# Nontechnical Skills in a Technical World


Ophelie Loup, MD
Department of Cardiovascular Surgery, Inselspital, Bern University Hospital, University of Bern, Bern, Switzerland

Steven D. Boggs, MD, MBA
Department of Anesthesiology, University of Tennessee Health Science Center, Memphis, Tennessee

Markus M. Luedi, MD, MBA
Department of Anesthesiology, Inselspital, Bern University Hospital, University of Bern, Bern, Switzerland

Christopher R. Giordano, MD
Department of Anesthesiology, University of Florida College of Medicine, Gainesville, Florida




## What are "Nontechnical Skills" (NTS)?

NTS are the social, personal, and cognitive abilities that complement technical skills.[1] Historically, these skill sets fell under the category of "soft skills," which did not interest health care professionals because they were not considered quantitative, rigorous, or reproducible. Consequently, they were not consistently taught to new learners or explicitly developed, and were tacitly adopted into practice. By contrast, psychologists have long appreciated that many of these "human factor skills" enhance workers' performance and minimize error rates.[2] Although there is no definitive list of essential NTS, authors have utilized several frameworks, including:

- Crew Resource Management (CRM).
- Anesthesia Non-Technical Skills (ANTS).
- Emotional Intelligence (EI).
- Team Cognition: knowledge, skills, and attitudes (KSA).


**Address Correspondence to: Christopher R. Giordano, MD, Department of Anesthesiology, University of Florida College of Medicine, 1600 SW Archer Road, P.O. Box 100254, Gainesville, FL 32610-0254. E-mail: cgiordano@anest.ufl.edu**



INTERNATIONAL ANESTHESIOLOGY CLINICS
*Volume 57, Number 1, 81–94, DOI:10.1097/AIA.0000000000000215*

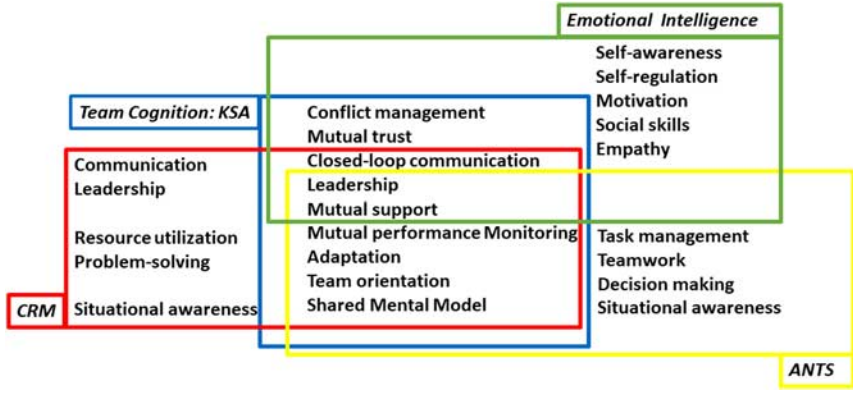


**Figure 1.** *Schematic depiction of the substantial overlap in skills between the various approaches used to develop nontechnical skills. ANTS indicates anesthesia Non-Technical Skills; CRM, crisis resource management; KSA, knowledge, skills, and attitudes.* full color online

Despite the multiple approaches, the overlap of skills between each NTS methodology is substantial (Fig. 1). As a result, the level of overlap in each framework leads to the simultaneous development of the others. In this paper, we will chronicle the emergence and development of NTS, their utilization in the health care field, the various approaches for implementing NTS training in an acute care medicine curriculum, and future goals and challenges.

## NTS: A Historical Perspective

The aviation industry was the first to recognize the significant impact of NTS on safety over 40 years ago. The advent of the cockpit voice recorder led to the recognition that communication and human error were the root causes in a series of commercial aviation accidents. In the Tenerife crash of 1977 (Fig. 2), miscommunication between 2 crews and the control tower resulted in 2 jumbo jets crashing into each other on an active runway, resulting in the loss of 583 lives. In 1989, a crash in Kegworth, United Kingdom, killed 47 passengers when the crew inadvertently shut down the wrong engine mid-flight. The recordings from cockpit voice recorders showed that conversations in the cockpit before accidents were rife with poor team coordination, communication breakdowns, inattentiveness, poor decision-making, and a dearth of leadership. Further, evaluations of black box recordings from aviation accidents have shown that over 70% of accidents resulted from pilot error.[3,4]

