ISSN: 3069-0684
medicaleducationclinic.com

Volume 2 | Issue 4
November 2026

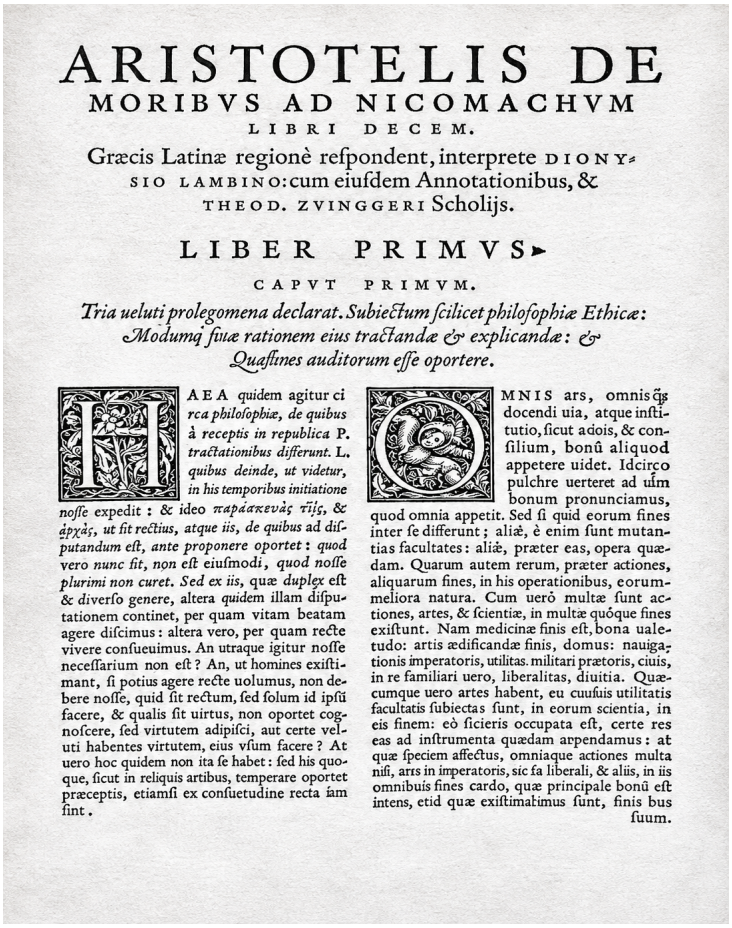
CLINICS IN MEDICAL EDUCATION

Docendo Discimus
(By teaching we learn)



Beth Israel Lahey Health
Beth Israel Deaconess Medical Center
Department of Anesthesia, Critical Care and Pain Medicine
Center for Education Research, Technology and Innovation

HARVARD MEDICAL SCHOOL



ARISTOTELIS DE
MORIBVS AD NICOMACHVM
LIBRI DECEM.

Græcis Latinæ regionè reſpondent, interprete DIONYSIO LAMBINO: cum eiuſdem Annotationibus, & THEOD. ZVINGGERI Scholijs.

LIBER PRIMVS.

CAPVT PRIMVM.

Tria ueluti prolegomena declarat. Subiectum ſcilicet philoſophiæ Ethicæ: Modumq́ ſuæ rationem eius tractandæ & explicandæ: & Quaſtines auditorum eſſe oportere.

TAEA quidem agitur circa philoſophiæ, de quibus à receptis in republica P. tractationibus differunt. L. quibus deinde, ut videtur, in his temporibus initiatione noſſe expedit: & ideo παράσκευὰς τῆς, & ἀρχὰς, ut ſit rectius, atque iis, de quibus ad diſputandum eſt, ante proponere oportet: quod vero nunc ſit, non eſt eiuſmodi, quod noſſe plurimi non curet. Sed ex iis, quæ duplex eſt & diverſo genere, altera quidem illam diſputationem continet, per quam vitam beatam agere diſcimus: altera vero, per quam recte vivere conſueuimus. An utraque igitur noſſe neceſſarium non eſt? An, ut homines exiſtimant, ſi potius agere recte uolumus, non debere noſſe, quid ſit rectum, ſed ſolum id ipſũ facere, & qualis ſit uirtus, non oportet cognoſcere, ſed virtutem adipiſci, aut certe veluti habentes virtutem, eius vſum facere? At uero hoc quidem non ita ſe habet: ſed his quoque, ſicut in reliquis artibus, temperare oportet præceptis, etiamſi ex conſuetudine recta ſam fint.

OMNIS ars, omnisq́ docendi uia, atque inſtitutio, ſicut adois, & conſilium, bonû aliquod appetere uidet. Idcirco pulchre uerteret ad uſm bonum pronunciamus, quod omnia appetit. Sed ſi quid eorum fines inter ſe differunt; aliæ, è enim ſunt mutantias facultates: aliæ, præter eas, opera quædam. Quarum autem rerum, præter actiones, aliquarum fines, in his operationibus, eorum meliora natura. Cum uerò multæ ſunt actiones, artes, & ſcientiæ, in multæ quóque fines exiſtunt. Nam medicinæ finis eſt, bona ualetudo: artis ædificandæ finis, domus: nauigationis imperatoris, utilitas. militari prætoris, ciuis, in re familiari uero, liberalitas, diuitia. Quæcumque uero artes habent, eu cuuſuis utilitatis facultatis ſubiectas ſunt, in eorum ſcientia, in eis finem: eò ſicieris occupata eſt, certe res eas ad inſtrumenta quædam arpendamus: at quæ ſpeciem affectus, omniaque actiones multa niſi, arts in imperatoris, sic fa liberali, & aliis, in iis omnibuis fines cardo, quæ principale bonũ eſt intens, etid quæ exiſtimatimus ſunt, finis bus ſuum.

Nicomachean Ethics,
First page of a 1566 edition of the Aristotolic Ethics in Greek and Latin, the philosophical study of the good for human life, that which is the goal or end at which all our actions aim toward.

"The purpose of knowledge is action, not knowledge"

Aristotle



Nyansapo "Wisdom Knot": A symbol of wisdom, ingenuity, intelligence, and patience. The proverb associated with this Adinkra is "Nyansapo wosane no badwenma," to wit, "A wisdom knot is untied (only) by the wise."



Our Website

Check us out online! medicaleducationclinic.com offers the latest updates in research, academia, and pedagogy from the Department of Anesthesia, Critical Care and Pain Medicine at BIDMC. The site features extra content, interactive courses, quizzes, and a wide array of engaging resources. Click here to explore and enhance your learning experience!

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DOCENDO DISCIMUS

Usman Ahmed

CLINICS IN MEDICAL EDUCATION

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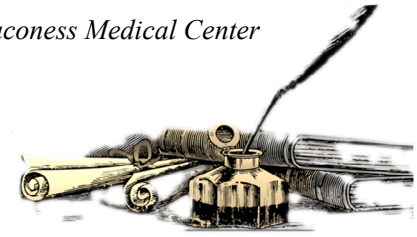
EDITOR'S WELCOME

We are thrilled to share our latest issue of the Clinics in Medical Education Journal. This interactive educational journal reaches up to 750+ healthcare professionals through our electronic newsletter to academic institutions across the United States and globally. Our website reaches approximately 600 viewers who repeatedly visit our latest articles and educational resources. Every month, we continue to remain devoted to our mission of providing educational resources to residents and faculty. We are presenting unique, complex clinical cases embedded in the pages of this journal. This journal serves as a continued resource for learning, encompassing quizzes, visual aids, ultrasound images, CT scans, X-rays and interpreting invasive and non-invasive monitoring.

In addition to innovative ideas and academic writing being showcased, this journal has become the result of a rigorous, rapid turn-over peer review process. The journal will be released bi-monthly and continue to endorse peer-review. We look forward to your continued readership!

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OUR MISSION

- Empowering scholarly dialogue and advancing knowledge through rigorous research and insightful perspectives.
- Advancing medical education through effective teaching practices and ongoing mentorship.
- Fostering excellence in medical teaching through continuous innovation and professional growth.

Coaching as a Tool, Helping Trainees Think for Themselves

Daniel Walsh MD



Anesthesiology faculty give feedback to residents and students every day, and many also serve as mentors. Coaching is a third tool that often gets blurred into those two, yet it can shift a conversation in a way that neither feedback nor mentoring does. Some scenarios where a coaching approach may be helpful include debriefing a case that didn't go as planned, renewing motivation in a competent trainee that may have become checked out, end-of-rotation conversations, when straightforward feedback hasn't moved the needle, or a learner that likely has the knowledge yet lacks confidence. You don't need a coaching certification or a medical education background to begin using any of this approach.

Three Tools You Can Implement Today

Three habits that you can begin to implement today include: 1. Ask before you tell, 2. Get comfortable with silence, 3. Resist solving it for them. Coaching isn't a replacement for feedback or mentoring, but as a third tool it can help many conversations. Think about reaching for a coaching approach when you want the resident to own the answer, and not simply hear yours. Small moves can make a big difference; one good question can shift an entire conversation.

For those interested in pushing their coaching skills even further. Check out the Coach Training for Leaders and Educators in Healthcare program through SEA partnered with SeattleCoach - https://www.seahq.org/coach-training-for-leaders-educators - registration is open for the 2027 course now.

Structure to Start With: The GROW Model

GROW (Goal, Reality, Options, Way Forward) is a widely used coaching structure and a great place to start.

Same Moment, Three Approaches

A resident struggled with a difficult airway — three attempts.

Feedback	Mentoring	Coaching
"Your positioning was off — that's likely why intubation took three attempts. Next time, use a higher ramp for a patient built like that."	*"I struggled with difficult airways too as a resident. What helped me most was time in bariatric anesthesia and pediatric anesthesia cases. You will get plenty of those experiences."*	*"What's your read on how that went? ...* *What would you want to try differently next time?"*

Same facts, same resident — the coaching version is the only one where the resident does the thinking.

Click here to watch our talk on "Coaching as a Toolkit for Leadership"

AI Use in Education

Samir Kendale MD



Artificial intelligence is moving into medical education from tools that personalize studying to tools that residents and attendings may use to streamline applications. We discussed in our presentation, how AI assisted application screening compared with actual faculty perception of applicants in recently published reviews. Currently, numerous educational resources exist for anesthesia residents, however the resources are often scattered across multiple platforms, making it difficult to access critical information quickly during the demands of a busy workday. Due to this gap that existed, a CA-1 resident at BIDMC leveraged large language model (LLM) technology to develop Anes360, a web-based reference guide created by anesthesia residents, for anesthesia residents. Designed to support a smoother transition from intern year to CA-1, Anes360 was conceived as a one-stop resource, to be used as a point-of-care companion that consolidates essential tools and information into a single, user-friendly platform. The platform offers a comprehensive drug reference, covering all essential agents used for induction, muscle relaxation, opioids, and reversal agents.

AI is not a monolith but a broad label for many technologies, so its uses and risks vary widely. Learners already use it daily, and educators must respond to keep up with the pace of AI.

How AI is used in Medical Applications: The Bigger Picture

In a study of nearly 4,000 medical school applicants, interview recommendations from an algorithm and from faculty were assessed, and models applied to residency applications were able to discriminate between them. AI stations in multiple mini-interviews were consistent with traditional ones, and applicants who used AI gained no advantage. These tools improve efficiency, but cannot predict who will become an excellent physician, and they carry forward historical bias.

Although AI has been used to structure these medical interviews, only after AI has generated questions, did faculty review and refine those specific questions. Studies we explored in the talk: 1) AI LLMs as oral examiners (using dedicated models), 2) AI grading of short answers, and 3) MMI style interviews.
During our talk we discuss the AI standardized Clinical Encounter (ASCE), as published in the 2025 NEJM. This AI system was aimed at early clerkship students to provide structured repeatable virtual patient encounters with AI generated feedback over two and a half months. The main outcome of the study showed a modest but statistically significant improvement (11.4 vs 10.7, P=0.02). For residency programs, the idea that the Lavigne trial was supporting was that structured AI practice may be useful as an adjunct instead of a replacement for traditional clinical skills training.
Oral board practice only works if you have guard rails around the LLM with these oral board exam-style question design.

Judgment grows from building plans, explaining physiology and defending decisions. Fears of deskilling are not new; they arose with the stethoscope, CT and ultrasound. New technologies continue to arrive and its role continues to develop, the goal should be to continue to encourage responsible use. AI is different to pre-existing technology as it sounds confident even if it is wrong. The DEFT framework from the New England Journal of Medicine states: “Show me what you did”.

Conclusion
Overall, among these frontiers of large language models, no single platform is clearly better. The reason for this is because performance depends on the task. AI offers anesthesiology education real opportunities in adaptive learning, simulation, clinical reasoning. The evidence is still early and the rate of development is significant. In conclusion, the common thread is that AI should support the president’s own reasoning rather than replace their thinking.

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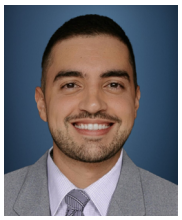
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Click here to watch our talk on "AI Uses in Medical Education"

How to Make a Great Problem-Based Learning Discussion

Miguel Magallanes-Esqueda MD, Federico Puerta-Martinez MD

A good problem-based learning discussion gives people a chance to think out loud. Participants commit to a plan, say why, and revise it when the situation changes. The case itself can be ordinary. What makes the session work is whether the group has a real decision in front of it and more than one reasonable way to go. So the first thing to settle is what you want the group to decide. The rest of the planning follows from that.

Start with the decisions

Begin where your learners get stuck. Before writing the case, ask what they find hard to decide in practice. For residents, it might be whether new respiratory symptoms should change an anesthetic plan that already seemed settled. Once you can name that difficulty, build three to five objectives around it, using verbs that describe something you could watch someone do: identify, compare, justify, revise. “Understand perioperative respiratory risk” gives you nowhere to go. “Justify a perioperative plan using this patient’s risk factors” tells you what to ask in the room. Give each objective one task, then check the step that is easy to skip: does the case actually give learners a chance to do it?

Choose a case with room for judgment

Once the decisions are set, the case only has to carry them. Open with three or four sentences: who is the patient, what is planned, what makes this difficult, and what is known right now. A rare diagnosis is not required. A familiar case works as long as it offers real options, while an unusual one with a single correct answer tends to stall. Leave learners enough to begin reasoning and a reason to ask what happens next.

Let the case unfold

Plan the turning points before filling in the narrative. If the case spans preoperative, intraoperative, and postoperative care, let each phase bring a new decision, though you do not have to cover all three. One well-built phase is usually better than three thin ones. Reveal each finding at the point where it would change or test the plan on the table. If a detail adds atmosphere but changes no decision, it can usually go. Say the group has just settled on a plan for a patient with pulmonary disease. That is a good moment to mention the recent change in symptoms and ask what they would do differently now.

Ask questions that make people think

How you ask matters as much as when. Compare “What complications can occur?” with “Which complication matters most for this patient, and why?” The first checks recall. The second asks for judgment and gives the group something to discuss. Keep the questions open, let several people answer before you respond to any of them, then ask the group to defend or revise what it said. When the room goes quiet, offer a prompt rather than the answer. When one voice takes over, ask for another view before moving on. The aim is to keep the reasoning moving without turning the session into a lecture.

Prepare the discussion and test it

Facilitating that lightly in the moment takes preparation. Write brief instructor notes under each question: why a reasonable choice fits this case, why the alternatives are weaker, and what new finding would change the answer. Cite a few key references, and say where the evidence is thin. Then test the session. Ask a colleague, or better, someone from the intended audience, to work through it while you watch. Did they have enough information at each step? Did the case give them a chance to meet every objective you wrote? Does the timing leave room for several voices? A short outline and a few focused references sent ahead help participants arrive prepared. Close with a decision. One question is usually enough: “What

would change your plan in the next patient?" If participants can answer that, they leave with something more useful than a list of facts.

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Beyond the Checklist: The Promise of Artificial Intelligence in Clinical Education and Patient Safety

Nadav Levy MD



Artificial intelligence (AI) offers new opportunities in clinical education, particularly through its ability to analyze performance, recognize patterns, and provide feedback without requiring continuous faculty observation. Yet much of the current discussion focuses on what AI can automate rather than what it might meaningfully improve.

