and genetic counselling to help prevent future episodes from reoccurring.

Declarations

Informed consent for publication

Informed consent was obtained from the patient for the inclusion of the clinical data and images contained in this case report. The informed consent for publication form has been completed, signed, and submitted along with the manuscript.

Competing interests

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Case report
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Resection of tracheal tumour under cardiopulmonary bypass: a case report

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Abstract

Primary tracheal tumours can cause critical airway obstruction, challenging standard anaesthetic management. We report the case of a 66-year-old male with a large subglottic tracheal tumour causing severe airway compromise. Due to a high intubation risk, endoscopic transoral laser resection was performed using femoro-femoral cardiopulmonary bypass (CPB) for oxygenation, uniquely deferring endotracheal intubation until after tumour removal. Despite a brief intraoperative desaturation episode and postoperative bleeding requiring intervention, the benign oncocytoma was successfully resected, and the patient recovered well. This case demonstrates femoro-femoral CPB as a safe and effective alternative for airway management during resection of severely obstructing tracheal tumours.

Keywords: airway management, cardiopulmonary bypass, oncocytoma, tracheal tumour

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Introduction

Primary tracheal tumours represent rare neoplasms, constituting approximately 0.2% of all malignancies, with an annual incidence rate of merely 0.142 per 100,000 individuals.[1] The nonspecific nature of their clinical manifestations, including persistent cough, progressive dyspnoea, and intermittent stridor, frequently results in diagnostic delays and potentially severe complications, notably critical airway obstruction.[1] The anaesthetic management of tumour excision in such instances can pose significant challenges, particularly when standard airway techniques are rendered impractical due to the extent of obstruction.

This case report delineates the effective management of a 66-year-old male patient presenting with a substantial tracheal tumour that induced severe airway compromise. We portray the effectiveness of femoral veno-arterial cardiopulmonary bypass (CPB) as a viable alternative to standard endotracheal intubation for airway control. This approach fulfils 2 essential functions: it alleviates the dangers associated with conventional intubation in a critically compromised airway and it affords the surgeon an operative field unobstructed by the endotracheal tube (ETT), thereby enhancing the precision of tumour resection.

Although the clinical presentation shares similarities with previously documented cases, our management strategy differed notably from those reported in the literature. Prior reports describe distinct approaches, such as initiating CPB as a rescue measure following failed intubation attempts in one instance[2] or, in another scenario, performing endotracheal intubation attempts only after CPB had been established prior to the surgical intervention.[3] In contrast to these methods, endotracheal intubation in our case was deferred until the conclusion of the surgery.

Case presentation

A 66-year-old, 75-kg male with a significant history of chronic tobacco use, presented with a clinical picture characterised by persistent cough, progressive dyspnoea, and intermittent stridor. A positron emission tomography scan identified a hypermetabolic mass situated posterior to the infra-cricoid region of the subglottic at the C6/C7 vertebral level, measuring 1.6 cm x 1.5 cm x 1.5 cm, which was obstructing more than two-thirds of the tracheal lumen (Fig. 1A).

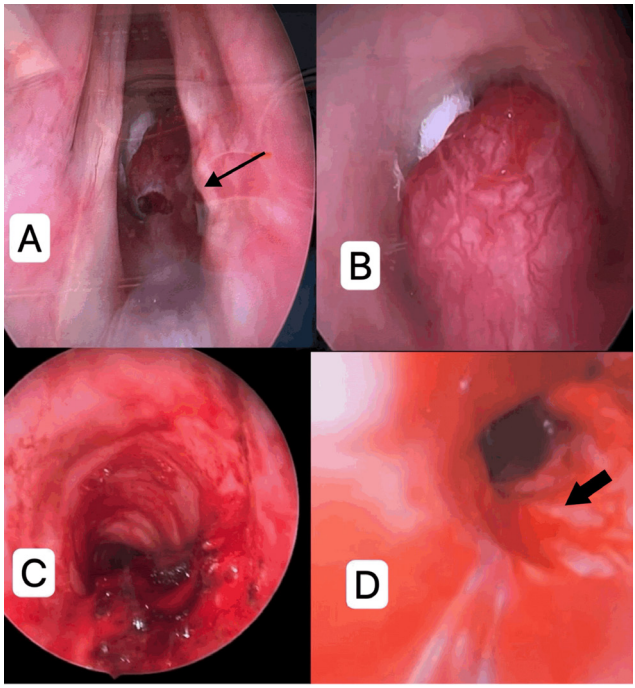

Fig. 1. Image obtained during a bronchoscopy procedure. *(A)* Tracheal tumour, inferior to the vocal cord (thin arrow). *(B)* Ribbon gauze is packed adjacent to the tracheal tumour (11 o'clock position). *(C)* Post-resection of tracheal tumour. *(D)* Blood is seen dripping beyond the ETT (thick arrow).