The alarming realization that pervasive nontechnical failures were the leading cause of accidents and deaths led the aviation industry to develop a reliable and valid list of NTS for good airmanship. The approach was a "bottom-up" design that first sought to elicit data (eg, tacit components of good aviation skills) and then build these data into a framework. The

**Figure 2.** *Aviation accidents such as the Tenerife crash triggered reflections on safety and nontechnical skills in anesthesiology and surgery some 40 years ago. Photograph reprinted with the permission of photographer/crash survivor David Y. Alexander, from his book "Never Wait for the Fire Truck."* full color online

Directorate General of Civil Aviation developed the Non-Technical Skills (NOTECHS) program to assess pilots' NTS performance, help minimize pilot error and increase aviation safety. NTS are now considered essential attributes for pilots[2] and have become hardwired into aviation training in CRM.[5] CRM describes itself as "a management system which makes optimum use of all available resources—equipment, procedures, and people—to promote safety and enhance efficiency of flight deck operations."[6] Today, CRM has led to a decrease in nontechnical pilot errors. Other industries, including the armed forces, prisons, nuclear power, chemical manufacturing, emergency services, and health care, have followed suit and adopted similar training mechanisms.

Anesthesiology, surgery, and aviation share work environments that are complex, dynamic, and stressful. Critical events occur at a nexus that involves multiple participants under intense pressure and time constraints. For example, patients undergoing anesthesia and surgery and passengers flying on commercial airlines entrust their lives to anesthesia and surgical team members and airplane crews, respectively. Similarly, human error, as in aviation, is the most common cause of anesthesiology-related complications for patients in the perioperative process.[7,8]

## The NTS Movement

**NTS in Health Care** Human factors not primarily related to clinical knowledge or technical skills play a major role in >80% of anesthesiology-related complications. In response, an assessment and training method for NTS, ANTS, has been designed specifically for the field of anesthesiology.[7,9]

A growing body of literature underscores the point that technical skills are necessary, but not sufficient by themselves to maintain high levels of performances or a high-reliability organization. Gaba[10] has pointed out that "the issue of patient safety is no longer a hidden epidemic." To address this NTS gap head-on, the United Kingdom has assimilated NTS training programs and competencies into its medical practice. Physicians practicing in the United Kingdom go through a "revalidation process," which includes an assessment of communication, teamwork, and leadership skills, as defined by the General Medical Council in their "Good Medical Practice" document. Mandatory courses addressing team leadership and resource management have been integrated into the postgraduate training path, and the emphasis on human factors' impact in resuscitation practice has been introduced into the obligatory advanced life support courses.

**Team Cognition in Health Care** As the aviation industry adopted the principles of CRM, psychologist Eduardo Salas applied a similar focus in health care. He found that medical teams are at a significant disadvantage because of the infrequency with which they work together, their task interdependency, and the absolute mutual reliance required to perform their shared goals.[11] For a team to be successful, efficient, and overcome these obstacles, he found, the members had to manifest a certain composite of KSA. A team that reliably demonstrates KSA has high team cognition, which shifts the emphasis from the individual to the team (Fig. 3).

Team cognition occurs when team members functionally interact while working interdependently to achieve a shared goal. There has been a shift from skills demonstrated by the individual practitioner to those manifested by the team. This team-centric approach stems from the functional role structure, the short team life span, high skill differentiation, rotating leadership structure, and low temporal stability.[13] To counter these disadvantages, teams have to become aware of these handicaps and practice team KSA training. Improving team cognition through training activities improves clinical performance, organizational efficiency, hospital culture, and most importantly patient outcomes.[14–16] The US Department of Defense and the Agency for Healthcare Research and Quality sponsored this new emphasis on teamwork and partnered with Salas in developing a streamlined version of Team Cognition known as Team Strategies and Tools to Enhance Performance and Patient Safety (TeamSTEPPS).[12]

## EI in Health Care

*IQ and technical skills are important, but emotional intelligence is the sine qua non of leadership.*