One of the most accessible applications is evaluating adherence to checklists and predefined performance criteria. Given reliable data, AI can identify completed actions, detect omissions, and generate consistent performance reports. It may perform these tasks more systematically than human observers, who must divide their attention among multiple aspects of a clinical encounter. This has clear value for assessment and quality assurance. But is it necessarily good education?

Knowing that a trainee missed three steps in a checklist tells us something about performance, but relatively little about why those steps were missed or how to prevent similar errors in the future. Clinical competence requires more than remembering and executing a prescribed sequence of actions. It involves recognizing relevant information, anticipating problems, making decisions under uncertainty, and adapting to changing circumstances.

The more interesting question, therefore, is whether AI can help us accomplish the tasks that make good clinical educators and debriefers effective.

From Assessment to Learning

Effective clinical teaching goes beyond identifying correct and incorrect actions. Experienced educators explore the reasoning behind decisions, identify gaps in knowledge or understanding, and help learners consider alternative approaches. A trainee may follow every step of a protocol yet fail to recognize a deteriorating patient. Another may appropriately depart from an established sequence because the situation demands it. An assessment based solely on checklist adherence may struggle to distinguish between these performances. AI could offer a more comprehensive assessment by examining not only individual actions but also their timing, sequence, and relationship to the evolving clinical situation.When provided with physiologic data, clinical interventions, and communication records, AI systems may identify significant decision points, delayed responses, or missed opportunities for intervention. However, observing what happened is not equivalent to understanding why it happened. Even with detailed information, AI cannot reliably determine a learner's reasoning or intentions. Its observations may help generate questions for discussion, but they should not be treated as definitive explanations of behavior. This distinction is central to the educational potential of AI. Rather than simply providing answers or listing errors, an effective AI-supported learning system might help educators identify which questions to ask, which decisions deserve further exploration, and where focused teaching could be most valuable.

Augmenting Simulation Training

Simulation provides a practical environment for exploring these capabilities. It allows trainees to practice clinical management and decision-making while generating information that can be reviewed without placing patients at risk. During simulation, instructors must often observe several dimensions of performance simultaneously, including clinical decisions, technical skills, situational awareness,communication, and teamwork. Even experienced faculty cannot reliably capture every relevant event. AI may help address this limitation by analyzing recorded encounters and presenting observations that might otherwise be

missed. The goal would not be to replace faculty-led debriefing, but to improve the information available to instructors and learners. Early studies are encouraging. Brügge and colleagues (2024) reported improved clinical decision-making scores among medical students who received structured feedback during AI-supported patient simulation, although the study involved only 21 participants. Tscholl and colleagues (2026) demonstrated the feasibility of AI-generated reports for team-based simulation debriefing. Experts valued the detailed observations and transcripts, while identifying limitations including inaccurate categorization, speaker misidentification, and insufficient clinical context. These studies suggest that AI can contribute useful information to clinical education, but they do not establish that AI- generated feedback produces learning outcomes comparable or superior to expert debriefing. A potentially more important application is the ability to examine performance over time.

Faculty typically observe individual trainees intermittently and may have limited accessto their earlier performances. AI-supported systems could potentially track recurring difficulties, document progress, and identify learning needs across multiple encounters. Such longitudinal information could support more individualized teaching and help distinguish isolated errors from persistent gaps in performance. The educational value would depend on whether these observations lead to more effective teaching and measurable improvements in subsequent performance.

Beyond Simulation: From Observation to Patient Safety

The potential applications of AI are not limited to simulation. In actual clinical practice, much of what clinicians do occurs without systematic observation or structured feedback. Learning often depends on personal reflection, informal discussions, and the review of significant adverse events. AI could potentially expand these opportunities by observing selected aspects of routine clinical care. In procedural environments, for example, AI might integrate information from physiologic monitors, electronic records, equipment, and recorded communication. Such systems could help identify delays in recognizing deterioration, communication failures, deviations from expected management, or patterns of performance that warrant further review. This could create opportunities to learn not only from adverse events, but also from routine encounters, near misses, and examples of effective clinical management. Importantly, it could provide a more complete picture of clinical performance than retrospective documentation alone.

The more ambitious possibility is to move from retrospective observation to real-time clinical assistance. Rather than identifying a missed opportunity after an encounter, an AI system might recognize an emerging safety concern and alert clinicians while corrective action remains possible. This could include identifying concerning physiologic trends, discrepancies between available information and clinical decisions, or overlooked changes in a patient's condition.

There is already evidence that selected AI-based clinical alerts can improve outcomes. In a randomized trial involving nearly 16,000 hospitalized patients, Lin and colleagues (2024) found that AI-enabled electrocardiogram alerts identifying patients at increased risk of mortality were associated with reduced 90-day mortality. However, recognizing a specific risk signal is very different from interpreting the full complexity of clinical care. These findings do not establish that AI can reliably evaluate clinical decision-making across an entire encounter or determine when intervention is appropriate.

Moving toward such applications would require careful validation, attention to false alerts and unintended consequences, and clear definitions of clinical responsibility. Fornow, the role of AI in supporting real-time clinical decisions should be distinguished from the broader goal of independently evaluating or directing patient care.

Challenges and Future Directions

The value of AI-generated feedback depends on the quality of the information available and the validity of its interpretation. A system may consistently identify predefined actions while missing the clinical circum-

stances that explain them. It may also produce convincing but incorrect assessments, particularly when important information is absent. These limitations are especially relevant when AI is used to evaluate clinical reasoning, communication, or teamwork. A transcript may capture what was said without adequately representing nonverbal communication, competing demands, or the situational factors influencing a decision.

Implementation also raises questions about privacy, transparency, and learner trust. Continuous observation could improve opportunities for feedback, but it could also be perceived as surveillance, particularly if educational data are used for formal assessment or punitive purposes. Clear boundaries between formative education, competency assessment, and patient safety monitoring will be essential. Future research should move beyond asking whether AI can generate plausible feedback. The more consequential questions concern its educational impact: Can AI help identify learning needs that faculty might otherwise miss? Can it improve the quality of debriefing? Can it help learners recognize errors in their reasoning, retain skills, and perform better in subsequent encounters? Ultimately, the most important outcome is whether these improvements transfer to actual clinical practice.

The Promise

Checklist adherence, standardized scoring, and automated feedback represent useful starting points for AI in clinical education. Their value, however, should not define the limits of our ambition. The greater opportunity is to use AI to connect clinical observation with meaningful learning. By identifying patterns across encounters, supporting more focused debriefing, and providing information that might otherwise go unnoticed, AI could help educators and learners better understand clinical performance.

Beyond education lies the possibility of applying similar capabilities directly to patient safety, recognizing developing problems while there is still an opportunity to influence the outcome. The goal is not to build an artificial instructor who remembers every checklist item. It is to develop tools that help clinicians learn from their decisions, improve their judgment, and ultimately deliver safer care.

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Research in Medical Education

Aviva Green MD, Inna Epstein MD



Medical education presents unique challenges for those seeking to conduct rigorous evidence-based research. Unlike many clinical or laboratory studies, teaching and learning take place in complex settings, where interventions are difficult to standardize and outcomes are not always easy to measure . Medical education research asks not only whether something works, but also how people learn, why an approach works, and for whom. This work can help us update educational methods, promote knowledge retention, with the overall goal of providing excellent patient care. Research questions should not be only relevant to a specific program. They must be considered in the broader context of learning, making learning theories and conceptual frameworks a critical part of the study. Generalizability is important if educators hope to apply findings to their own teaching methods. Qualitative and quantitative methods offer complementary ways of understanding complex topics such as professional development, clinical reasoning, motivation, and more.

Quantitative Research

Quantitative research begins with an idea shaped into a clear research question. One useful format for developing and evaluating intervention-focused questions **is PICOTS: Population, Intervention, Comparison groups, Outcome, Timing, and Setting .** The research question helps determine the appropriate study design, while educational theories or frameworks provide a foundation for understanding why a particular outcome might occur.

For example, consider a residency program aiming to train residents in massive transfusion protocol management. One might ask: “Among anesthesia residents in a large teaching hospital, does taking part in a simulated scenario of a bleeding patient improve adherence to hospital guidelines compared with watching an informational video on the topic?” Conceptual frameworks such as situated learning, in which people learn through participation in practice, or experiential learning, in which people learn through experience and reflection, could help explain why simulation might be effective.

Study designs include cross-sectional and cohort studies, which observe exposures and outcomes without assigning an intervention; quasi-experimental studies, which evaluate interventions without random assignment; and experimental studies, which use randomization. Each design has its own benefits and limitations.

Outcomes can be categorized using Kirkpatrick’s four levels of training evaluation:

1. Reaction—learner satisfaction

2. Learning—changes in attitudes, knowledge, or skills

3. Behavior—application of learning in practice

4. Results—broader effects on patients or organizations .

In our massive transfusion example, performance during a simulated scenario would generally reflect learning (Level 2), whereas adherence to guidelines during actual clinical care would reflect behavior (Level 3). Data are collected using appropriate, valid measurement tools and analyzed with suitable statistical tests. Confounders, potential biases, and the many related factors that contribute to learning all create challenges in medical education research.

Qualitative Research

While quantitative research focuses on measuring variables and relationships, qualitative research aims to understand and highlight participants' different perspectives, experiences, and the context in which learning occurs. Quantitative studies can also measure subjective experiences, such as satisfaction, but qualitative research explores these in greater depth. Qualitative research often takes place in participants' natural settings. Data may be collected through in-depth interviews, observations in situ, documents (journal entries, social media posts, etc.), or a combination of these. While sometimes viewed as less rigorous than quantitative research, it's often an appropriate tool for answering medical education questions, highlighting insights that would otherwise be missed with quantitative data alone.

Several methodologies are used in qualitative research. Grounded theory explores social processes and builds a theory to explain the phenomenon being studied. With our residents learning massive transfusion protocols, we might ask: "How do anesthesia residents develop and apply clinical decision-making strategies for massive transfusion protocols following simulation-based training?"

Qualitative descriptive studies provide a comprehensive account of an event as described by those experiencing it. Theoretical frameworks, such as situated learning, can guide what researchers ask, observe, and interpret.

Qualitative Research Methodologies

Methodology	Definition
Grounded theory	Explores social processes to develop a theory grounded in the data.
Phenomenology	Examines how individuals experience and make sense of a particular phenomenon.
Ethnography	Explores a group's shared culture, behaviors, and practices.
Case study research	Examines a clearly defined case or problem in depth within its context.
Qualitative descriptive studies	Provides a straightforward, detailed account of experiences or events using participants' descriptions.

Qualitative data analysis often begins during data collection and helps shape subsequent rounds. Identifying recurring patterns and organizing data into categories is part of coding. The researcher's perspective can offer insight, and it is not something to be controlled for or minimized. Having said that, the researcher's assumptions and influence must be examined through reflexivity. Criteria for rigorous qualitative research include reflexivity about the researcher's influence, adequacy of the data collected, authenticity of participants' accounts, trustworthiness of the analysis, and resonance of interpretations with the group being studied.

Conclusion

Medical education research can, and should, be conducted with scientific rigor. Quantitative research is useful for measuring outcomes and relationships, while qualitative research lends itself to understanding experiences, context, and learning processes. Mixed-methods research integrates both approaches to provide a fuller understanding of an educational question. A sound theoretical framework, meaningful outcomes, and rigorous methods help produce high-quality medical education research.

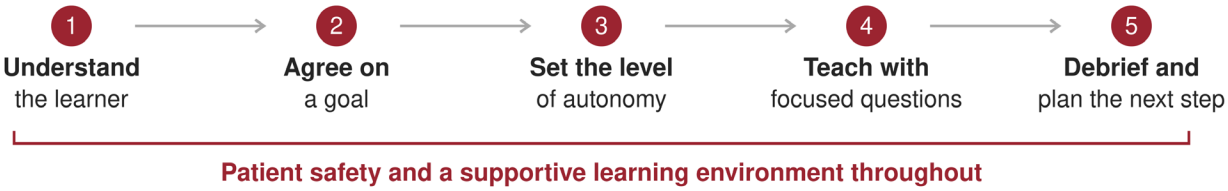
Teaching in the Operating Room

David Benavides-Zora MD, Amna Irfan Ansari MD





Much of learning in anesthesia residency happens in the operating room, where decisions have immediate consequences and time is often limited. Teaching in this setting takes planning, but it can fit into the work day through brief conversations before, during, and after a case.



What residents want

Residents appreciate teachers who explain their decisions and give them room to learn, with guidance that matches their experience. For a junior resident, this may mean talking through a procedure step by step, while a more experienced resident may be ready to take the lead with supervision. That balance can change quickly during an emergency, when the attending may need to step in to keep the patient safe. Staying calm and explaining decisions aloud helps the residents understand what is happening, even when they can no longer lead. Once the patient is stable, a brief discussion can help them make sense of the experience and identify what to carry into the next case.

Briefing before the case

Start with a simple question: “What would you like to work on today?” Together, choose one or two goals that suit the resident’s experience and the planned case. These might include improving a procedural skill or understanding a difficult clinical decision. For a more advanced topic, agreeing on it the day before gives both people time to prepare. Return to the goal during the case and afterward, so the resident can see what they have learned and what still needs work.

Autonomy with clear expectations

Tell residents what they will manage themselves and when you will step in. The amount of help they need depends on what they can safely do, how difficult the task is, and the patient’s condition. Some will need a demonstration or hands-on guidance; others can work with supervision and occasional prompting. Explaining this beforehand helps prevent an intervention from feeling like an unexpected failure. Give residents more responsibility as their skills develop, while remaining ready to help.

Making time for teaching

A short discussion is useful when it addresses something the resident needs to learn. Start with a factual question to check their understanding, then ask about their reasoning: “What concerns you about this induction?” The One-Minute Preceptor approach builds on this: ask for a plan and the reasons behind it, explain a relevant principle, reinforce good practice, and correct mistakes. A quick drawing or demonstration can help. If patient care interrupts the discussion, make a note and return to it later.

Debriefing and constructive feedback

Constructive feedback includes telling residents what they did well and what they can improve. Describe what you observed, explain your concern, and ask what they were thinking. This approach, called advo-

cacy–inquiry, helps avoid assumptions. A resident who responds slowly may understand the problem but struggle to prioritize several tasks. Ask them to reflect on the case, then agree on something to work on next time. Also ask what you could have explained or taught better. Teachers need feedback, too.

Summary

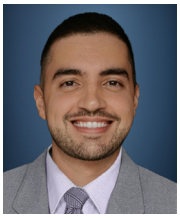
Each case gives residents something to carry into the next one. A brief debrief helps make that lesson clear: what should they keep doing, and what should they change? Following up on those points turns everyday experience into learning, with patient safety guiding how much responsibility the resident takes on.



Click here to review our presentation on "Teaching in the OR"

What Are Non-technical Skills, Anyway?

Federico Puerta-Martinez MD MMSc, Shazaan Nadeem MD





Non-technical skills are the cognitive, social, and personal skills that help us put our clinical knowledge into practice safely and effectively. They include how we communicate, make decisions, organize tasks, and work with others. In anesthesia, we use them when we recognize that a situation is changing, ask for help, or make sure everyone understands the plan. We spend years learning what to do for our patients. These skills help us do it together.

To see why they matter, let's briefly leave the operating room.

On January 15, 2009, US Airways Flight 1549 struck a flock of birds shortly after leaving LaGuardia, causing an almost complete loss of thrust in both engines. Within minutes, Captain Chesley "Sully" Sullenberger and First Officer Jeffrey Skiles had to assess their options and prepare for a landing in the Hudson River. Sullenberger flew the aircraft while Skiles worked through emergency procedures. The cabin crew prepared passengers and managed the evacuation. All 155 people survived. The investigation specifically recognized the crew's decision-making and coordination as contributors to that outcome.

What makes this particularly relevant to healthcare is that this was an *ad hoc team*: people brought together for a particular assignment, rather than a permanent team with an extensive history of working together. Sullenberger and Skiles were on their first trip sequence together. They brought shared training, familiar procedures, and clear expectations about their roles. That gave them a way to coordinate under extraordinary pressure. Sound familiar? Think about the people who arrive when we call a code.