Preoperative imaging substantiated the degree of the obstruction. Following a discussion with the surgical team, a strategic plan for an endoscopic transoral resection, facilitated by veno-arterial extracorporeal oxygenation through the utilisation of a CPB device, was formulated. The patient was apprised of the potential risks and benefits inherent to the procedure, and formal consent was procured.

To ensure optimal management throughout the surgical intervention, a multi-disciplinary team decided on an extracorporeal oxygenation technique using CPB. Attempts at endotracheal intubation were deemed inadvisable due to the elevated risk of unsuccessful intubation and the possibility of iatrogenic injury to the tracheal tumour. A pre-procedural ultrasound scan on the femoral vessels was performed, and both the anaesthesia and surgical team decided on right femoral artery and vein cannulation.

The anaesthesia team administered a 3-in-1 right femoral nerve block (FNB) using 30 ml 0.5% ropivacaine for analgesia and immobilisation during femoral cannula insertion. Ensuring that the local anaesthetic dose did not exceed the toxic dose, we allowed the cardiothoracic surgeon to supplement this with further local infiltration of 10 ml 0.5% bupivacaine during cannulation.

We administered 30,000 units of heparin, equivalent to 400 units/kg. The surgeon performed the cannulation, guided by a transthoracic echocardiogram (TTE). A 19 Fr cannula was placed in the right femoral artery, whereas the right femoral vein was cannulated with a multi-staged 25 Fr cannula. After ensuring adequate heparinisation, CPB was initiated, allowing for a secure airway management strategy without the need for endotracheal intubation.

Once CPB was established at full flow, the patient was anaesthetised using total intravenous anaesthesia with target-controlled infusion (TCI) of remifentanil and TCI propofol. Depth of anaesthesia was guided by processed electroencephalogram throughout the surgery. Anaesthesia was maintained using propofol at a target concentration of 1.0–4.0 µg/ml and remifentanil at a target concentration of 2.0–3.0 ng/ml.

Five minutes after CPB commencement, the perfusionists informed that the venous drainage was inadequate and not able to achieve the targeted cardiac index. The patient then desaturated to 85% due to the shunt. Saturation was restored promptly with immediate, gentle bag-mask ventilation with FiO2 1.0 and repositioning of the venous line under TTE guidance, using subcoastal bicaval view. The tip of the venous line was seen in the superior vena cava. Adequate gas exchange with good oxygenation was achieved.

The surgery was then continued. A 2 x 2 cm, well-rounded, broad-based vascular tumour was observed arising from the membranous trachea. To prevent soiling of the lower airway, ribbon gauzes were packed adjacent to the mass (Fig. 1B). Endoscopic transoral resection of the tracheal tumour was performed utilising a laser by the otolaryngologist, with a total resection time of 1.5 hours. Post-resection, a bronchoscopy was performed to inspect the lower airway, and residual old blood was suctioned out (Fig. 1C).

Following adequate haemostasis, the patient was intubated with an 8.5-mm ETT prior to weaning from CPB. Once ventilation was established, the patient was weaned from CPB, and heparin was reversed with 240 mg protamine using a protamine:heparin ratio of 0.8:1.0. Total CPB time was 100 minutes. The patient was kept ventilated in the cardiac intensive care unit (CICU) overnight.

On the following day, a moderate amount of blood-stained secretion was noticed from ETT suctioning. Bedside bronchoscopy in the CICU revealed active bleeding in the lower airway and around the ETT (Fig. 1D). The patient underwent an immediate examination under anaesthesia using a rigid direct laryngoscope (DL). The ETT was removed, and the oxygenation was maintained by low-frequency jet ventilation through the side port of the DL. After satisfactory haemostasis, the patient was re-intubated with an 8.5-mm ETT and kept ventilated for another day.

