Behavioural science approaches to enhancing surgical performance

Steven Yule

Steven Yule is Professor of Behavioural Sciences at the Usher Institute, University of Edinburgh where he leads the Surgical Sabermetrics Laboratory and MSc in Clinical Human Factors and Patient Safety. He is also Director of Non-Technical Skills for the Royal College of Surgeons of Edinburgh. Steve is an academic psychologist with 20 years' experience studying team performance and non-technical skills in high risk/high reliability industries (surgery, healthcare, energy, transportation, space exploration).

In the realm of surgery, proficiency extends beyond mere technical prowess; it involves a nuanced understanding and application of non-technical skills (NOTSS) that are indispensable for optimal performance[1]. Recognised as pivotal components in surgical practice, NOTSS encompasses a range of abilities including situation awareness, decision-making, communication, teamwork, and leadership. These skills are fundamental in successful navigation of the complex and dynamic surgical environment, where split-second decisions and effective collaboration can mean the difference between success and failure. Non-technical skills constitute the bedrock upon which surgical proficiency is built for professional life, complementing technical skills to ensure optimal performance, patient care and team well-being in the demanding environment of the operating room. As such, cultivating and refining these skills is imperative for surgeons seeking to excel in their practice and enhance the quality and safety of surgical interventions. In this article, I will describe the evidence base for non-technical skills in surgery, introduce surgical sabermetrics and data-science approaches to measuring operative performance, and suggest future implementation of NOTSS in surgical training and practice for all.

Situation awareness lies at the core of NOTSS, enabling surgeons to maintain a comprehensive understanding of the evolving picture during a procedure. This entails not only recognising the current state but also anticipating future developments and potential complications. Decision-making, another crucial aspect, involves the ability to evaluate various options swiftly and effectively under pressure, often with incomplete information.

Communication serves as the linchpin of teamwork in the surgical setting. Clear and concise communication among team members facilitates coordination, enhances efficiency, and mitigates errors. Moreover, effective communication extends beyond verbal exchanges to encompass non-verbal cues and active listening, fostering mutual understanding and trust among team members. Teamwork, in conjunction with leadership, forms the basis of collaborative efforts in surgery. A cohesive surgical team, characterised by mutual respect, shared goals, and distributed leadership, can enhance patient outcomes, and mitigate adverse events. Leadership within this context involves not only directing and coordinating team activities but also fostering a culture of safety, accountability, and continuous improvement. It is important to emphasise that leadership is action, rather than position – and although surgeons are often thought of as the leader in the operating room, other team members can provide leadership during different phases of the procedure.

Surgical sabermetrics

Sabermetrics involves the systematic analysis of video footage and performance data to glean actionable insights and facilitate informed decision-making. While traditionally associated with sports such as baseball, its application in fields like trauma and orthopaedic surgery holds immense promise for enhancing patient care and refining surgical techniques (Figure 1). Sabermetrics involves a multidimensional examination of performance factors, encompassing individual skills, team dynamics, system resources, and patient variables, such as surgical techniques, non-technical proficiencies, >>