—Daniel Goleman

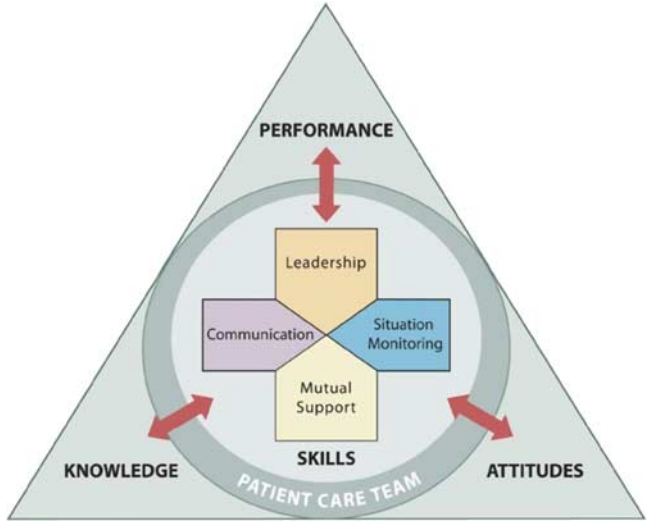


**Figure 3.** *TeamSTEPPS is based on the premise of Team Cognition, which teaches 4 fundamental skills: communication, leadership, situation monitoring, and mutual support. The team-related outcome and the 4 skills are mutually connected by the bidirectional arrows. The patient care team, seen encircling these skills, is accountable for exemplifying them as a unit. Original figure from King et al[12] and the US Agency for Healthcare Research and Quality. TeamSTEPPS indicates Team Strategies and Tools to Enhance Performance and Patient Safety.* full color online

More than 2 decades ago, Goleman[17] argued that every successful leader shares the common fundamentals of EI, despite the many different leadership styles. EI combines the ability to focus both on oneself and on others.[18] Leaders with high levels of EI are able to maintain both self-awareness (eg, awareness of sensory impressions or emotional states) and self-control. Goleman found that high levels of EI create group cultures rich in information sharing, trust, learning, and healthy risk-taking behaviors.[19] Not surprisingly, when a surgeon or an anesthesiologist lacks EI, the deficit can have a major impact on the mood and team dynamics in the operating room.

Further, effective leadership is less about mastering social skills than about developing a genuine interest in individuals on whom you rely for support, according to Goleman. This skill interconnects with the last component of EI, social control, which collectively refers to the social skill of building relationships and rapport. Social intelligence can be broken down into cognitive empathy (ie, understanding something from someone else's perspective) and emotional empathy (ie, feeling what someone else feels).[18] Empathy, whether cognitive or emotional, reflects an individual's ability to make connections with others and effectively inspire them.[20] In the high-pressure environment of the perioperative service, the ability of surgeons, operating room nurses, technicians, and anesthesiologists to work together significantly impacts the success of the team and patient outcomes.

EI and resilience are now recognized as necessary individual skill sets to create conditions for optimal clinical care and efficient systems.[21] For anesthesia health care providers, patient care demands are 24/7, each member possesses a unique skill set that is required for the team's success, and teams have high member fluidity and lower temporal stability. Therefore, anesthesia health care providers need to be trained in common core skills that allow them to seamlessly interact with each other in an ad hoc manner. Health care teams need to establish a collaborative leadership (or complex adaptive leadership) structure that permits various members to orchestrate decisions and take over roles on the basis of the needs of the team.[22] In the operating room environment, a shared and dynamic leadership structure between the anesthesiologist and surgeon can affect clinical decisions to operate on patients, the management of physiological crises, and the needs of the surgical team.

Health care training systems have traditionally focused on teaching and assessing specific clinical and technical skills. Currently, in almost all health systems, acute care physicians, such as anesthesiologists and surgeons, are promoted after residency training mainly on the basis of these technical and knowledge-based competences. Yet, a rigorous scientific education is not the only component necessary for a successful career in acute care medicine.[23,24] With the increasing complexity of modern health care systems and the concomitant increase in handoffs and multidisciplinary teams, communication and coordination are more essential than ever.