The Center for Medical Simulation (CMS) offers a useful framework for these moments: Name, Claim, Aim. It helps a newly assembled healthcare team establish what is happening, who is doing what, and where the team is heading. We can recognize those same actions in Flight 1549, even though the crew was not using the CMS framework.

Name: Say what is happening

During Flight 1549, the pilots explicitly recognized the loss of thrust in both engines. Naming the problem gave their actions a common starting point.
In healthcare, this might sound like, "We have severe hypotension and ongoing bleeding. I'm concerned about hemorrhagic shock." Saying it out loud helps colleagues understand why we are concerned and what resources we may need. It also creates an opportunity for someone to add information or question our interpretation. We can describe what we see while acknowledging uncertainty. A working diagnosis can evolve as more information becomes available.

Claim: Make the roles clear

Sullenberger's "My aircraft" and Skiles's "Your aircraft" made the transfer of control explicit. One pilot would fly while the other addressed the emergency procedures.
At the bedside, we similarly need to establish who is coordinating the response and how the work will be shared. "I'll coordinate. Can you manage the airway? Who can obtain additional access?" Team members can also volunteer for roles within their competence. This reduces the chance that several people tackle the same task while another task goes unattended. The leader helps organize the team and remains receptive to what others are seeing.

Aim: Give the team a direction

As the available landing options narrowed, Sullenberger made the plan clear: they would land in the Hudson. The instruction to brace translated that decision into an immediate action for those on board.
Our teams need that same shared understanding of the situation and the next steps, often called a *shared mental model*. "Our immediate priorities are to support circulation and control the bleeding. Let's reassess after these interventions." Brief updates help people follow the reasoning and contribute to it. CMS also emphasizes revisiting Name, Claim, Aim as conditions change.

A few specific skills help make this work. **Communication** includes calling out important changes so others hear them and using closed-loop exchanges to confirm that a message was understood. In practice, that means directing a request to someone, hearing it repeated back, and confirming its accuracy. Reporting completion then lets the team know where things stand. **Situational awarenes**s means noticing what is happening, understanding its significance, and anticipating what might happen next. Sharing those observations helps colleagues update their own picture of the situation.

One final thought about how we speak. *Mitigated speech* means softening a message, sometimes out of politeness or deference. In an emergency, that can make urgency harder to recognize. Staying with our beloved aviation examples, consider the crash of Avianca Flight 052 in 1990. After encountering poor weather and spending approximately 77 minutes in holding patterns while approaching New York, the aircraft eventually ran out of fuel. The crew communicated concerns about fuel but did not clearly declare a fuel emergency to air traffic control. The plane crashed, and 73 people lost their lives. The investigation identified the failure to communicate the emergency, along with inadequate fuel management, as probable causes of the accident. Malcolm Gladwell discusses this case and mitigated speech in *Outliers*, which I recommend if you'd like to explore the topic further.

In conclusion, while we may not get to choose who joins us in the next emergency, but we can help everyone work as a team. Name what's happening, clarify roles, share the plan, and keep communicating as things change. And remember: Speak up!

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EXPERT SECTION

The Top Pearls of Wisdom on Interview Technique

Ruma Bose MD, Mike Haering MD, Bala Subramanian MD





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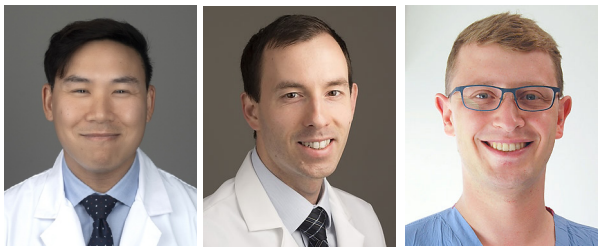
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Update on Best Perioperative Anesthesia Practices for Shoulder Surgery

Khoi Do MD, Andrey Rakalin MD, Victor Polshin MD

Establishing standardized perioperative anesthesia guidelines for elective shoulder surgery is critical to delivering consistent, high-quality patient care and reducing clinical variability across surgical services. These clinical guidelines are built upon established standards of care recommended by national specialty organizations, specifically the American Association of Orthopedic Surgery (AAOS) and the American Society of Anesthesiology (ASA). By translating current evidence-based practices into structured clinical workflows, this framework serves to educate healthcare providers on optimal perioperative pathways for primary, elective shoulder joint arthroplasty and/or arthroscopy. The primary strategic objective is to optimize clinical outcomes by implementing multimodal, opioid-sparing analgesia strategies designed to maximize post-procedural pain relief while minimizing reliance on perioperative opioids, establishing precise intraoperative physiological and blood pressure monitoring targets, standardizing surgical site infection (SSI) and bleeding prevention protocols, and applying structured antiemetic pathways.

With this clinical scope established, the following section outlines the preoperative optimization and regional analgesia protocols recommended prior to surgical incision. The routine administration of preoperative non-opioid analgesia serves as an essential foundation for multimodal pain control. Pre-medicating patients prior to surgical incision ensures therapeutic tissue concentrations are achieved early and reduces intraoperative and postoperative opioid consumption (21). The baseline non-opioid pre-medication regimen consists of oral acetaminophen administered at 1000 mg (21). Clinicians should also consider the addition of non-selective NSAIDs, such as ketorolac, or selective COX-2 inhibitors, such as celecoxib, depending on patient history and available hospital formulary. In general, non-selective NSAIDs offer lower risks of thrombosis; however, have higher risks of bleeding and GI complications. Selective COX-2 inhibitors offer an opposite risk profile. At our institution, celecoxib is readily available and commonly used. The standard preoperative dose for oral celecoxib is 200 mg to 400 mg, provided no patient-specific contraindications exist (21). Celecoxib must be avoided in patients with documented hypersensitivity or allergy to celecoxib, nonsteroidal anti-inflammatory drugs (NSAIDs), aspirin, or sulfonamides. Additional relative contraindications to celecoxib administration include third-trimester pregnancy, breastfeeding, uncontrolled heart failure, active gastrointestinal ulceration or bleeding, inflammatory bowel disease, active cerebrovascular bleeding, severe hepatic impairment, and severe renal impairment defined as a creatinine clearance (CrCl) of less than 30 mL/min. For patients with moderate renal impairment (CrCl between 30 and 60 mL/min) or low total body weight (TBW) (less than 50 kg), a reduced celecoxib dose of 100-200 mg should be considered. If CrCl is less than 30 mL/min, celecoxib should be omitted entirely.

Peripheral regional anesthesia is the cornerstone of analgesia for shoulder procedures. In fact, a number of regional anesthesia techniques, including several discussed here, are robust enough to serve as the sole anesthetic and multiple strategies that utilize regional anesthesia as the primary anesthetic for shoulder surgery have been extensively described (8, 21). The interscalene brachial plexus block represents the clinical gold standard for shoulder surgery due to its robust analgesic efficacy (21). **(Figure 1)** However, clinicians must critically evaluate potential PACU complications associated with interscalene blockade, including respiratory compromise secondary to ipsilateral diaphragmatic paresis from phrenic nerve involvement, Horner's syndrome, and rebound pain (21). In clinical scenarios where interscalene blockade presents safety risks—specifically in patients with underlying pulmonary compromise or severe restrictive lung disease—phrenic nerve-sparing regional techniques should be considered. Phrenic-sparing alternative block strategies include suprascapular nerve block combined with an infraclavicular brachial plexus block or suprascapular nerve block combined with an axillary nerve block (16, 19). The incidence of postoperative rebound pain for shoulder surgery after interscalene blockade is approximately 20% (10). Strategies to minimize its incidence focus primarily on a strong multimodal approach, many of which are discussed here.

Pharmacological adjuvants may be combined with local anesthetics to extend the duration of regional blockade and assist with postoperative analgesia, including rebound pain (5). Perineural preservative-free (PF) dexamethasone may be administered at a dose of 4 mg (15, 17). Alternatively, systemic intravenous dexamethasone may be administered at a dose of 8-10 mg (1, 12). Recent literature suggests that perineural dexamethasone may add slightly longer analgesic duration; however, the evidence is not definitive enough to deem one route of administration more clinically appropriate over the other. That said, there is a theoretical risk of drug crystallization for perineural dexamethasone, which clinicians should keep into consideration. Apart from this, clinicians should exercise caution and reduce the intravenous dexamethasone dose in patients with poorly controlled diabetes mellitus to avoid severe perioperative hyperglycemia (13). Dexmedetomidine may also be employed as an alternative regional adjuvant at doses ranging from 0.5-1.5 mcg/kg, up to a maximum dose of 60 mcg (15). When utilizing dexmedetomidine, diligent intraoperative and postoperative hemodynamic monitoring is mandatory due to the heightened risk of drug-induced hypotension and bradycardia. Besides pharmacological adjuvants, peripheral nerve catheters can also be utilized to extend the duration of regional blockade and assist with postoperative analgesia (7). However, this is dependent on establishing an appropriate system of postoperative inpatient and/or outpatient follow-up care that includes, but not limited to, an acute pain service (APS) and appropriate nursing education and guidelines.

Following optimized preoperative analgesia and regional blockade, the next section reviews intraoperative physiological management and hemodynamic safeguards. Intraoperative management requires balancing adequate depth of general anesthesia with the critical preservation of cerebral perfusion. General anesthesia (GA) should be maintained using an endotracheal tube (ETT) or a laryngeal mask airway (LMA), selected based on individual airway anatomy and patient aspiration risk. GA offers several advantages such as decreased patient movement and discomfort, especially if surgery impacts an area not covered by peripheral nerve blockade (i.e. biceps tenodesis and anterior or posterior arthroscopy insertion sites). However, if avoidance of airway instrumentalization is preferred, sedation can be considered provided that adequate surgical-level anesthetic blockade of the shoulder is established. When surgery is performed in the upright or beach-chair position, strict adherence to a minimum target mean arterial pressure (MAP) of 70 mm Hg, measured at the level of the brain or the external auditory meatus (EAM), is strongly advised to prevent occult cerebral hypoperfusion, ischemic brain injury, and syncope (3). For patients with additional comorbidities, including documented history of cerebrovascular accident (stroke), coronary artery disease (CAD), peripheral artery disease (PAD), and/or chronic hypertension, clinicians should consider establishing a higher baseline intraoperative MAP target and using an arterial line or non-invasive continuous pressure monitoring systems. Additionally, cerebral oximetry can also be considered for high-risk patients. Intravenous fluid resuscitation should be administered using balanced crystalloid solutions. The standard fluid administration target entails delivering 1-2 L of Lactated Ringer's (LR) or normal saline (NS) intraoperatively (4).

Inadvertent perioperative hypothermia increases surgical bleeding, surgical site infection rates, and cardiac morbidity. Active forced-air warming devices must be initiated intraoperatively to maintain patient normothermia, defined as a core body temperature greater than 36 °C (2). Clinical teams must verify that an adequate surface area of the patient's body remains covered by active warming devices throughout the operation (2).

To optimize surgical visualization and minimize intraoperative blood loss, an antifibrinolytic protocol utilizing tranexamic acid (TXA) is recommended (19, 20). This includes intravenous administration of TXA in two doses for shoulder arthroplasty (1 g in 10 mL over 20 minutes prior to surgical incision and 1g in 10 mL over 20 minutes during surgical closure) or 1 dose for shoulder arthroscopy (1 g in 10 mL over 20 minutes prior to surgical incision). Patients with a TBW less than 60 kg should be considered for a reduced dose of 10 mg/kg. Cumulative intraoperative dosing of TXA should be limited to a maximum of 30 mg/kg.

Transitioning from intraoperative maintenance to optimized postoperative recovery, the final section summarizes structured risk-mitigation strategies for postoperative nausea and vomiting (PONV) control and SSI prevention. Proactive, risk-stratified management of PONV is vital to enhancing patient comfort and expediting PACU discharge efficiency (2). Antiemetic therapy is guided by the patient's calculated Apfel score. The Apfel scoring system provides an estimated 24-hour percent risk of PONV depending on the presence of four patient risk factors: female gender, non-smoking status, history of motion sickness or

PONV, and use of postoperative opioids. The presence of each risk factor incrementally elevates the incidence of 24-hour PONV. A patient with 0-1 risk factors (24-hour PONV incidence = 10-20 %) should be considered for administration of ondansetron (4-8 mg). A patient with 2 risk factors (24-hour PONV incidence = 40 %) should receive ondansetron and be considered for dexamethasone (4-8 mg). A patient with 3 or more risk factors (24-hour PONV incidence = 60-80 %) should receive ondansetron and dexamethasone and should be considered for preoperative placement of a scopolamine patch and/or intraoperative maintenance via total intravenous anesthesia with propofol. Note, if dexamethasone is utilized as a regional analgesia adjuvant and is simultaneously administered for PONV prophylaxis, the combined cumulative dose of dexamethasone across both indications must not exceed 10 mg (2).

SSI prevention relies on timely, weight-adjusted prophylactic intravenous antibiotic administration completed prior to incision (10). All patients should receive cefazolin unless there is a known history of a true allergy to cefazolin. Patients with a TBW less than 120 kg should receive 2 g cefazolin, ideally 30-60 minutes prior to surgical incision. Patients with a TBW greater than 120 kg should receive 3 g cefazolin, ideally 30-60 minutes prior to surgical incision. If a patient has a true allergy to cefazolin, then he/she should alternatively receive vancomycin, ideally 1-2 hours prior to surgical incision. Patients should receive 15 mg/kg (maximum dose = 2 g). If a patient has current MRSA colonization or known prior infection, they should receive both cefazolin and vancomycin with dosing recommendations as above.

In conclusion, elective, primary shoulder joint arthroplasty and/or arthroscopy are common surgeries performed at many hospitals and ambulatory surgery centers. By integrating standardized perioperative clinical protocols ensures high-quality medical care, optimizes patient safety, promotes rapid postoperative recovery, and minimizes variability across different surgical services.

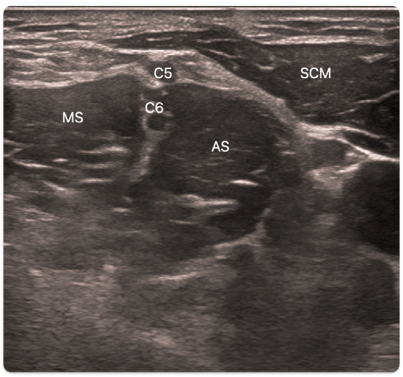


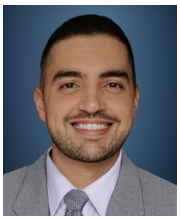
Figure 1. *Ultrasound image of interscalene nerve block. MS = middle scalene muscle, AS = anterior scalene muscle, C5/C6 = C5 and C6 nerve roots, and SCM = sternocleidomastoid muscle.*

Explore the anatomy of the interscalene region through this interactive presentation

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Neurogenic Shock After Acute Thoracic Spinal Cord Injury: Hemodynamic and Anesthetic Considerations


Federico Puerta-Martinez MD,
Juan D. Caicedo-Jaramillo MD,
Amna Irfan Ansari MD

Introduction

Traumatic spinal cord injury (TSCI) is associated with substantial neurologic and systemic morbidity, especially when cervical and upper thoracic cord injuries may disrupt descending sympathetic pathways. (1) This leads to vasodilation, venous pooling, hypotension, and bradycardia, the hallmarks for neurogenic shock. (2–4) Recognition of neurogenic shock is complicated by coexisting hemorrhagic, cardiogenic, or obstructive shock further compromising spinal cord oxygen delivery exacerbating secondary injury. (3,5) Perioperative management therefore requires coordinated resuscitation, vasoactive support, airway and anesthetic planning.

We describe a patient with TSCI at T1 vertebral level who developed profound hypotension and recurrent bradycardia secondary to neurogenic shock. The case illustrates the challenges of providing cardiovascular support and spinal cord perfusion during urgent surgical management of upper thoracic SCI.