The patient was successfully extubated on day 2 post-surgery and discharged well from the hospital on postoperative day 5. Histopathology showed an oncocytoma/nodular oncocytic hyperplasia with no cytological atypia and no apparent mitosis. Given the benign nature of the tumour, further tracheal resection was not required.

Discussion

Anticipated challenges

Haemorrhage risk and management

Intraoperative heparinisation increases the risk of postoperative bleeding, which is a significant concern after tumour resection. Established protocols were in place to manage this risk. Bleeding management was planned to be guided by point-of-care viscoelastic testing, which was readily available. This approach allows for targeted transfusion therapy, aiming to optimise the use of blood products and minimise risks associated with over-transfusion. If bleeding occurred that compromised the airway, immediate steps would include suctioning the distal airway to maintain patency. Should severe bleeding lead to an inability to ventilate effectively (initially supported with bag-valve-mask ventilation and airway clearance), the contingency plan involved converting the CPB circuit to veno-arterial extracorporeal membrane oxygenation (ECMO). Subsequent management would occur in the CICU to maintain adequate oxygenation and perfusion.

CPB: risks and specific precautions

The use of CPB entails known risks, including cannulation site injury, thromboembolism, haemodilution, trauma to blood components, systemic inflammation potentially leading to organ dysfunction (such as neurological, cardiac, renal, pulmonary), and air embolism. Neurological complications, such as stroke or cognitive changes, are notable concerns. To minimise the risk of vascular access

failure, pre-cannulation ultrasound was used to assess the planned site, and the contralateral side was evaluated as a backup option. If desaturation occurred upon initiating CPB, the primary assessment would focus on the adequacy of venous drainage. While acknowledging these potential complications, CPB was considered necessary for the planned procedure, with the anticipated benefits judged to outweigh the inherent risks.

Laser airway surgery safety protocols
Although laser airway surgery is a tubeless technique that avoids direct oxygen delivery to the surgical field, following specific safety protocols during the procedure remains essential. A preoperative team briefing reinforced these standard operating procedures. Key safety measures included using appropriate protective shields for the patient's eyes and ensuring all staff in the operating room wore wavelength-specific laser safety eyewear. Additionally, moist gauze barriers were placed in the airway distal to the operative site, and sterile water was kept immediately available for emergency use should thermal injury or fire occur.

Management
The management of tracheal tumours, particularly those causing severe airway obstruction, presents significant challenges for both anaesthesiologists and surgeons.[2,4] This case report highlights the successful use of femoro-femoral CPB for airway management during the resection of a large tracheal tumour.

The decision to utilise CPB in this case was crucial for several reasons. Firstly, it provided a secure means of oxygenation without the need for endotracheal intubation, which could have been hazardous given the extent of tracheal obstruction.[5] This approach aligns with findings that CPB is an effective method for oxygenation during difficult tracheal surgeries where airway control is predictably difficult or impossible.[6] Secondly, the use of CPB allowed for a clear, unobstructed surgical field, facilitating precise tumour resection. This advantage is particularly important in cases of near-total tracheal occlusion, as noted by Spaggiari *et al.*, who emphasised the benefits of CPB in providing an optimal surgical view for robotic-assisted tracheal resections.[7]

The perioperative management in our case, including the use of regional anaesthesia for femoral cannulation and careful monitoring during CPB initiation, reflects best practices in complex airway management. The desaturation episode during CPB initiation highlights the need for vigilant monitoring and prompt intervention, as highlighted by Surman in his review of CPB in non-cardiac surgery.[6]

Postoperatively, the development of bleeding complications necessitating surgical revision is a known risk in tracheal surgery. Our management approach, including prompt bronchoscopy and surgical intervention, aligns with recommendations emphasising the importance of early detection and management of postoperative complications in tracheal cancer surgery.[5,6]

The histopathological finding of an oncocytoma in our case is noteworthy. While squamous cell carcinoma and adenoid cystic carcinoma are more common, the diverse histological types of tracheal tumours underscore the need for individualised treatment approaches. Importantly, oncocytoma is a benign tumour, and therefore, extensive tracheal resection was not necessary in this case. This highlights the importance of accurate histopathological diagnosis in guiding the extent of surgical intervention.[1]