The literature from both surgery and anesthesiology indicates that EI, adaptive coordination, and resilience are characteristics that allow acute care physicians to perform optimally under stressful circumstances. Individuals who possess and improve these attributes are more likely to be successful in their specialties.[21] Physicians need these emotional skills to successfully navigate stressful situations, maintain resilience during long shifts, and work within fluid team structures (Fig. 4). Managing this complexity has an impact on the outcome of the patient and the general welfare of the individual and team.

**Anesthesia Crisis Resource Management (ACRM)** In the 1990s, Gaba and colleagues from Stanford, CA, adapted the concepts and interventions essential to aviation's CRM for anesthesia and created ACRM.[25] Much like Salas' work with team cognition, ACRM prioritizes teamwork over individual performance and concomitantly places the team's focus on the patient. This philosophical approach utilizes simulation-based training (SBT) to expose gaps in performance and to identify opportunities for developing better practice habits. ACRM directly challenges the notion that anesthesiologists can tacitly develop skills in crisis management using only abstract scientific lessons and routine daily operating room cases.

**Figure 4.** *One of the attributes that helps acute care physicians cope in stressful situations is emotional intelligence. Drawing by Steven D. Boggs.*

The emergence of SBT allowed learners new and old to manage infrequent or critical events. Gaba approaches ACRM by breaking down theories surrounding patient safety and dynamic events, cataloguing critical events with appropriate responses, and improving methods of debriefing new learners on their behaviors and performance. ACRM training, supplemented with SBT and cognitive aids (http://emergencymanual.stanford.edu), equips physicians with the technical and psychological skills to address difficult aspects of anesthesiology such as complexity, time pressure, risk, dynamism, and uncertainty.[26] Use of SBT has grown exponentially in the field of anesthesiology, to the extent that anesthesiologists can satisfy a significant proportion of their recertification requirements with a full-day ACRM course. ACRM has highlighted the advent and expansion of cognitive aids, which better equip practitioners to handle critical events using algorithms, an approach that has proven successful in aviation and other high-reliability organizations.

**The Development of ANTS** Anesthesiologists in the United State were among the first to adapt the aviation CRM approach for anesthetic training. This platform originated in Gaba's and Salas' work with ACRM[27] and TeamSTEPPS.[12] At around the same time in the United Kingdom, it was recognized that a more robust methodology for measuring anesthetists' NTS was needed. There, a team of anesthetists and psychologists

developed an ANTS system based on the NOTECHS framework used in aviation.[28] The NOTECHS system is used to select crew members by assessing cognitive and social skills.

The ANTS skills framework is divided into 4 categories, which are further subdivided into elements. These categories and elements are supported by behavioral markers to facilitate the application and assessments of these skills:

- Task management: planning and preparing, prioritizing, providing, and maintaining standards, identifying and utilizing resources.
- Teamwork: coordinating activities with team members, exchanging information, using authority and assertiveness, assessing capabilities, supporting others.
- Situational awareness: gathering information, recognizing and understanding, anticipating.
- Decision-making: identifying options, balancing risks, selecting options, re-evaluating.

Further, ANTS training incorporates aspects of both emotional and social intelligence:

- Cognitive or mental skills (eg, situation awareness, risk assessment, decision-making, adaptability).
- Social or interpersonal skills (eg, communication, leadership, teamwork).[7,9]

Intuitively, individuals who possess both an inner focus (self-awareness/self-control) and an outer focus (social awareness/social control) are better able to visualize and anticipate events with a broader perspective (ie, vision, strategy, disruptions).[18] Numerous advancements in anesthetic safety have occurred over the past decade. The focus on social and cognitive skills has been invaluable in improving safety, and ANTS has provided the essential tools.

**The Multidisciplinary Development of NTS in the Operating Room** Helmreich[3] suggested a model of operating room performance focusing on the entire operative team rather than on individual anesthesiologists' mental processes (Fig. 5). After the creation of the ANTS system, an NTS taxonomy and behavioral rating tools were adopted and tailored by other health care providers, including surgeons (Nontechnical Skills for Surgeons: NOTSS) (www.abdn.ac.uk/iprc/notss/), nurse practitioners (SPLINTS), and anesthesia assistants (A-ANTS).[28–30] The main components of these models are strikingly similar to those of ANTS[7]:

- Team input factors.
- Team performance function.
- Team, individual, and organizational outcomes.