Case Presentation

A 75-year-old woman with hypertension, type 2 diabetes mellitus, asthma, and hypothyroidism presented after fall from two stories. Her initial recorded blood pressure was 50/30 mmHg, with intermittent sinus bradycardia and heart rates of 30-40 beats/min. She remained alert, with a Glasgow Coma Scale score of 15. There was complete absence of motor function and sensations in both lower extremities, with a sensory level at T4. Upper-extremity motor function was relatively preserved, but she had asymmetric weakness and pain.

Initial resuscitation included intravenous fluids and dual vasopressors with reported mean arterial pressure (MAP) of approximately 110 mmHg. A third vasopressor was added due to recurrent bradycardia. Thoracic and cervical magnetic resonance imaging reported a severe T1 fracture-dislocation with a Chance-type fracture pattern and approximately 2 cm of posterior displacement with complete spinal cord transection at the T1 vertebral level (Figure 1). Additional trauma imaging demonstrated bilateral hemothoraces and a small pneumothorax.

She underwent urgent fracture reduction and posterior decompression with instrumented fusion from C4 to T4. A cerebrospinal fluid leak was encountered intraoperatively. Estimated blood loss was approximately 750 mL, and reported resuscitation included 4.5 L of intravenous fluid, three units of packed red blood cells, and one unit of fresh frozen plasma. She remained intubated after surgery and was admitted to the neurocritical care unit for continued vasoactive support, neurologic monitoring, and management of the TSCI.

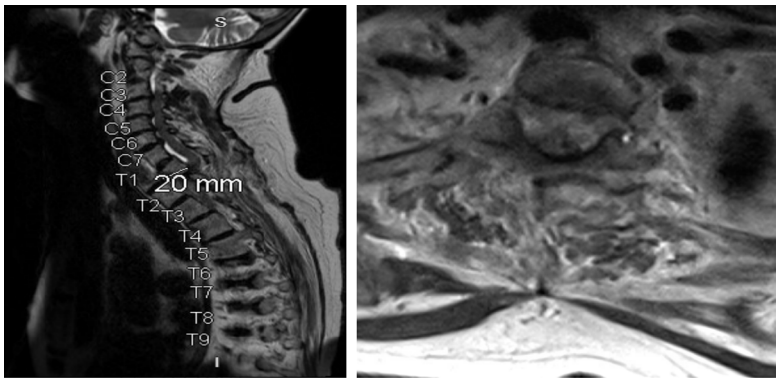
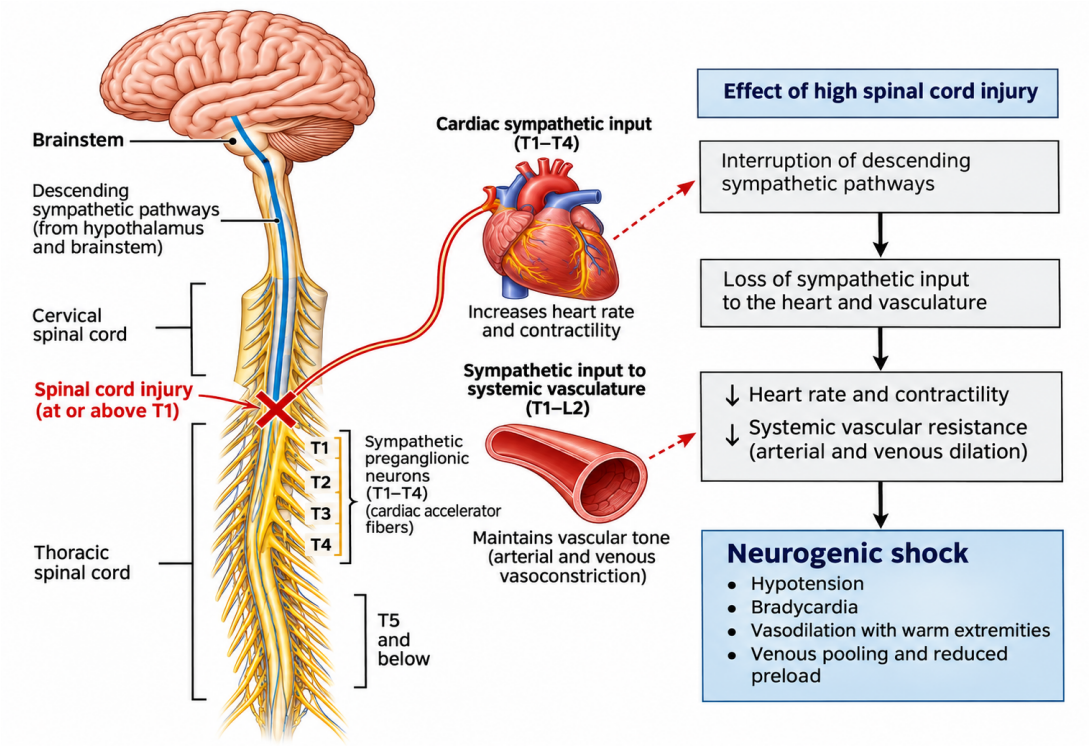


Figure 1. Thoracic and cervical MRI without contrast, sagittal (left) and axial (right) views. Severe traumatic fracture-dislocation at T1, with approximately 2 cm posterior displacement

Discussion



The profound hypotension and bradycardia in this patient were consistent with neurogenic shock following upper thoracic SCI. Disruption of descending sympathetic pathways can impair vascular tone and cardiac sympathetic activity, resulting in vasodilation, venous pooling, and bradycardia due to relatively preserved vagal influence. (3,4,7) However, these findings do not exclude other causes of shock (Table 1). In this patient, bilateral hemothoraces raised concern for concurrent hemorrhage, emphasizing the importance of evaluating associated injuries while initiating resuscitation. (3,5)

Hemodynamic management following acute SCI aims to maintain systemic and spinal cord perfusion while minimizing secondary injury. The 2024 AO Spine/Praxis guideline suggests a lower MAP augmentation limit of 75–80 mmHg and an upper limit of 90–95 mmHg for 3–7 days, although these recommendations are supported by very low-certainty evidence. (2) A 2025 randomized trial found no significant improvement in neurologic recovery with augmented MAP targets but reported more respiratory complications and organ dysfunction, supporting an individualized approach. (12) The reported MAP of approximately 110 mmHg in this patient highlights the need for continued reassessment of hemodynamic support, although a single measurement cannot establish excessive augmentation.

Vasoactive therapy should be guided by the relative contributions of vasodilation, bradycardia, and impaired cardiac output. No specific vasopressor is recommended by current SCI guidelines, making individualized selection and frequent reassessment important. (2,8) In this patient, recurrent bradycardia required additional chronotropic support. Perioperative management must also account for hemodynamic deterioration during anesthetic induction, positive-pressure ventilation, and prone positioning. Continuous arterial pressure monitoring, adequate resuscitation, and readily available vasoactive medications are essential during urgent surgical management (Table 2). (3,10)

Table 1. Differentiating shock states following traumatic spinal cord injury

Shock type	Mechanism	Clinical features	Initial management
Neurogenic	Disruption of descending sympathetic pathways causes vasodilation, venous pooling, and reduced cardiac sympathetic activity. (3,4,7)	Hypotension with relative bradycardia; warm skin may be present. High-level SCI is an important clue, but findings are not diagnostic. (3,7)	Assess for concurrent hemorrhage; restore volume when indicated, provide vasoactive support, and treat significant bradycardia. (2,3,5)
Spinal shock*	Transient depression of spinal cord function below the lesion, particularly reflex activity and muscle tone; not a circulatory shock state. (3,7,16)	Flaccidity and areflexia or hyporeflexia below the injury, with motor and sensory impairment. No defining BP or heart-rate pattern. (3,7,16)	Stabilize the SCI and reassess neurologic and reflex findings. Evaluate and treat concurrent circulatory shock separately. (3,7,16)
Hemorrhagic	Acute blood loss reduces circulating volume, venous return, and cardiac output. (14,15)	Hypotension, usually with tachycardia; external or occult bleeding (including hemothorax) and poor peripheral perfusion. (5,14,15)	Identify and control bleeding; give blood products and activate massive transfusion when indicated. (5,15)
Cardiogenic	Impaired cardiac pumping due to myocardial injury, ischemia, or significant arrhythmia. (14,15)	Hypotension with evidence of cardiac dysfunction; ECG and echocardiography may help distinguish it. Heart rate varies. (14,15)	Identify and treat the cardiac cause; tailor inotropic or vasoactive support to hemodynamics. (14,15)
Obstructive	Mechanical impairment of cardiac filling or output, e.g., tension pneumothorax or cardiac tamponade. (14,15)	Hypotension, often with tachycardia; chest examination and focused ultrasound may identify the cause. (14,15)	Relieve the obstruction promptly, including pleural decompression for tension pneumothorax. (14,15)

Table 2. Perioperative management of neurogenic shock following traumatic spinal cord injury

Management domain	Key recommendations	References
Initial assessment	Assess concurrent shock mechanisms, volume status, associated injuries, and cardiac function.	(3,5)
MAP augmentation	Suggested lower limit 75–80 mmHg and upper limit 90–95 mmHg during active augmentation for 3–7 days; very low-certainty evidence.	(2)
Vasoactive support	Individualize vasopressors. Norepinephrine provides vasoconstriction and β_1 activity; phenylephrine may worsen bradycardia.	(2,6,8,13)
Bradycardia	Treat significant bradycardia with atropine or chronotropic support; consider pacing if refractory.	(3,5)
Spinal cord perfusion	Avoid hypotension and hypoxemia. Routine SCPP-guided management is not established.	(2,6,9)
Airway and induction	Anticipate hypotension and vagal bradycardia; maintain arterial monitoring and immediate vasoactive support.	(3,10,11)
Intraoperative management	Reassess after prone positioning; guide fluid and blood-product replacement by clinical status and ongoing losses.	(3,10)

Conclusion

Profound hypotension accompanied by marked bradycardia after upper thoracic SCI should prompt recognition of neurogenic shock while maintaining concurrent evaluation for hemorrhagic and other traumatic causes of instability. Management requires support of vascular tone, heart rate, and systemic perfusion, together with individualized spinal cord perfusion targets. Careful airway planning, anticipation of induction- and positioning-related deterioration, and repeated reassessment of vasoactive and volume requirements are central to the perioperative care of these patients.

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Redesigning the Liver Transplant Anesthesia Learning Environment: A Paired Resident Rotation to Promote More Consistent Clinical Exposure



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Abstract

Background. Unpredictable transplant timing can make pager-based resident participation uneven. We evaluated whether a protected paired-resident rotation would improve the distribution of participation rather than increase the typical case count.

Methods. We introduced a two-week paired rotation on October 1, 2025. We compared five months of participation with the same period one year earlier and surveyed participating residents and faculty.

Results. Sixteen rotation residents and 17 historical residents were evaluated; 47 and 49 liver transplants occurred, respectively. Median participation was 3 cases in both cohorts (interquartile range, 2-3.25 after implementation vs 2-4 historically). No rotation resident had zero cases, compared with 3 of 17 historical residents (Fisher exact P = .23), and the exploratory Gini coefficient decreased from 0.38 to 0.26. All 16 residents rated the rotation as educationally valuable, 13 reported improved learning compared with pager coverage, and all 7 faculty respondents supported continuation.

Conclusions. During the study period, every resident in the paired rotation participated in at least one liver transplant, whereas 3 of 17 residents in the historical cohort participated in none. Median participation remained unchanged at 3 cases per resident, although the overall distribution of exposure was less unequal. Longer follow-up should determine whether this pattern persists and improves performance.

Keywords: anesthesiology residency; curriculum; graduate medical education; liver transplantation; workplace-based learning; educational equity

Introduction

Liver transplantation offers anesthesiology residents concentrated experience with hemodynamic instability, coagulopathy, large-volume transfusion, advanced vascular access, point-of-care coagulation testing, and multidisciplinary care. Because many anesthesiologists who care for transplant recipients do not complete a transplant fellowship, residency remains the principal setting for foundational training.1-3 These high-acuity skills also benefit residents who do not pursue transplant practice.

However, pager coverage is often added to routine operating room work. Participation then depends on case timing, overnight workflow, service demands, and whether a resident can leave another assignment. Exposure may consequently be fragmented and uneven. Comparable variability in operative experience has been reported across surgical trainees.4 This variability is particularly relevant to competency-based education, which depends on access to experiences that permit repeated supervision, feedback, and progressive autonomy.5-9

We replaced pager coverage with a protected two-week rotation for paired senior residents. We evaluated whether the rotation would reduce zero-case outcomes and variability in participation while supporting continuity and interdisciplinary learning. We compared the first five months with the corresponding period one year earlier and surveyed participating residents and faculty.

Materials and Methods

Study Design and Intervention

We conducted a single-center program evaluation in the 77-resident anesthesiology residency at Beth Israel Deaconess Medical Center, an Accreditation Council for Graduate Medical Education-accredited tertiary referral center. We compared residents participating from October 1, 2025, through February 28, 2026, with residents eligible during

the corresponding period one year earlier. The institutional review board deemed the project exempt (protocol 2026P000470). Surveys were voluntary and anonymous, and no protected health information was collected.

Under the historical model, clinical anesthesia year-3 residents carried a 24-hour transplant pager in addition to routine operating room assignments. The new two-week rotation paired two residents who exchanged primary and backup roles after one week (Figure 1; Table 1). The primary resident was protected from routine weekday assignments and preferentially staffed liver transplants; the second resident provided backup, relief, and coverage for other transplant-related cases. Interdisciplinary activities and a faculty presentation were also included. Table 1 provides the complete schedule, case types, and duty-hour provisions.

Outcomes and Analysis

The primary outcome was the distribution of liver transplant participation, particularly zero-case outcomes and variability. Secondary outcomes were total case volume, median participation, and exposure yield, defined as cases divided by eligible historical pager days or intervention primary-resident days. Epic SlicerDicer supplied case-volume data, and QGenda supplied resident assignments. Residents without historical pager coverage or a completed intervention rotation were excluded from resident-level analyses.

After five months, residents and supervising faculty completed anonymous surveys; the instruments are provided in Supplementary Materials 1 and 2.

We report descriptive statistics, with interquartile ranges calculated using linear interpolation, and used Fisher's exact test to compare zero-case proportions. Survey summaries combine Agree and Strongly agree. Open-ended responses were reviewed for recurring themes but were not formally analyzed. Lorenz curves and Gini coefficients were exploratory (Supplementary Figure S1).

Results

Clinical Exposure

Annual institutional transplant volume is summarized in Supplementary Table S1. The intervention included 16 residents and 47 liver transplants; the historical cohort included 17 residents and 49 transplants.

Every rotation resident participated in at least one liver transplant, whereas 3 of 17 historical residents (18%) participated in none (Fisher exact P = .23; Figure 2). Median participation remained 3 cases per resident (interquartile range, 2-3.25 after implementation vs 2-4 historically), with ranges of 1-7 and 0-6, respectively.

Exposure yield was similar after implementation and historically (0.31 vs 0.33 cases per eligible day). The resident-level yield range shifted from 0-1.00 to 0.13-0.57, and the exploratory Gini coefficient decreased from 0.38 to 0.26 (Table 2; Supplementary Table S2; Supplementary Figure S1).

Resident survey responses after the structured rotation (n = 16).

Domain and item	n	SA	A	N	D	SD	A + SA, %
Exposure and equity							
Adequate liver transplant exposure	16	10	5	1	0	0	94
Equitable access among residents	16	6	7	1	1	1	81
Clinical engagement							
Active intraoperative decision making	16	10	6	0	0	0	100
Meaningful experience with end stage liver disease	16	11	5	0	0	0	100
Structure and predictability							
R1/R2 model improved organization	16	7	6	3	0	0	81
Predictable, well organized experience	16	4	8	2	2	0	75
Appropriate clinical/educational balance	16	6	8	1	1	0	88
Fewer disruptions than pager coverage	16	9	4	3	0	0	81
Interdisciplinary learning							

Domain and item	n	SA	A	N	D	SD	A + SA, %
Better understanding of interdisciplinary care	16	10	6	0	0	0	100
Hepatology and blood bank activities enhanced learning	16	6	4	5	1	0	62
Workload and fairness							
Appropriate workload	16	7	7	1	1	0	88
Fair distribution of R1/R2 duties	16	8	3	3	2	0	69
Confidence and readiness							
More confident managing liver transplant anesthesia	16	11	5	0	0	0	100
Better prepared for complex perioperative cases	16	11	5	0	0	0	100
Overall value							
Valuable educational experience	16	11	5	0	0	0	100
Improved learning compared with pager coverage	16	9	4	3	0	0	81

Abbreviations: A, agree; D, disagree; N, neutral; SA, strongly agree; SD, strongly disagree.