It is worth noting that CPB is generally more cost-effective compared to venovenous-ECMO for short-term support during surgical procedures.[8] However, the risks and benefits of CPB versus venovenous -ECMO need to be carefully considered, as CPB may require central cannulation and comes with a higher risk of neurological complications.[6,8]

FNB offers several advantages over neuraxial techniques for cannulation prior to CPB. FNB provides targeted analgesia without affecting systemic blood pressure, which is crucial during CPB initiation. It poses a lower risk of spinal hematoma in heparinised patients compared to neuraxial blocks. In cases of CPB-related coagulopathy, FNB is safer and easier to manage. Unlike neuraxial blocks, FNB preserves lower extremity motor function, allowing for early mobilisation post-procedure.[3,4]

Despite the use of CPB, laser ENT surgery still presents several challenges. The oxygen-rich environment in the airway continues to pose a fire risk during laser use, requiring extreme caution and specialised safety protocols. Laser plume formation from tissue vaporisation can create potentially harmful particles and pathogens, necessitating effective smoke evacuation systems. The procedure demands specialised laser-resistant equipment, including ETTS and instruments, which may not be readily available in all settings. Precise coordination between the surgical and anaesthesia teams is crucial to manage ventilation and laser activation safely.[5]

Conclusion

This case demonstrates the safety and viability of using femoro-femoral CPB as an oxygenation method for complex tracheal cancer surgeries where conventional intubation is almost impossible. Meticulous planning and clear communication with team members across multiple disciplines are crucial to ensure patient safety and ultimately a successful surgery.

Declarations

Informed consent for publication
The patients provided written informed consent to publish the clinical data and images contained in this report.

Competing interests
None to declare.

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None to declare.

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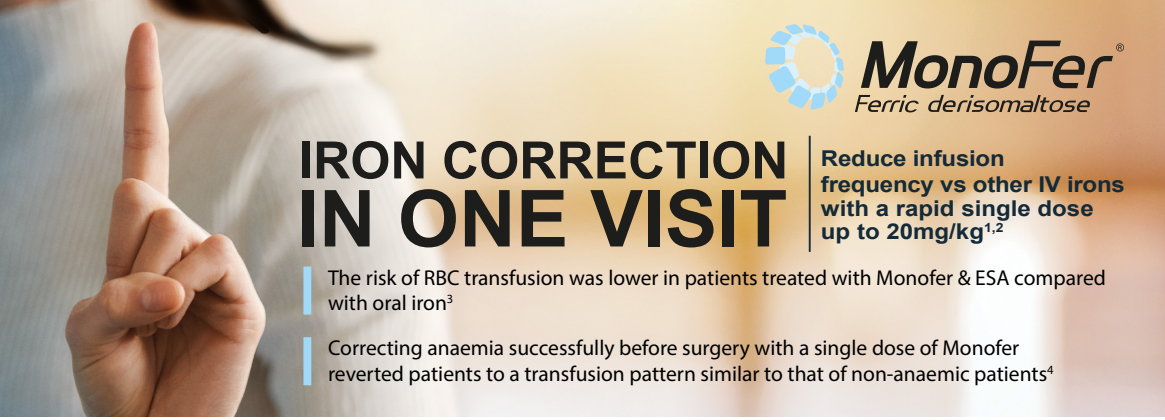

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Recommendations for Management Of Anemia In Surgical Patients

Preoperative anemia is associated with worsened clinical outcomes (e.g., increased morbidity and mortality). Additionally, anemic patients are at a much higher risk of being transfused

Anemia and transfusions are independently associated with poor clinical outcomes. Together, they amplify the risk. Appropriate management of anemia can reduce patients' exposure to transfusions and improve clinical outcomes

Clear evidence-based guidelines for the management of anemia are needed owing to conflicting results from clinical studies

Expert panel → Review of literature → Consensus-based clinical recommendations for the management of anemia in surgical patients

Recommendations

- All patients except those undergoing minor procedures should be screened for anemia preoperatively
- If anemia is detected, its cause should be diagnosed
- Cause-appropriate treatment is then initiated
- Preoperative iron-deficiency anemia should be treated with iron therapy unless contraindicated
- Intravenous iron therapy is preferable to oral therapy
- Postoperative anemia should be treated without delay (before discharge)

Early identification and effective treatment of anemia could improve clinical outcomes in surgical patients

PBM: Patient Blood Management,

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