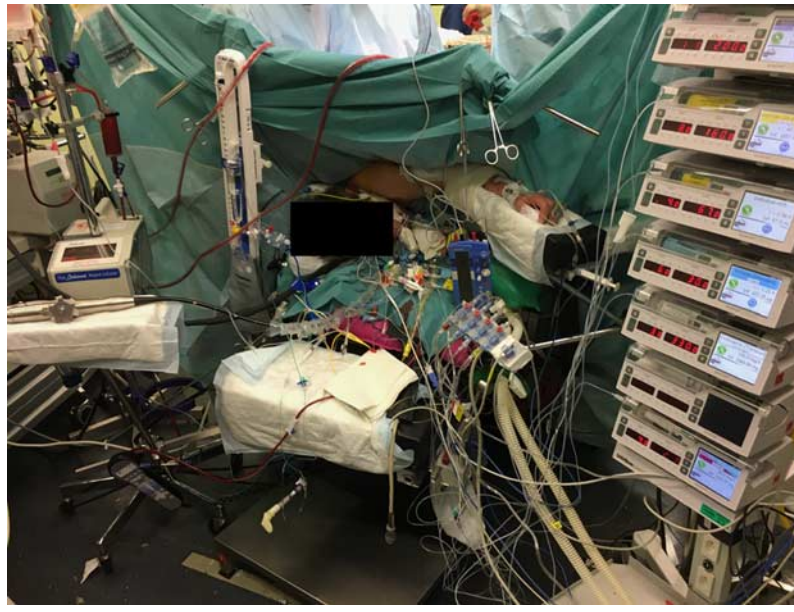

**Figure 5.** *An anesthesia setup at the Inselspital, Bern University Hospital, for an open intervention in a patient suffering from a thoracic aortic aneurysm. ANTS training can help deal with the complexity of intraoperative anesthesia. Photograph by Markus M. Luedi. ANTS indicates Anesthesia Non-Technical Skill.* full color online

- Identification and analysis of factors affecting overall team performance.

Half of the analyzed team performance functions are nontechnical tasks such as forming and maintaining a team, leadership, communication, decision-making, managing workload, and maintaining situational awareness. This model considers anesthesiologists' performance as part of the broader team working in the operating room, highlighting the fact that anesthetists do not work independently. Again, the overlap among the frameworks suggests that collaboration lies at the heart of any team dynamics in the operating room.

## Teaching NTS

**Teaching ANTS** Flin et al[1] developed a reliable and comprehensive ANTS-based assessment tool that maintains content validity and can be used to measure NTS, including situational awareness, teamwork, task management, and decision-making. The ANTS system provides residents and faculty with a language for evaluating the "behavioral aspects" of clinical performance. This tool was validated through literature reviews, comparison with other existing metrics, theoretical modeling,

cognitive task analysis, and expert analysis that proceeded through iterative workshops.[31] Today, ANTS has been tested in both the clinical and simulation environments.[7,29,32,33]

Giordano and colleagues at the University of Florida in Gainesville developed a unique resident rotation that placed each senior resident into a managerial role in an operating room suite. The resident—who was in charge of a 20-OR suite and individually responsible for 2 to 3 operating rooms—was evaluated daily by both the charge nurse and the supervising anesthesiologist using Flin's ANTS tool. Each night, the resident had reading assignments that addressed different aspects of NTS, EI, and OR management logistics. At the conclusion of each day, the resident, charge nurse, and attending gathered for a debriefing. The Gainesville study results, presented by Cole et al,[34] further validated the ANTS tool and showed that NTS could be embedded in a curriculum.

The ANTS framework creates a context and taxonomy for previously ill-defined and imprecise skills. With ANTS, health care educators can look at specific behaviors during performance reviews and minimize the use of personal judgments about character and motivations. This framework also provides a systematic approach for assessing these skills, debriefing new learners on their behaviors, and teaching better clinical approaches. At a very basic level, this system creates a common language or lexicon that can be used to communicate more meaningfully in the educational arena.

**Teaching Team Cognition: KSA** Many departments are either inadequately staffed or uncomfortable placing a new learner into a clinical leadership or a managerial role. Instead, they opt to implement SBT to address NTS education. As discussed previously, Team Cognition training focuses on the KSAs needed for a team to function efficiently and successfully. It redirects the focus of training in NTS from individual outcomes to team outcomes, with groups of individuals training together as teams to improve performance. These team-based exercises highlight how teamwork is perceived, reinforced, and valued in the organization.