Resident Perceptions

All 16 residents responded (Supplementary Table S3). All rated the rotation as educationally valuable and endorsed its clinical, interdisciplinary, confidence, and readiness outcomes. Thirteen (81%) reported improved learning compared with pager coverage. Ratings were lower for role fairness (69%) and the educational value of hepatology and blood bank activities (62%).

Comments emphasized continuity and immersion while identifying overnight relief, backup expectations, and more active use of nonclinical time as priorities.

Faculty Perceptions

All seven faculty responded (Supplementary Table S4). All considered the rotation an improvement over pager coverage, supported its continuation, and would recommend a similar model. Six (86%) endorsed improved preparation, decision-making, autonomy, and interdisciplinary learning. Comments identified post-call workflow, backup coverage, communication, and role clarity as priorities.

Discussion

During the five-month evaluation, every resident in the paired rotation participated in at least one liver transplant, whereas 3 of 17 residents in the historical cohort participated in none. Median participation remained 3 cases per resident, and case volume and exposure yield were similar. The rotation therefore changed the distribution of exposure rather than the typical number of cases. The narrower interquartile range and lower exploratory Gini coefficient also suggested less unequal exposure, although the zero-case comparison was not statistically significant. Favorable resident and faculty responses support the rotation's educational value and acceptability, but do not establish improved competence.

Under pager coverage, participation depended on case timing and competing assignments. Protected time and a backup resident reduced this dependence and allowed more continuous involvement. This structure may support repeated observation, feedback, and progressive responsibility, consistent with experience-based learning and competency-oriented supervision.7-10 From a competency-based perspective, reasonable access to essential experiences may be more important than identical case counts.5,6,9 Whether more reliable access improves performance remains unknown.

Interdisciplinary activities broadened learning beyond intraoperative care, but resident ratings suggested that observation alone was not consistently useful. Defined tasks, presentations, or quality-improvement projects may make this time more active. The paired schedule also supported post-call and simultaneous-case coverage, although staffing, productivity, and workflow effects were not measured. Future iterations should clarify overnight relief, backup

responsibilities, communication, and the use of nonclinical time.

The model may be relevant to other high-acuity, low-frequency experiences. Because formal transplant anesthesiology fellowships remain limited, residency provides foundational training for many anesthesiologists who later care for transplant recipients.1-3 The rotation does not replace fellowship training, and adaptation elsewhere would require consideration of local volume, staffing, and educational needs.

This evaluation was limited to one center, 33 residents, five months of intervention data, and a nonconcurrent historical comparison. The zero-case difference was not statistically significant. Surveys were locally developed and unvalidated; respondents knew the curriculum's purpose; and confidence was self-reported. The needs assessment was based on departmental observations, and open-ended responses were not formally analyzed. We did not assess entrustment, performance, patient outcomes, sustainability, or operational effects; distribution analyses were exploratory.

Conclusion

During the study period, every rotation resident participated in at least one liver transplant, while median participation remained unchanged. Full-year follow-up should determine whether this distribution persists and whether more reliable participation improves assessment, entrustment, or performance.

Acknowledgments

OpenAI Codex was used to assist with language editing and manuscript formatting. The authors reviewed and approved all content and take full responsibility for the final manuscript.

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Acute Right Ventricular Failure: Recognition and Initial Management

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Acute right ventricular (RV) failure occurs when impaired RV filling or ejection produces systemic venous congestion, reduced cardiac output, or both.[1] It represents the circulatory consequence of RV dysfunction and can develop with pulmonary embolism, RV infarction, acute respiratory distress syndrome, sepsis, decompensated pulmonary hypertension, or cardiac surgery.[2] Recognition integrates evidence of hypoperfusion and venous congestion with echocardiographic findings.[1]

Pathophysiology

The RV normally accommodates changes in preload but is particularly sensitive to abrupt increases in afterload[3]. A sudden rise in pulmonary vascular resistance impairs RV ejection and can cause dilation; excessive volume loading can also produce RV distension and failure.[1] The ventricles share the interventricular septum and are enclosed within the pericardium. Through this ventricular interdependence, RV pressure and volume influence left ventricular (LV) filling, while LV and septal contraction contribute to RV pressure generation.[2] The septum normally curves toward the RV, and its position reflects the pressure difference between the ventricles and their relative volumes.[2] Leftward septal displacement and reduced pulmonary blood flow limit LV preload and systemic cardiac output.[1] RV dilation can also cause functional tricuspid regurgitation, further increasing venous congestion.[1] Hypotension and increased RV wall tension compromise coronary perfusion, promoting ischemia and further contractile dysfunction.[1] An underfilled LV in this setting can therefore reflect RV failure and be mistaken for hypovolemia.[2]

Bedside recognition

RV and LV failure share manifestations of hypoperfusion, including hypotension, oliguria, cool extremities, and rising lactate.[4] Accompanying jugular venous distension or elevated central venous pressure (CVP) should prompt assessment for RV involvement.[1] Elevated venous pressure contributes to renal dysfunction and hepatic congestion.[2] Superimposed hypoperfusion can cause acute hypoxic liver injury, reflected by a marked rise in aminotransferases; impaired hepatic clearance can also contribute to persistent lactate elevation.[4]

Bedside echocardiography connects these hemodynamic findings to ventricular function. Transthoracic or transesophageal imaging assesses RV and LV size, RV contraction, septal configuration, and tricuspid regurgitation.[5] Systolic septal flattening indicates RV pressure overload, while predominantly diastolic flattening suggests volume overload.[5] An enlarged RV with leftward septal displacement and a small LV suggests impaired RV forward flow and restricted LV filling.[1] Tricuspid annular plane systolic excursion (TAPSE) and fractional area change (FAC) complement this assessment (Table 1). Interpret these measurements together with ventricular geometry, loading conditions, and the clinical course.[5]

Initial management

Treatment addresses the precipitating cause while restoring perfusion and optimizing RV loading conditions (Table 2).[2] Fluid decisions integrate CVP trends, tissue perfusion, and echocardiography.[1] Inadequate preload supports a small fluid challenge followed by immediate reassessment.[6] Rising CVP without improved output or perfusion is a signal to stop further fluid loading; congestion may require diuresis.[1]

Maintaining systemic arterial pressure supports RV coronary perfusion.[3] Norepinephrine is an initial vasopressor for hypotension; vasopressin can be added when further systemic vasoconstriction is needed.[3]

Correction of hypoxemia, hypercapnia, and acidemia reduces RV afterload.[3] Ventilation should preserve recruitment while limiting overdistension.[6] Intubation requires preoxygenation, hemodynamic preparation, and immediate vasopressor availability.[6] Preserving sinus rhythm and atrioventricular synchrony supports RV filling.[6]

Serial echocardiography and trends in CVP, tissue perfusion, urine output, lactate, and renal and hepatic indices establish the response to treatment.[2,4] Persistent hypoperfusion or escalating vasoactive requirements warrant early multidisciplinary evaluation for mechanical circulatory support.[6]

Table 1. Bedside recognition of acute RV failure

Combine hemodynamic findings with assessment of ventricular size, septal shape, and systolic function.

Assessment	Finding	Clinical interpretation
Hemodynamics	Raised JVP or CVP with hypotension or oliguria	Venous congestion with hypoperfusion.
CVP and fluid response	Rising CVP without improved cardiac output or perfusion during fluid administration	Poor tolerance of fluid loading; stop further fluid and reassess.
Echocardiography	Enlarged RV	RV enlargement relative to the LV.
	Enlarged RV, small LV, and leftward septal displacement	Reduced LV preload from impaired RV forward flow and ventricular interdependence.
	Systolic septal flattening with a D-shaped LV	RV pressure overload.
	Reduced RV free-wall contraction	RV systolic dysfunction.
	TAPSE ≤17 mm	Reduced longitudinal RV systolic function.
	RV FAC ≤35%	Reduced RV systolic area change; incorporates free-wall and septal contraction.
	Annular dilation or leaflet tethering with regurgitation	Functional TR can increase venous congestion and reduce effective forward flow.
End-organ injury	Rising creatinine, aminotransferases, or lactate	Renal or hepatic injury and impaired tissue perfusion; follow serial trends.

TAPSE and FAC thresholds follow ASE 2025 reference limits: normal TAPSE >17 mm and FAC >35%. After cardiac surgery, interpret TAPSE with FAC and the overall echo assessment. These findings support RV dysfunction; clinical and hemodynamic consequences establish RV failure.[3]

CVP, central venous pressure; FAC, fractional area change; JVP, jugular venous pressure; LV, left ventricle; RV, right ventricle; TAPSE, tricuspid annular plane systolic excursion; TR, tricuspid regurgitation.

Table 2. Initial management of acute RV failure

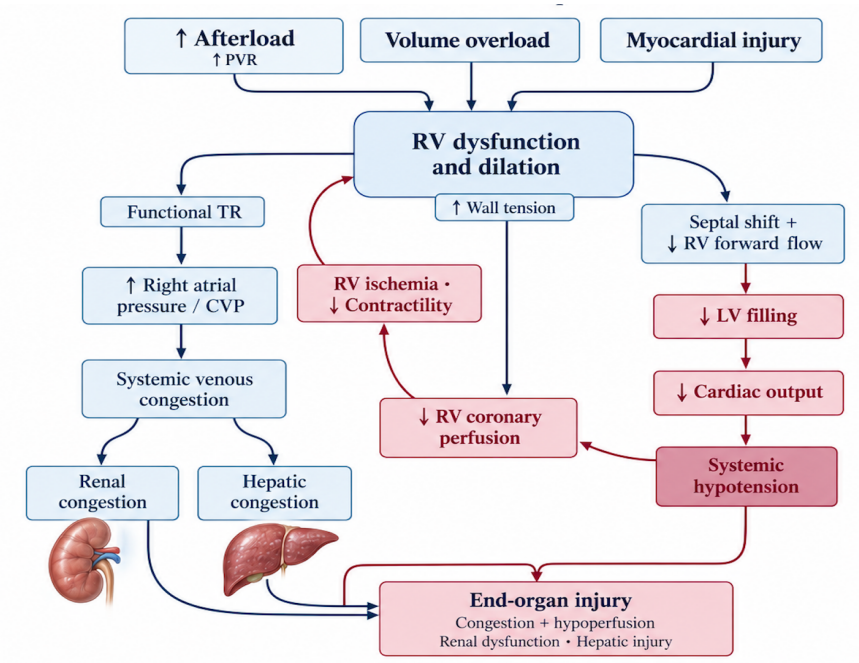
Treat the precipitating cause in parallel with circulatory support. The following priorities are reassessed together after each intervention.

Target	Physiological objective	Initial approach
Afterload	Reduce elevated PVR	Correct hypoxemia, hypercapnia, and acidemia. Use low tidal volumes. Reduce PEEP while preserving alveolar recruitment; both collapse and overdistension increase PVR. Consider prone positioning in appropriate ARDS patients. Inhaled nitric oxide or epoprostenol can provide temporary pulmonary vasodilation; monitor oxygenation and hemodynamic response.

Target	Physiological objective	Initial approach
Perfusion pressure	Increase SVR and maintain coronary and organ perfusion	Use norepinephrine for hypotension: increases SVR. Add low-dose vasopressin when further vasoconstriction is required: differentially increases SVR without affecting PVR.
Contractility	Improve RV forward flow	Consider dobutamine or milrinone for persistent low output despite adequate arterial pressure and optimized loading conditions. Both can cause hypotension and arrhythmias; milrinone also lowers PVR. Reassess output and use the lowest effective dose.
Preload	Maintain filling while limiting RV distension	If assessment supports inadequate filling, give a small fluid challenge, and immediately reassess CVP, perfusion, and echo. Stop if CVP rises without improved output or perfusion. Use diuresis for congestion while monitoring arterial pressure and renal function.
Ischemia	Restore oxygen supply and coronary perfusion	Evaluate suspected RV infarction with ECG, including right-sided leads, and urgent cardiology assessment for reperfusion. Correct hypotension and hypoxemia and reduce excessive RV wall stress. Treat hemodynamically significant arrhythmias promptly and preserve atrioventricular synchrony.

Inhaled pulmonary vasodilators require particular caution when left-sided filling pressures are elevated because pulmonary edema can develop. Their role is short-term hemodynamic support; evidence for improved clinical outcomes remains limited.[2]

ARDS, acute respiratory distress syndrome; CVP, central venous pressure; ECG, electrocardiogram; PEEP, positive end-expiratory pressure; PVR, pulmonary vascular resistance; RV, right ventricle; SVR, systemic vascular resistance.



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Suzetrigine: Current Evidence in Multimodal Analgesia

Daniel Haddad MD David Benavides-Zora MD



Practical Points for the Anesthesiologist

- Suzetrigine is an oral, non-sedating, non-opioid layer that can be added to acetaminophen, an NSAID and regional anesthesia. Expect analgesia comparable to hydrocodone/acetaminophen 5/325 mg; it is not a rescue drug for severe breakthrough pain.
- We propose a loading dose of 100 mg at least 2 hours (Tmax is 3 hours) before incision when perioperative use is planned, then 50 mg every 12 hours. Reassess at 2 to 4 hours and supplement with the rest of the multimodal plan if relief is inadequate.
- Screen the medication list for CYP3A inhibitors and inducers, apply the reduced schedule for Child-Pugh B disease or moderate inhibitors, anticipate reduced exposure of CYP3A substrates such as midazolam, and counsel women on contraception. Do not combine it with strong CYP3A inhibitors, and avoid it in Child-Pugh C disease and at an eGFR below 15 mL/min. There are no human data on pregnancy or lactation, and it is not approved in children.
- Confirm coverage or prior authorization before discharge; a 14-day course costs about $450 at list price.

Introduction

Suzetrigine (Journavx, Vertex Pharmaceuticals) is the first selective NaV1.8 inhibitor to reach the market and the first new class of non-opioid analgesic approved in more than two decades. The FDA approved it in January 2025 for moderate to severe acute pain in adults.[1,2] Data regarding its use have grown considerably since its inception, and along with it so have its clinical applications in the perioperative setting.[3,4] It represents a valuable non-opioid analgesic with low abuse potential and limited side effects.[3,4] However, it has several limitations: it was not superior to hydrocodone/acetaminophen in its pivotal trials; it is both a substrate and an inducer of CYP3A; it has not been studied beyond 14 days, and it is expensive.[5,6] This suzetrigine review summarizes its pharmacology, clinical considerations, and current evidence for the clinical anesthesiologist.