The 3 competency categories listed in KSAs each address a unique component of team training. All teams must share a mental model of the goals for the event on hand, and have the *Knowledge* and understanding of the roles and responsibilities of each member. Teams must have behavioral *Skills* that incorporate team monitoring, information exchange, leadership, and backup behaviors. Finally, team member *Attitudes* must foster team-based orientation and nurture mutual trust. In short, Team Cognition reflects how individuals within a team think, feel, and act.

In a series of educational publications, Giordano et al developed facsimiles of various clinical scenarios.[35,36] These instructional activities were highly regarded by new learners because they were able to simultaneously work on team training activities and diagnose and manage critical care-related events during SBT. The overall team training strategy used to transfer the

educational material is not limited to SBT; other modes of content delivery can include demonstrations (eg, videos, live actors) or information-sharing resources (eg, lectures, articles, online modules). The use of > 1 instructional strategy (information, demonstration, practice) is more likely to be effective because it is applicable to multiple learner styles and incorporates passive and active learning strategies.[37,38]

**Teaching NTS Peer-to-Peer** To foster the development of EI, adaptive coordination, and resilience throughout one's career, Loup and Luedi[39] suggest the use of peer reviews in addition to the regular feedback process. These 2 coaching strategies take place at different levels. Unlike feedback, which is generally hierarchical, peer review is a horizontal assessment from a co-worker with similar knowledge and expertise.[39] Crucial for the development of a successful peer review process, the organizational culture must support the growth of EI. At the individual level, Goleman et al[19] believe that peer-to-peer development requires a passion for work itself, a self-deprecating sense of humor, a thirst for constructive criticism, comfort with ambiguity and change, maintenance of optimism in the face of failure, an ability to develop others, and sensitivity to cross-cultural differences.

## *Challenges and Future Directions*

Despite the aviation industry's overall success in reducing pilot error, there is much more work to be done in both the airline industry and acute care medicine. As an example, the inability to cope with fatigue and stress led a psychologically disturbed junior pilot to intentionally crash an Airbus A320-211 into the Alps in 2015.[23] This is a dramatic illustration of the catastrophic impact of a failure because of human factors in a high-reliability industry, where the imperfections of a single technically well-trained "dark horse" can be hidden from leadership and the team.[23] In health care crisis situations, technical and nontechnical performance decreases.[33] Therefore, the goal is to bolster both the technical performance and NTS performance of all health care providers and this includes anesthesia specialists.

There is evidence indicating that tacit instruction established in medical school education leads students to adopt behaviors that hinder fellowship and collaboration.[40] This weakness has not been addressed in any medical educational training or postgraduate career development course.[40] A joint initiative by the Accreditation Council for Graduate Medical Education (ACGME) and the American Board of Anesthesiology (ABA) seeks to close this gap by measuring outcomes of general medical education, depicting specific anesthesiology competencies that should be attained during residency.[12,41]

As physicians are pressured to drive hospital-wide changes to improve value-based care by providing better clinical outcomes with greater efficiency, they will invariably need strong clinical leadership

skills.[42–45] These leadership skills mirror NTS, and lead to better quality clinical outcomes by improving team behaviors and skills.[16,46,47] The cost of not developing leadership skills, EI, and team cognition at early stages in training is much greater than temporarily losing an anesthesia provider in the operating room.

It will take a while until NTS are systematically applied in daily practice and technical and NTS are considered of equal importance for new learners. The assessment of NTS needs to be not just standardized but also specifically tailored for each specialty. Further, these frameworks need to be validated, reproducible, and translatable to specific work environments. Training and familiarity with the principles of NTS should start as early as possible in postgraduate training, if not during medical school. This will help minimize resistance caused by unfamiliar NTS concepts, avoid the adoption of negative behaviors early in a clinical career, and maximize the opportunity for integrating NTS in the workforce.

Introducing an ANTS assessment tool into the educational and clinical curriculum will be challenging. Anesthesiology and surgery departments are constantly required to balance service and educational commitments, and moving trainees from a primary clinical role to an educational or an experiential role carries an expense along with a risk. There are 3 fundamental attributes that must be incorporated to successfully make this change: leadership, a culture of safety, and robust process improvement.[24] For anesthesiologists, these concepts are nothing new.

## ■ Acknowledgments

The authors thank Jeannie Wurz, medical writer/editor, Department of Anaesthesiology and Pain Medicine, Inselspital, Bern University Hospital, University of Bern, Bern, Switzerland, for her contributions to the manuscript.

The authors declare that they have nothing to disclose.

## ■ References

1. Flin R, O'Connor P, Crichton M. *Safety at the Sharp End: A Guide to Non-technical Skills*. Aldershot: Ashgate; 2008.
2. Munsterberg H. *Psychology and Industrial Efficiency*. Boston: Houghton Mifflin; 1913.
3. Helmreich RL. On error management: lessons from aviation. *BMJ*. 2000;320:781–785.
4. Reason J. *Human Error*. Cambridge: Cambridge University Press; 1990.
5. Ruff-Stahl H-JK, Vogel D, Dmoch N, et al. Measuring CRM aptitude: is NOTECHS a suitable tool for pilot selection? *Int J Aviat Aeronautics Aerospace*. 2016;3:4.
6. Civilian Aviation Authority Handbook. 2006 guidelines for regulation of aviation safety, page 1. 2006.

7. Fletcher G, McGeorge P, Flin RH, et al. The role of non-technical skills in anaesthesia: a review of current literature. *Br J Anaesth*. 2002;88:418–429.
8. Schulz CM, Burden A, Posner KL, et al. Frequency and type of situational awareness errors contributing to death and brain damage: a closed claims analysis. *Anesthesiology*. 2017;127:326–337.
9. Flin R, Glavin R, Maran N, et al. *Anaesthetists' Non-Technical Skills (ANTS) System Handbook Vol 10*. Aberdeen: University of Aberdeen; 2012:1–18.
10. Gaba DM. Structural and organizational issues in patient safety: a comparison of health care to other high-hazard industries. *Calif Manage Rev*. 2000;43:83–102.
11. Salas E, Wilson KA, Burke CS, et al. Does crew resource management training work? An update, an extension, and some critical needs. *Hum Factors*. 2006;48:392–412.
12. King HB, Battles J, Baker DP, et al. TeamSTEPP: team strategies and tools to enhance performance and patient safety. In: Henriksen K, Battles JB, Keyes MA, Alonso A, Salas E, Webester J, Toomey L, Salisbury M, eds. *Advances in Patient Safety: New Directions and Alternative Approaches (Vol 3: Performance and Tools)*. Rockville, MD: Agency for Healthcare Research and Quality; 2008.
13. Hughes AM, Gregory ME, Joseph DL, et al. Saving lives: a meta-analysis of team training in healthcare. *J Appl Psychol*. 2016;101:1266–1304.
14. Schmutz J, Manser T. Do team processes really have an effect on clinical performance? A systematic literature review. *Br J Anaesth*. 2013;110:529–544.
15. Salas E, Rosen MA. Building high reliability teams: progress and some reflections on teamwork training. *BMJ Qual Saf*. 2013;22:369–373.
16. Neily J, Mills PD, Young-Xu Y, et al. Association between implementation of a medical team training program and surgical mortality. *JAMA*. 2010;304:1693–1700.
17. Goleman D. *Working with Emotional Intelligence*. New York: Bantam Books; 1998.
18. Goleman D. The focused leader. *Harv Bus Rev*. 2013;91:131–135.
19. Goleman D, Boyatzis R, McKee A. Primal leadership: the hidden driver of great performance. *Harv Bus Rev*. 2001;79:42–53.
20. Goleman D, Boyatzis R. Social intelligence and the biology of leadership. *Harv Bus Rev*. 2008;86:74–81.
21. Luedi MM, Doll D, Boggs SD, et al. Successful personalities in anesthesiology and acute care medicine: are we selecting, training, and supporting the best? *Anesth Analg*. 2017;124:359–361.
22. Wildman JL, Thayer AL, Rosen MA, et al. Task types and team-level attributes: synthesis of team classification literature. *Hum Res Dev Rev*. 2012;11:97–129.
23. Luedi MM, Boggs SD, Doll D, et al. On patient safety, teams and psychologically disturbed pilots. *Eur J Anaesthesiol*. 2016;33:226–227.
24. Boggs SD, Doll D, Stueber F, et al. In response. *Anesth Analg*. 2017;124:1738–1739.
25. Holzman RS, Cooper JB, Gaba DM, et al. Anesthesia crisis resource management: real-life simulation training in operating room crises. *J Clin Anesth*. 1995;7:675–687.
26. Gaba DM, Fish KJ, Howard SK, et al. *Crisis Management in Anesthesiology*, 2nd ed. Philadelphia: Elsevier Saunders; 2015.
27. Gaba DM. Crisis resource management and teamwork training in anaesthesia. *Br J Anaesth*. 2010;105:3–6.
28. Flin R, Patey R. Non-technical skills for anaesthetists: developing and applying ANTS. *Best Pract Res Clin Anaesthesiol*. 2011;25:215–227.
29. Yule S, Flin R, Paterson-Brown S, et al. Non-technical skills for surgeons in the operating room: a review of the literature. *Surgery*. 2006;139:140–149.
30. Doumouras AG, Hamidi M, Lung K, et al. Non-technical skills of surgeons and anaesthetists in simulated operating theatre crises. *Br J Surg*. 2017;104:1028–1036.
31. Kuo AK, Thyne SM, Chen C, et al. An innovative residency program designed to develop leaders to improve the health of children. *Acad Med*. 2010;85:1603–1608.