Mechanism of Action

Suzetrigine selectively inhibits NaV1.8, a voltage-gated sodium channel expressed almost exclusively in peripheral nociceptors, including dorsal root ganglion neurons, where it carries much of the action potential upstroke in pain fibers. Local anesthetics block all NaV isoforms and therefore every excitable tissue. Because NaV1.8 is essentially absent from the central nervous system, the drug produces analgesia without sedation, respiratory depression, or reward.[6,7]

Pharmacokinetics

Suzetrigine is taken orally and reaches maximum plasma concentration (Tmax) at a median time of 3 hours under fasting conditions, and 5 hours with food. The effective half-life is close to 1 day (23.6 hours), with

therapeutic plasma levels maintained on twice daily dosing. Metabolism of both suzetrigine and M6-SUZ is by cytochrome P450 3A (CYP3A).[6] Potent CYP3A inhibitors, such as itraconazole, can increase suzetrigine exposure by 4.8 fold, and inducers like rifampin can reduce its exposure by over 90%.[6]

Clinical Considerations and Dosing

Remarkably, there are no observed clinically significant differences in suzetrigine pharmacokinetics based on age (18-75 years), sex, race, body weight (44-126kg), or in renal impairment down to an eGFR of 15 mL/min.[6] The drug has not been studied below that threshold or in severe hepatic impairment, and the label advises against its use in both.[6] Only 6.3% of patients treated with suzetrigine in the Phase 3 program were 65 or older.[6] The label also advises patients using hormonal contraceptives containing progestins other than levonorgestrel or norethindrone to add a non-hormonal method during treatment and for 28 days after stopping.[6]

Table 1. Suzetrigine dosing and dose modifications [6]

Patient situation	Initial dose	Doses 2–4	Dose 5 onward (14 days total)
Normal or mild hepatic impairment	100 mg fasting	50 mg every 12 hr	50 mg every 12 hr
Moderate hepatic impairment or moderate CYP3A inhibitor	100 mg fasting	50 mg every 12 hr	50 mg every 24 hr, starting 12 hr after dose 4
Severe hepatic impairment (Child-Pugh C)	Avoid	—	—
Strong CYP3A inhibitor	Contraindicated	—	—
Strong or moderate CYP3A inducer	Avoid	—	—

Side Effects

The safety profile and abuse potential of suzetrigine is particularly favorable. Among 874 patients who received suzetrigine in the two Phase 3 trials, side effects were mostly mild. The most common were pruritus (2.1%), muscle spasms (1.3%), elevated CPK (1.1%), and rash (1.1%). Discontinuation for adverse events was 0.6%, the same as with hydrocodone/acetaminophen. Nausea or vomiting was less common than with hydrocodone/acetaminophen (20% vs 33% after abdominoplasty and 9% vs 16% after bunionectomy) and no more common than with placebo. No clinically significant QTc prolongation was seen at twice the maximum recommended exposure, and no signal of sedation or respiratory depression has been reported.6 A systematic screen of all adverse events across the three Phase 3 studies (2,447 participants, 1,130 treated with suzetrigine) against nearly 200 MedDRA terms associated with abuse found no evidence of abuse potential.7

Clinical Efficacy: Landmark Trials

The safety and efficacy of suzetrigine were established in two Phase III double-blind, placebo- and active-controlled trials after bunionectomy (n=1,073) and full abdominoplasty (n=1,118).[5] Patients with moderate to severe pain were randomized to suzetrigine (100 mg, then 50 mg every 12 hours), hydrocodone/acetaminophen (5/325 mg every 6 hours), or placebo for 48 hours, with ibuprofen as rescue in all arms. [5,6] Both trials met the primary end point, a reduction in pain over 48 hours (SPID48) versus placebo. Suzetrigine also reached a 2-point or greater reduction in pain faster than placebo (119 vs 480 minutes after

abdominoplasty, 240 vs 480 minutes after bunionectomy). Neither trial showed superiority over hydrocodone/acetaminophen. After abdominoplasty the two had similar pain reduction (SPID48 difference 6.6, 95% CI −5.4 to 18.7), and after bunionectomy the result favored hydrocodone/acetaminophen (−20.2, 95% CI −32.7 to −7.7).[5,6] Participants were mostly female, under 65, and treatment lasted 48 hours. Suzetrigine was also not tested within a multimodal regimen or compared to full-dose opioid therapy.

Emerging Evidence and Off-label Use

Evidence for suzetrigine within multimodal and ERAS protocols is growing but remains uncontrolled. In a single-surgeon retrospective series of 236 hip and knee arthroplasties, adding suzetrigine to an established multimodal protocol was associated with 89% of patients never filling an opioid prescription, although the drug's independent contribution cannot be isolated.[3] Two small, manufacturer-sponsored phase 4 studies combined suzetrigine with acetaminophen and/or ibuprofen. In these studies, 90.9% of patients after aesthetic and reconstructive surgery (n=99) and 76.1% after laparoscopic or arthroscopic procedures (n=47) did not require opioid rescue.[8,9]

Conclusion

In the short time since its release in January 2025, the novel non-opioid analgesic suzetrigine has demonstrated widespread usage across the field of pain management beyond its original FDA-approved indication for moderate to severe acute pain in adults. While there are notable obstacles - the lack of substantial research demonstrating efficacy against full-dose opioids, limitations in severe liver disease and strong CYP3A inhibitor use, and high cost - its potential as an opioid-sparing analgesic should not be ignored. New research shows promising usage in multimodal regimens, with low abuse potential, onset of meaningful relief within 2 to 4 hours, and limited CNS side effects. Adequately powered randomized trials, several of which are now recruiting, will define whether it earns a routine place in perioperative protocols.

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Perioperative Temperature Management: Physiology, Clinical Consequences, and Evidence- Based Strategies for Maintaining Normothermia

Mansi Arora MD, Robina Matyal MD





1. Introduction

Temperature regulation is a fundamental component of perioperative homeostasis. Despite the controlled operating-room (OR) environment, anesthetized patients are vulnerable to unintended reductions in core temperature. Inadvertent perioperative hypothermia (IPH), generally defined as a core temperature below 36.0°C, may develop during any phase of the perioperative pathway and remains a relevant quality and safety concern [1–3].

IPH results from the interaction of anesthetic-induced vasodilation, impaired thermoregulatory responses, exposure of the skin and surgical field, administration of unwarmed fluids, and the thermal characteristics of the operating environment. Its significance extends beyond patient discomfort: hypothermia has been associated with impaired coagulation, increased blood loss, surgical site infection (SSI), cardiovascular events, delayed drug metabolism, shivering, and prolonged recovery [1–4]. The strength of evidence differs across outcomes and is modified by the severity and duration of hypothermia, underlying patient risk, and surgical context.

Contemporary practice emphasizes prevention rather than treatment of established hypothermia, yet implementation remains inconsistent, with persistent variation in monitoring, device selection, and adherence to recommended workflows. This review examines the physiological basis of perioperative heat loss, its clinical consequences, monitoring and warming strategies, and practical measures for maintaining normothermia, with particular emphasis on settings in which thermal management is complicated by surgical exposure, hemodynamic vulnerability, or specialized OR environments.

2. Thermoregulation and the Pathophysiology of Perioperative Heat Loss

2.1 Physiological regulation and the effect of anesthesia

Thermoregulation integrates afferent input from central and peripheral thermoreceptors; the hypothalamus coordinates vasomotor tone, shivering, and sweating to maintain core temperature within a narrow range. Physiologically, the interthreshold range i.e., the span between the sweating and vasoconstriction thresholds- is only approximately 0.2–0.5°C [2,5]. The body may be conceptualized as a tightly regulated central compartment (thorax, abdomen, and central nervous system) and a cooler, more variable peripheral compartment, chiefly the extremities, that functions as a thermal reservoir. Tonic peripheral vasoconstriction normally maintains a core-to-peripheral gradient of approximately 2–4°C.

Both general and neuraxial anesthesia shift this balance toward heat loss. General anesthetics raise the warm-response thresholds slightly and lower the cold-response thresholds markedly, widening the interthreshold range to as much as 2–4°C or more (Figure 1A) [2,5]. Neuraxial anesthesia abolishes vasoconstriction and shivering below the level of blockade and impairs thermal perception, so that patients may become hypothermic without feeling cold. Consequently, anesthetized patients are poorly able to compensate for environmental losses.

2.2 Redistribution hypothermia and the three-phase pattern

Core temperature characteristically declines in three phases (Figure 1B) [2,4]. In phase I, during the first hour after induction, core temperature typically falls by 1–1.5°C. This decline reflects redistribution rather than net heat loss and mainly attributed to anesthetic-induced vasodilation that permits flow of heat from the core to cooler peripheral tissues. Its magnitude depends on the pre-induction core-to-peripheral

gradient. In phase II, a slower, approximately linear decline over the next 2–3 hours reflects heat loss exceeding metabolic heat production. In phase III, a plateau develops once core temperature reaches the anesthetic-modified vasoconstriction threshold, or when heat production and loss equilibrate in well-warmed patients. Because neuraxial blockade prevents vasoconstriction in the blocked territory, the plateau may be attenuated or absent during combined general–neuraxial anesthesia, producing the steepest and most sustained decline [2,5].

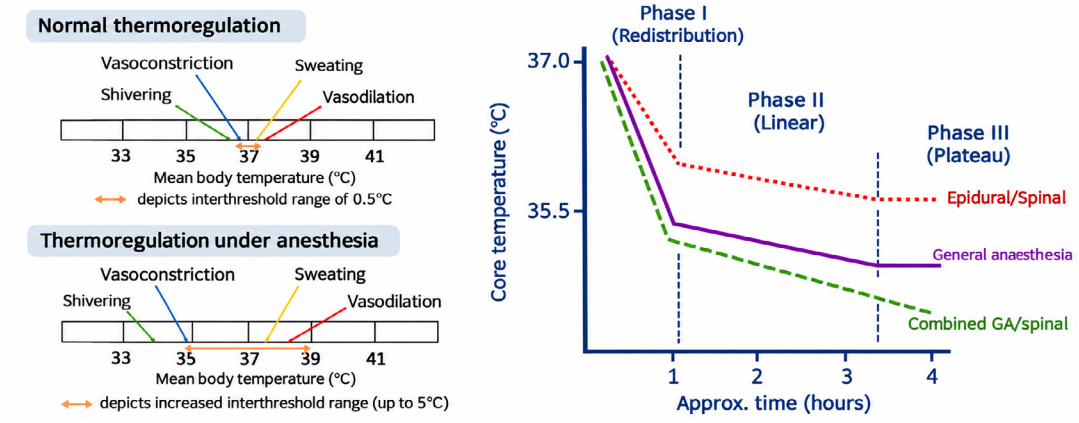


Figure 1. (A) Thermoregulatory thresholds in the awake state (interthreshold range ≈0.5°C) and under anesthesia (widened up to ≈5°C). (B) Three-phase decline in core temperature (redistribution, linear, and plateau) during general, epidural/spinal, and combined general–neuraxial anesthesia. Adapted from OpenAnesthesia [5].

2.3 Ongoing environmental heat loss

After redistribution, continued heat loss under anesthesia occurs through four mechanisms (Figure 2) [4]. Radiation, the transfer of infrared energy between the skin and cooler surrounding surfaces, is the dominant route and accounts for approximately 40% of intraoperative loss. Convection (≈30%) occurs as moving air removes heat from the skin; it is augmented by high air-exchange rates, laminar flow, and the cooling demands of imaging equipment. Evaporation (≈25%) arises from skin preparation solutions, exposed serosal surfaces, and the respiratory tract. Conduction (≈5%) occurs through direct contact with the operating table, positioning devices, and cold fluids. The relative contribution of each mechanism is influenced by the operative environment and surgical technique. Thermal insulation reduces cutaneous loss, active warming supplies heat, and warming of intravenous and irrigation fluids reduces the internal cooling load in proportion to the volume and rate administered [3,4].

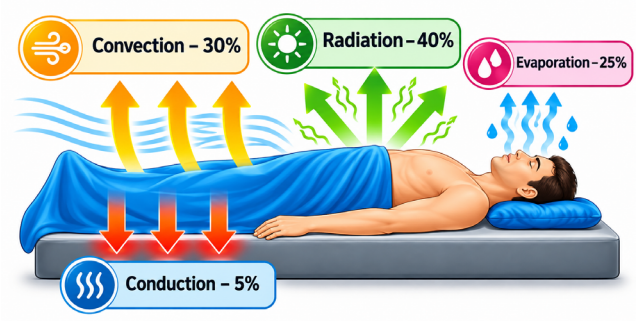


Figure 2. Relative contribution of radiation, convection, evaporation, and conduction to intraoperative heat loss.

3. Definition, Classification, and Epidemiology

IPH is conventionally defined as a core temperature below 36.0°C occurring at any time from induction of anesthesia until recovery [1–3,6]. It is commonly graded as mild (35.0–35.9°C), moderate (34.0–34.9°C), and severe hypothermia (Figure 3) [6]. As the thresholds for severe hypothermia vary across the literature

(e.g., <34.0°C versus ≤33.0°C), studies reporting outcomes should state the classification used explicitly. Clinical risk depends not only on the lowest recorded temperature but also on the duration of exposure, the rate of decline, and the patient's physiological reserve.

Reported incidence of IPH varies widely, reflecting differences in surgical population, definitions, measurement site and timing, procedural duration, and institutional warming practices [1,3]. Older estimates may not reflect institutions with established prewarming and active-warming protocols. A single postoperative temperature may miss an earlier intraoperative nadir, and values obtained from different anatomical sites are not directly comparable; underscoring the need for standardized temperature measurement policies at institutional level (Section 6).

4. Risk Factors

Risk assessment should incorporate patient, anesthetic, procedural, and environmental factors (Figure 3) [1,6,7]. Patient-related factors include advanced age (reduced thermoregulatory reserve and vasomotor responsiveness), low body mass index and limited insulation, preoperative hypothermia, higher ASA physical status, significant cardiovascular disease, and endocrine or autonomic disorders affecting thermoregulation (e.g., thyroid, hypothalamic, or pituitary dysfunction; diabetic autonomic neuropathy). Anesthetic factors include general anesthesia, combined general–neuraxial techniques, and prolonged anesthetic duration. Procedural factors include major or open surgery, extensive skin preparation and exposure, large-volume infusion or transfusion, cold irrigation, and interruptions in active warming during positioning or transfer; minimally invasive surgery reduces but does not eliminate risk. Environmental factors include low ambient OR temperature and high air-exchange rates. The latter are particularly relevant in hybrid ORs and interventional suites, where equipment heat loads, OR ventilation requirements, and staff comfort may conflict with the thermal needs of an exposed patient.

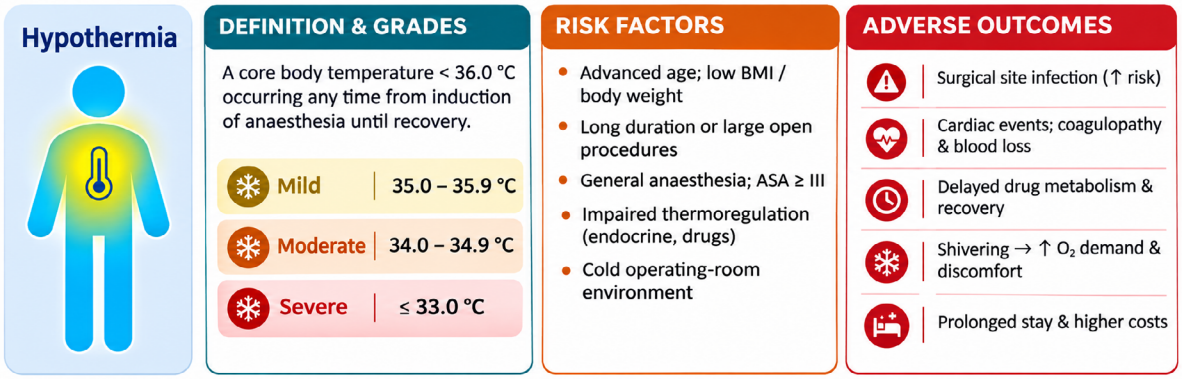


Figure 3. Definition and severity grades, principal risk factors, and adverse outcomes associated with inadvertent perioperative hypothermia.

5. Clinical Consequences

Coagulation and blood loss. Hypothermia impairs platelet function and slows temperature-dependent enzymatic reactions of the coagulation cascade. Because standard laboratory coagulation tests are performed at 37°C, they may underestimate the in vivo deficit. Even mild hypothermia has been associated with increased blood loss and transfusion requirement [2,3]. Temperature should therefore be considered alongside conventional and viscoelastic coagulation assessment.

Surgical site infection. Thermoregulatory vasoconstriction reduces subcutaneous oxygen tension and impairs oxidative neutrophil killing and collagen deposition [2]. The association between hypothermia and SSI has been reported across several surgical populations, although its magnitude varies by study design [1,3]. Normothermia complements but does not replace asepsis and antimicrobial prophylaxis.

Cardiovascular effects. Hypothermia increases sympathetic tone, plasma catecholamines & systemic vascular resistance, and may precipitate myocardial ischemia or arrhythmia in patients with limited reserve [1,2] especially alongside other concurrent stressors such as hypotension, anemia, and hypoxemia.

Drug disposition and recovery. Reduced hepatic metabolism and altered pharmacodynamics prolong the action of various anesthetic drugs such as, propofol, opioids, and neuromuscular-blocking agents. For example, the duration of vecuronium, approximately doubles with a 2°C reduction in core temperature [2]. This contributes to delayed emergence and residual neuromuscular blockade, reinforcing the need for quantitative neuromuscular monitoring and temperature management.

Shivering, discomfort, and resource utilization. Postoperative shivering increases oxygen consumption and metabolic demand, which may be poorly tolerated in patients with limited cardiopulmonary reserve; thermal discomfort is frequently reported by patients as one of the most unpleasant aspects of recovery [4]. Hypothermia may also prolong PACU stay and increase monitoring and warming requirements [1,3].

6. Temperature Monitoring

Reliable temperature management depends on accurate measurement. The UK National Institute for Health and Care Excellence (NICE) recommends a site that provides a direct measurement or a validated estimate of core temperature and advises against indirect estimates that rely on correction factors [7]. The distal esophagus and pulmonary artery are reference standards during general anesthesia, whereas validated zero-heat-flux (deep-forehead) sensors enable continuous non-invasive monitoring across all perioperative phases, including during neuraxial anesthesia or sedation (Table 1) [2,7].

NICE recommends measurement before induction and at least every 30 minutes intraoperatively [7]. Association of periOperative Registered Nurses (AORN), USA supports continuous monitoring during general anesthesia lasting over 30 minutes and periodic measurement for shorter procedures, using the same site and device for serial readings [8]. Continuous monitoring is particularly valuable during prolonged surgery, rapid fluid administration, or anticipated temperature fluctuations. Changes in measurement site or device may produce apparent temperature shifts that do not reflect true changes in core temperature, underscoring the need to verify and secure probe position, particularly when access is restricted by surgical drapes or the operative field.

Table 1. Temperature-monitoring sites: relationship to core temperature and perioperative suitability [2,4,7].

Site	Category	Strengths	Limitations
Pulmonary artery	Core (reference)	Gold standard; continuous	Invasive; limited to patients with a PA catheter
Distal esophagus	Core	Accurate, continuous; standard under GA with a secured airway	Requires correct depth (lower third); unsuitable in awake patients; affected by thoracic surgery or cold irrigation
Nasopharynx	Core	Accurate when positioned near the soft palate	Mucosal bleeding risk; affected by airflow around the airway
Tympanic membrane (contact thermocouple)	Core	Reflects carotid blood temperature	Risk of membrane trauma; infrared aural devices are less accurate
Zero-heat-flux (deep forehead)	Validated core estimate	Non-invasive; continuous in awake, sedated, and anesthetized patients	Device cost; needs equilibration; sensor must remain adherent
Urinary bladder	Near-core	Continuous via catheter; useful postoperatively	Lags during rapid change; inaccurate at low urine flow and during lower-abdominal surgery
Rectal	Near-core	Simple	Marked lag during rapid change; affected by stool and perfusion
Oral (sublingual)	Near-core	Acceptable pre- and postoperatively in cooperative patients	Affected by breathing, intake, and oxygen therapy; unsuitable intraoperatively
Axillary / skin surface	Peripheral	Non-invasive and readily available	Underestimates core temperature, especially during vasoconstriction; not recommended for intraoperative decisions

GA, general anesthesia; PA, pulmonary artery.

7. Prevention and Management Across the Perioperative Continuum

Temperature management is most effective when prevention, monitoring, and treatment are integrated across all phases. The NICE guideline pathway (Figure 4) provides a practical, phase-based workflow that institutions may adapt to their patient population and available devices [7].

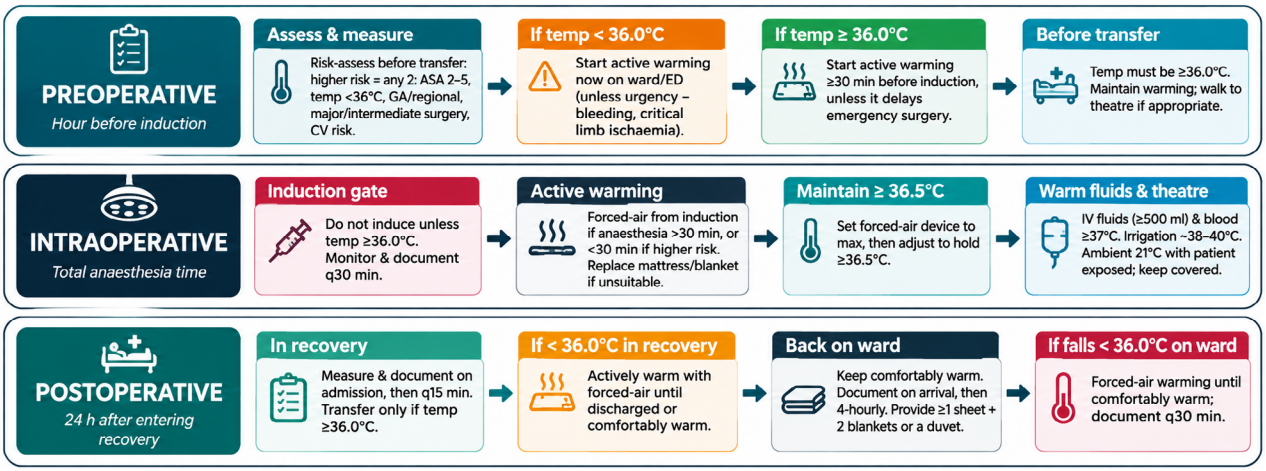


Figure 4. Phase-based perioperative hypothermia management workflow summarizing NICE Clinical Guideline CG65 [7].

7.1 Preoperative assessment and prewarming

Temperature should be measured and hypothermia risk assessed in the hour before transfer, to allow timely intervention. NICE identifies patients as being at higher risk if any two of the following apply: ASA II–V, preoperative temperature below 36.0°C, combined general and regional anesthesia, major or intermediate surgery, or risk of cardiovascular complications [7]. Patients below 36.0°C should be actively warmed before transfer, and induction should not proceed until core temperature is at least 36.0°C, unless surgery is urgent (e.g., major hemorrhage or critical limb ischemia), in which case warming should begin immediately and continue during transport and surgery. For normothermic patients, NICE recommends active prewarming at least 30 minutes before induction, provided this does not delay surgery [7].

Prewarming does not substantially raise core temperature; rather, it increases peripheral heat content and narrows the core-to-peripheral gradient before anesthetic-induced vasodilation, thereby attenuating phase I redistribution (Figure 5) [2,4]. Even 10–30 minutes of active prewarming meaningfully reduces post-induction hypothermia [3].

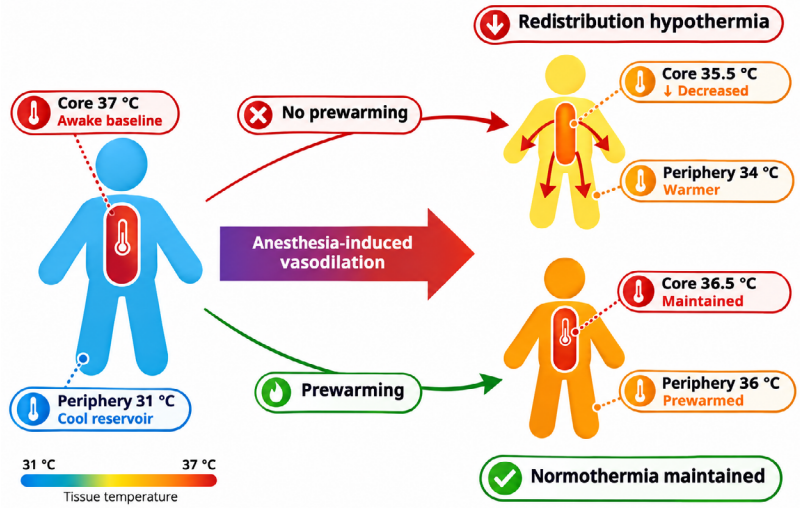


Figure 5. Effect of anesthesia-induced vasodilation on core and peripheral temperature without prewarming and with prewarming

7.2 Intraoperative active warming and insulation

Active warming should begin at induction for anesthesia exceeding 30 minutes, and for shorter cases in higher-risk patients identified preoperatively [7]. Forced-air warming is the most widely used and best-studied modality; NICE recommends setting the device to maximum and then titrating to maintain a core temperature of at least 36.5°C [7]. Resistive or conductive blankets and mattresses are alternatives when surgical access or positioning precludes forced-air coverage. When upper- and lower-body forced-air blankets are both infeasible, as in combined neck and femoral-access procedures, underbody, resistive, or circulating-water systems may need to be combined. Passive insulation of all non-operative areas reduces radiative and convective loss and complements active heating. Devices should be used according to manufacturers' instructions, with vigilance for burns and pressure injury in patients with impaired sensation or perfusion or compromised skin integrity. Warming hoses must never be applied directly to patients without the designated blanket, owning to the risk of thermal injury.

7.3 Intravenous fluids, blood products, and irrigation

Guidelines recommend warming intravenous fluids of 500 mL or more and all blood products to atleast 37°C, and irrigation fluids to 38–40°C in a thermostatically controlled cabinet [7]. In adults, infusion of 1 L of room-temperature crystalloid can decrease mean body temperature by approximately 0.25°C [2]. Fluid warming prevents additional loss but cannot transfer meaningful heat to the patient; it should therefore complement, rather than replace, external active warming.

7.4 Operating-room environment

An ambient temperature of at least 21°C should be maintained while the patient is exposed, with reductions considered once active warming is established [7]. Engineering standards specify temperatures of 20–24°C for ORs and 21–24°C for imaging rooms (ASHRAE/ASHE Standard 170) [12]. Hybrid ORs and interventional suites present additional challenges to temperature management, as high-volume air exchange for equipment cooling and room-temperature contrast and flush solutions may contribute to perioperative heat loss and increase IPH risk. Importantly, equipment operating ranges (e.g., 15–30°C for some angiography systems) reflect device tolerances rather than optimal ORs temperature. Hence, balancing patient warming, staff comfort, and equipment requirements requires effective coordination among clinical teams, facilities management, and biomedical engineering.

7.5 Postoperative care and handover

Active warming should continue throughout the emergence, as discontinuing it at the end of surgery may allow further temperature decline. NICE recommends documenting temperature on PACU admission and every 15 minutes thereafter, with transfer to the floor only when the temperature is at least 36.0°C. Patients below this threshold should receive active warming until discharge from recovery or until comfortably warm [7]. On the ward, temperature should be recorded on arrival and every 4 hours thereafter. Handover should include the most recent temperature, measurement site, ongoing warming interventions, and any concern regarding thermal instability [8].

8. Warming Technologies

Warming systems differ in their mechanism of heat transfer, heat-delivery capacity, compatibility with surgical access and positioning, and practical limitations (Figure 6; Table 2) [9–11].



Figure 6. Principal active warming modalities in the operating room: forced-air warming, resistive/conductive warming, circulating-water systems, and in-line intravenous fluid warming.

Forced-air warming transfers heat primarily through convection, while also reducing radiative heat loss. Its effectiveness depends on the surface area covered, blanket selection, and uninterrupted use. Resistive warming systems (carbon-fiber or polymer based) transfer heat by conduction and have demonstrated comparable efficacy to forced-air warming in several trials [3,11]. They offer a useful alternative when air movement or blanket placement is impractical. Circulating-water garments, wrapped around the trunk and limbs, are among the most effective systems. In contrast, circulating-water mattresses have limited efficacy because of the small posterior contact area and reduced capillary perfusion under pressure [2,10]. Passive insulation (cotton or reflective blankets) reduces cutaneous loss by approximately 30% with a single layer but provides no heat input. It is therefore useful during transport and preparation but should not replace active warming in at-risk patients [2]. Fluid warmers prevent cooling from infused volume and are essential during large-volume resuscitation.

Table 2. Warming systems: description and principal mechanism of heat transfer.

Warming device	Description	Mechanism
Forced-air warming	Warmed air is driven through a blanket in direct contact with the skin (usually a two-layer design); settings typically high (43°C), medium (38°C), or low (32°C)	Convection
Circulating-water garment	Water from a control unit circulates through polymer pads or a wrap-around garment; manual settings 4–42°C, automatic 30–39°C	Conduction
Heated (underbody) mattress	Limited effectiveness because only a small body-surface area is in contact	Conduction
Hot packs	Approximately 43°C; mean increase in temperature of ~1.4°C reported	Conduction
Humidified gases	Warm, humidified inspired gas; increases core temperature by ~0.5–0.65°C/h in reported studies	Evaporation (reduced loss)
Fluid warmer	Warmed fluids increased temperature by ~1.3°C in reported studies	Conduction

No single device is optimal for every procedure. Device selection should account for the predominant mechanism of heat loss, available skin surface, surgical field and position, device performance, cost, and urgency. A recent narrative review comparing intraoperative warming techniques ranked forced-air warming highest overall in terms of effectiveness and value, with resistive warming systems and fluid warming as strong complementary strategies, while circulating-water mattresses were least favorable (Table 3) [11]. Comparative evidence across devices and clinical settings is nevertheless heterogeneous, and prevention is consistently more effective than treating established hypothermia [3,9].

Table 3. Comparative appraisal of intraoperative warming techniques (★ = lowest, ★★★★★ = highest; for risk and cost, more stars indicate greater risk or cost). Adapted from Ji et al. [11].

Class	Intervention	Effectiveness	Risks	Cost	Quality–price	Overall
Active	Forced-air warming	★★★★★	★★	★★★	★★★★★	★★★★★
Active	Self-regulated heated-air garment	★★★★	★★	★★★	★★★	★★★
Active	Infusion-fluid warming	★★★★	★	★	★★★★	★★★★
Active	Circulating-water mattress	★★★	★★★★	★★★★★	★	★
Active	Carbon-fiber resistive heating	★★★★	★	★★	★★★★	★★★★
Active	Self-heating blanket	★★★	★	★★★	★★	★★★
Active	Chemical heat packs	★★	★	★	★★★	★★★
Passive	Thermal reflective blankets	★★	★	★	★★★	★★★

9. Guideline Frameworks, Implementation, and Quality Improvement

NICE, European best-practice recommendations, and AORN converge on a common phase-based structure: preoperative risk assessment and prewarming, continuous or regular intraoperative monitoring with uninterrupted active warming and fluid warming, and PACU reassessment with continued warming until normothermia is restored (Figures 4, 7, and 8) [3,7,8].

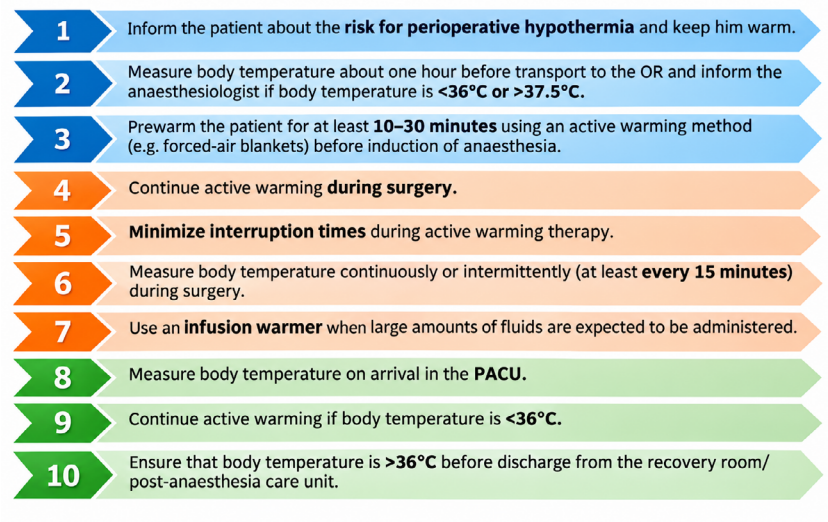


Figure 7. Ten European best-practice recommendations for preventing perioperative hypothermia, grouped into preoperative, intraoperative, and postoperative phases. Adapted from Rauch et al. [3].