32. Yule S, Parker SH, Wilkinson J, et al. Coaching non-technical skills improves surgical residents' performance in a simulated operating room. *J Surg Educ*. 2015;72: 1124–1130.
33. Riem N, Boet S, Tavares W, et al. Do technical skills correlate with non-technical skills in crisis resource management: a simulation study. *Br J Anaesth*. 2012;109:723–728.
34. Cole DC, Giordano CR, Vasilopoulos T, et al. Resident physicians improve nontechnical skills when on operating room management and leadership rotation. *Anesth Analg*. 2017;124:300–307.
35. Giordano C, Kiley S, Reed H, et al. Hyperkalemic arrest: developing team cognition. *MedEdPortal*. 2017;13:10614.
36. Ryan M, Giordano CR. Managing the complex issues of pediatric nonaccidental trauma: a simulation-based case of a critically injured child. *MedEdPortal*. 2017;10:15766.
37. Franzoni AL, Assar S. Student learning styles adaptation method based on teaching strategies and electronic media. *Ed Tech Soc*. 2009;12:15–29.
38. Zapp L. Use of multiple teaching strategies in the staff development setting. *J Nurses Staff Dev*. 2001;17:206–212.
39. Loup O, Luedi MM. Peer review in perioperative medicine. In: Fox CJ, Ghali GE, Cornett EM, eds. *Catastrophic Perioperative Complications and Management—A Comprehensive Textbook*. Cambridge University Press. In press.
40. Stoller JK. Developing physician-leaders: a call to action. *J Gen Intern Med*. 2009;24: 876–878.
41. Blumenthal DM, Bernard K, Bohnen J, et al. Addressing the leadership gap in medicine: residents' need for systematic leadership development training. *Acad Med*. 2012;87:513–522.
42. Ham C. Improving the performance of health services: the role of clinical leadership. *Lancet*. 2003;36:1978–1980.
43. Nembhard IM, Edmondson AC. Making it safe: the effects of leader inclusiveness and professional status on psychological safety and improvement efforts in health care teams. *J Organ Behav*. 2006;27:941–966.
44. Curry LA, Spatz E, Cherlin E, et al. What distinguishes top-performing hospitals in acute myocardial infarction mortality rates? *Ann Intern Med*. 2011;154:384–390.
45. Majmudar A, Jain AK, Chaudry J, et al. High-performance teams and the physician leader: an overview. *J Surg Educ*. 2010;67:205–209.
46. Kim MM, Barnato AE, Angus DC, et al. The effect of multidisciplinary care teams on intensive care unit mortality. *Arch Intern Med*. 2010;170:369–376.
47. Wheelan SA, Burchill CN, Tilin F. The link between teamwork and patients' outcomes in intensive care units. *Am J Crit Care*. 2003;12:527–534.