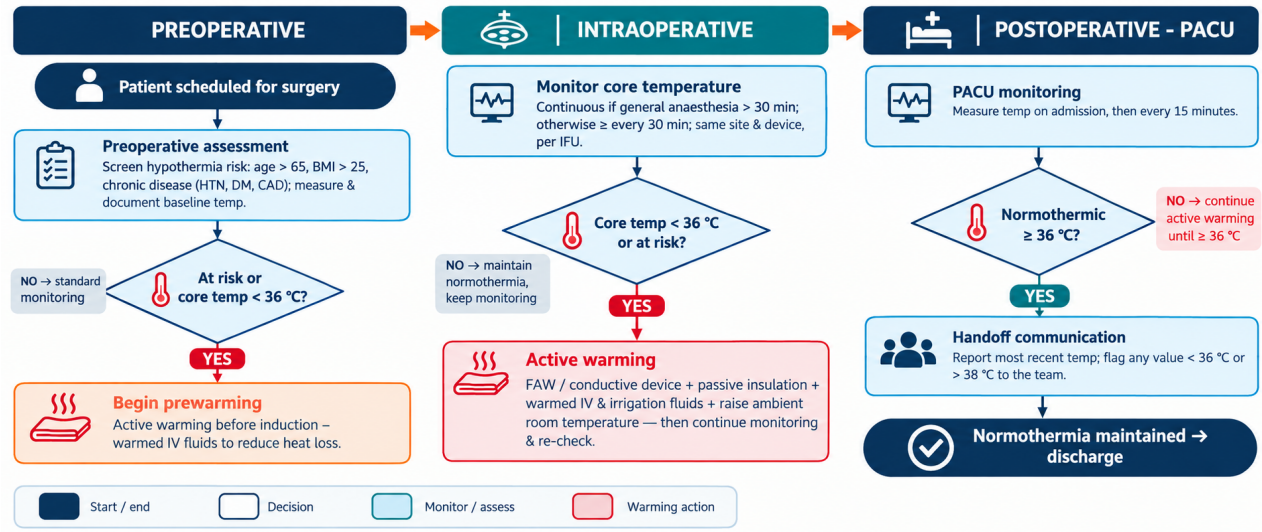


Figure 8. Perioperative temperature-management algorithm summarizing the AORN Guideline for Patient Temperature Management.

Common barriers to effective thermal management include inconsistent preoperative temperature measurement, delayed initiation or interruption of warming, unreliable intraoperative monitoring, device malfunction or incompatibility with the surgical field, low OR ambient temperature, incomplete fluid warming, and limited visibility of postoperative temperature data. Competing intraoperative priorities in complex multidisciplinary cases may further divert attention from thermal management. A standardized protocol should define temperature-measurement intervals, indications for prewarming, initiation and continuation of active warming, documentation requirements, and responses to temperatures below the institutional threshold. Integrating hypothermia-risk assessment into the anesthetic plan and surgical safety checklist can improve adherence.

Quality metrics may include the proportion of patients with a documented preoperative temperature, adherence to prewarming and active-warming protocols, intraoperative nadir temperature and duration below 36.0°C, PACU admission temperature, and time to normothermia. Such measures should be risk-adjusted rather than used as unadjusted indicators of clinician performance. A multidisciplinary approach involving anesthesiology, nursing, surgery, facilities, and biomedical engineering is particularly valuable in hybrid and interventional environments. Education should emphasize not only device use but also the physiological rationale for prewarming, the importance of reliable temperature monitoring, and the continued temperature management throughout postoperative recovery.

10. Evidence Gaps and Future Directions

Several areas warrant further investigation. First, guideline recommendations remain heterogeneous regarding prewarming duration (10–30 minutes versus at least 30 minutes) and intraoperative temperature measurement interval (every 15 versus 30 minutes, or continuous) [3,7,8]. Comparative-effectiveness studies are needed to establish optimal combinations of prewarming, active warming, insulation, and fluid warming for specific surgical populations. Second, the relationship between the magnitude and duration of hypothermia and clinically important outcomes requires clarification, distinguishing transient from sustained hypothermia while accounting for confounding. Third, dedicated studies are needed in underrepresented settings, including complex vascular and head-and-neck surgery, prolonged interventional imaging, and procedures involving extensive exposure or large-volume fluid administration. Finally, implementation research should identify effective strategies to improve protocol adherence, documentation, and meaningful quality measurement, as reliable workflows may be as important as the availability of warming technology itself.

11. Conclusion

Inadvertent perioperative hypothermia is a common and largely preventable complication arising from anesthetic impairment of thermoregulation, redistribution of body heat, and ongoing environmental heat loss. Its consequences extend beyond thermal discomfort to include coagulopathy and bleeding, surgical site infection, cardiovascular stress, altered drug disposition, shivering, and delayed recovery. Prevention requires a proactive, continuous approach spanning the entire perioperative pathway, beginning with prewarming before induction and continuing with active warming, insulation, fluid warming, environmental temperature control, and reliable core-temperature monitoring through recovery. Ultimately, a risk-stratified, protocolized bundle approach that integrates these measures and adapts them to the patient, procedure, and operating environment offers a practical framework for maintaining normothermia as a fundamental standard of perioperative care.

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Biostatistics Section

Relative and Absolute Risk: How Are These Different?

Miguel Magallanes-Esqueda MD, Robina Matyal MD





The Biostatistics Section introduces a new section in this journal that explores the concepts behind the numbers we encounter in clinical research. Alongside a series of lectures, these articles will use clinical examples to help readers understand study design, research methods, and the interpretation of results. They will also provide a reference to return to when questions come up while reading a paper.

The purpose of this section goes beyond conducting research projects. As clinicians, we need to understand what a study found and whether those findings apply to the patients. Several studies of physicians and trainees have documented difficulties interpreting commonly reported statistical findings.

We begin with relative and absolute risk comparison. Both compare the occurrence of an outcome between groups, but they answer different questions of the study. To understand the distinction, we need to define risk.

What is risk?

Risk is the proportion of people initially at risk of an outcome during a fixed period. It is also called *incidence proportion*. "At risk" means that a person is capable or susceptible of experiencing the outcome.

$$\text{Risk} = \frac{\textit{number of people with the outcome}}{\textit{total number of people at risk}}$$

This gives us the absolute risk within one group. To compare groups, we divide their risks to calculate a relative measure or subtract to calculate an absolute measure.

Relative comparison: the risk ratio

The risk ratio, commonly called relative risk, divides the risk in the comparison group by the risk in the reference group.

$$\text{Risk Ratio} = \frac{\textit{risk of the comparison group}}{\textit{risk of the refrence group}}$$

This tells us how many times the risk is higher in one group compared with the other. A risk ratio of 1 indicates equal risk, a value above 1 indicates higher risk in the comparison group, and a value below 1 indicates lower risk.

Absolute comparison: the risk difference

The risk difference subtracts the risk in the reference group from the risk in the comparison group.

Risk difference= (risk of the comparison group)-(risk of the refrence group)

This tells us how far apart the risks are, expressed as a proportion or percentage points. A risk difference of 0 indicates equal risk, a positive value indicates higher risk in the comparison group, while a negative value indicates lower risk.

Both measures matter. Risks of 2% versus 1% and 20% versus 10% both give a risk ratio of 2, but their absolute differences are 1 and 10 percentage points. The relative comparison alone does not reveal that distinction.

Which studies use these measures?

Risk ratios and risk differences are commonly used in randomized control trials and cohort studies, where researchers can estimate an outcome in each group over a defined period of time. In a randomized trial, groups are defined by treatment assignment. In a cohort study, groups are typically defined by an observed

exposure or treatment. Both designs can report either relative or absolute comparison. These measures can also be used in meta-analyses. However, RR alone may give a misleading impression of clinical importance and should be interpreted alongside absolute risks and confidence intervals.

Example:

Randomized group	Delirium	No Delirium	Total patients
Remimazolam	108	119	227
Propofol	71	157	228

$$\text{Risk} = \frac{\text{Number of patients with delirium}}{\text{Total patients in the group}} \qquad R_{\text{remimazolam}} = \frac{108}{227} = 0.4758 \approx 47.6\% \qquad R_{\text{propofol}} = \frac{71}{228} = 0.3114 \approx 31.1\%$$

Consider a randomized trial comparing remimazolam with propofol in patients aged 65 years or older undergoing lung resection. These investigators assessed delirium in the post-anesthesia care unit and during the first three postoperative days. The modified intention-to treat analysis included 455 patients.

Calculating the risk in each group:

$$RR = \frac{R_{\text{remimazolam}}}{R_{\text{propofol}}} = \frac{\frac{108}{227}}{\frac{71}{228}} \approx 1.53 \qquad RD = R_{\text{remimazolam}} - R_{\text{propofol}} = \frac{108}{227} - \frac{71}{228} \approx 0.1644$$

Risk ratio (RR) and Risk difference (RD)

Interpretation:

Risk ratio: Patients aged 65 years or older undergoing lung resection who were assigned to remimazolam had 1.53 times the risk of delirium compared with those assigned to propofol, during recovery in the PACU and the first three postoperative days.

Risk Difference: Among these patients, the remimazolam group had 16 additional cases per 100 patients compared to the propofol group during recovery in the PACU and the first three postoperative days.

The published counts give an absolute difference of 16.44 percentage points; the investigators reported 16.5. Reported 95% confidence intervals were 1.21–1.94 for the risk ratio and 7.7–25.3 percentage points for the risk difference, indicating uncertainty around the estimates.

Conclusion

Interpreting risk or incidence proportion begins with understanding what the outcome is, the assessment period, and how frequently the outcome occurred in each group. Relative measures describe the proportional difference between groups, while absolute differences show how many additional or fewer patients experience the outcome. Reading both together provides a clearer understanding of the finding's clinical relevance.

Key Takeaways: Relative and Absolute Comparisons of Risk

	Relative risk — risk ratio (RR)	Absolute comparison — risk difference (RD)
What does this tell us?	How many times as high the risk is compared with the reference group.	How many additional or fewer cases occur per 100 people compared with the reference group
Calculation	$\frac{risk\ of\ the\ comparison\ group}{risk\ of\ the\ refrence\ group}$	Comparison-group risk − reference-group risk
Value indicating equal risks	**1**	**0**
How is it expressed?	A ratio, without units	A proportion or percentage points

Clinical example	**RR = 1.53:** the remimazolam group had 1.53 times the risk of delirium compared with the propofol group.	**RD ≈ 0.1644:** approximately 16 additional patients per 100 experienced delirium in the remimazolam group during the same assessment period.
Main limitation	Does not reveal the underlying risks or the absolute difference.	Does not describe how large the difference is relative to the reference-group risk.

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Click here for Class 1

Click here for Class 2

Urgent Communication in High Risk Situations Workshop for Nursing Staff

Our department recently hosted a live workshop for certified registered nurse anesthetists (CRNAs) and nursing staff on urgent communication in high-risk clinical situations. In these moments physicians are often making rapid, high-stakes decisions, and the ability of every team member to communicate concerns clearly and promptly is important.

Adverse events occur due to communication breakdown, this workshop aimed to enhance identify gaps in communication and a multidisciplinary imitative to enhance communication skills in high-risk situations.

Participants reported feeling more confident in voicing concerns and in seeking the input of colleagues in a constructive and respectful way. Empowering each member of staff in this way strengthens relationships, improves communication, and reinforces a culture of safety across the department.

When Communication Breaks Down: Understanding the Human Factors Behind Patient Safety

Communication failures rarely occur in isolation. Under the time pressures of time-critical decision-making and high-risk clinical situations, it is important to ameliorate the hesitation staff demonstrate or lack of confidence with voicing concerns. We must identify and teach the team-level that contribute to serious safety hazards, and factors leading to never-events.





The Hidden Risks in the Operating Room with Communication Failure

A study that was done by Halverson and colleagues was able to identify communication failures occurring in the operating room. The study recorded: type of errors that occurred, the subject matter and the observed outcome. The results were 76 communication failures were observed over 150 hours of observation- following introduction of a structure team training curriculum the rate of communication failure went down from 0.737 to 0.270 per hour these all highlighted the importance of clear timely communication.

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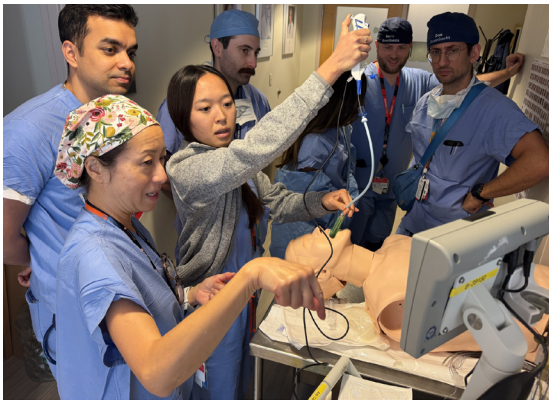
Airway, Lung Isolation, and Ventilation: Hands-on Training for Our Teams

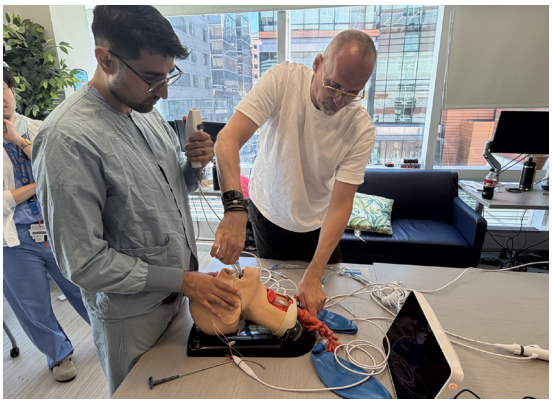
Two simulation session brought residents, faculty, and nursing staff together around intra-operative skills

This September, our department held two hands on sessions focused on airway management and ventilation. The first brought anesthesia residents and faculty together for a workshop on lung isolation and advanced airway techniques; the second took training directly into the perioperative environment, focussed more on communication.

Lung Isolation and Advanced Airway Workshop

Working in small groups at simulation stations, residents practiced placing airway devices with direct guidance from faculty. Residents had hands on training from UK thoracic anesthesia consultants, it involved how a bronchial blocker sits within the right and left main bronchi, while flexible bronchoscopes were connected to video displays to confirm position in real time. Video laryngoscopes were also available at the stations.





A Week of Celebrating the Harvard Post-Docs at BIDMC

Research is driven not only by scientific discovery, but by the people, ideas, and collaborations that make progress possible. This September, Harvard Medical School celebrated **National Postdoc Appreciation Week 2026**, recognizing the invaluable contributions of postdoctoral researchers to advancing science, medicine, and education.



> At the heart of Harvard's research community is a shared commitment to curiosity, collaboration, and discovery, and this week was a celebration of exactly that.

ASA CONFERENCE 2026

Highlights from Day of the ASA Annual Meeting

The second day of the **American Society of Anesthesiologists®** (ASA) Annual Meeting offered an academically enriching event full of clinical ideas, innovative research, and opportunity to connect with colleagues.

The program featured resident poster sessions, challenging case presentations, and research from across the department. Highlights included work on Perioperative Outcomes Laboratory; research, and also collaboration from multiple departments.









EKG SECTION

Amna Ansari MD, Robina Matyal MD





Clinical Overview

ECG interpretation and advanced cardiovascular life support (ACLS) are essential skills for recognizing and managing cardiovascular emergencies. Identifying the rhythm is the starting point; understanding its significance in the patient's clinical context guides what happens next. These cases bring ECG interpretation and ACLS decision-making together, asking learners to assess the patient, choose an appropriate intervention, and reassess as the situation evolves.

About These Cases

This series includes three interactive cases for independent learning. Each begins with a clinical history and handover, followed by questions supported by moving monitor traces and 12-lead ECGs. Explanations and annotated ECGs appear after answers are submitted, allowing learners to compare their reasoning with the case discussion. Work through each case at your own pace. For ECG interpretation questions, enlarge the 12-lead ECG on the right before selecting your answers. As the patient's condition changes, use the updated findings to decide what to do next.

Click here for Case 1

Click here for Case 2

Click here for Case 3