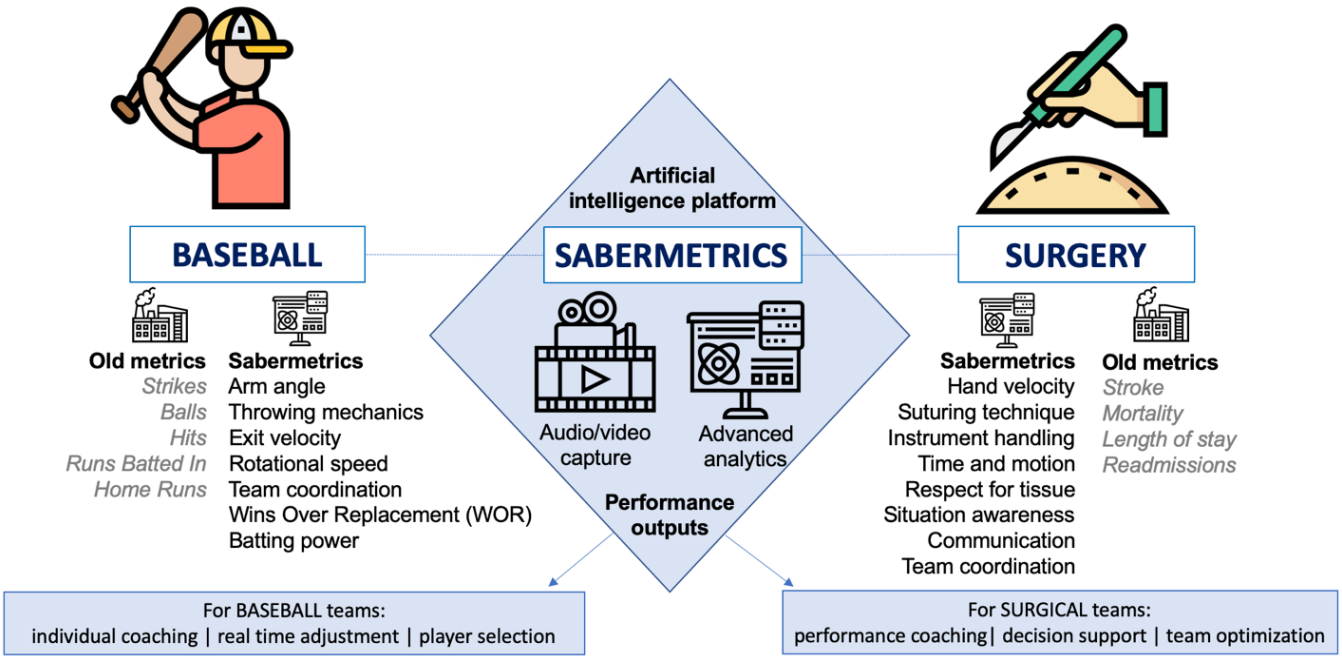

Figure 1: Surgical sabermetrics applies baseball-inspired data science to provide new insights into operating room performance that enhances patient safety and saves lives. [Reproduced with permission from Elsevier, original reference: Yule S, Janda A, Likosky DS. Surgical sabermetrics: Applying athletics data science to enhance operative performance. *Annals of Surgery Open* [Internet]. 2021;2(2):e054.

and clinical outcomes[2]. By harnessing data-driven methodologies, surgeons can deepen their understanding of surgical intricacies, pinpoint areas for enhancement, and enact tailored interventions to optimise patient results. Integrating sabermetrics alongside conventional surgical metrics may unveil additional insights into patient outcomes, bolstering patient safety, quality of care, and educational endeavours through personalised training, performance feedback, team refinement, and real-time clinical guidance.

Sabermetrics leverages surgical data science, an interdisciplinary field that involves extracting insights and knowledge from structured and unstructured data through various methods, including statistics, machine learning, and data visualisation. Surgeons can utilise data science to enhance their performance and patient outcomes by leveraging data-driven approaches. They collect and analyse surgical data, such as operative times, complication rates, and patient outcomes, to identify patterns, trends, and areas for improvement. Through predictive modelling, surgeons can anticipate potential complications or optimise surgical techniques tailored to individual patient characteristics. Additionally, data science enables surgeons to track their performance over time, receive personalised feedback, and engage in continuous learning and improvement. By integrating data science and sabermetrics into their practice, surgeons can make more informed decisions, enhance patient safety, and ultimately improve the quality of surgical care. Examples of non-technical skills and sabermetrics data relating to several orthopaedic surgical procedures are illustrated in Table 1.

Non-technical skills category	Illustrative orthopaedic surgical procedures	Potential sabermetric data sources for formative assessment
Situation awareness	**Total hip replacement:** Requires awareness of anatomical landmarks, implant size availability, potential complications, and patient positioning during the procedure.	• Video-based scenarios • Virtual reality simulations • Observation assessments
Decision-making	**Spinal fusion:** Involves complex decision-making regarding the selection of fusion levels, instrumentation, managing intra-operative challenges, and reviewing decisions.	• Case-based discussions • Decision-making exercises • Reflective practice activities
Communication	**ACL reconstruction:** Demands clear communication among surgical team members regarding graft selection, tunnel placement, and post-operative care instructions.	• Communication skills assessments • Simulated surgical team interactions • Debriefing sessions
Teamwork	**Total knee replacement:** Relies on effective collaboration among surgeons, anaesthetists, nurses, and other team members for efficient intra-operative workflow and patient safety.	• Team-based simulations • Peer evaluations • Surgical team observation assessments
Leadership	**Fixation of femoral shaft fracture:** Requires strong leadership to coordinate the surgical team, prioritise tasks, and manage unexpected complications during the procedure.	• Leadership role-play exercises • 360-degree feedback assessments • Crisis scenarios simulations

Table 1: Example NOTSS skills and sabermetrics data for orthopaedic surgery.

In laparoscopic bariatric surgery, peer evaluations based on video footage assessing technical skills, such as suturing movements and instrument handling, have yielded valuable performance insights predictive of outcomes[3]. The advent of artificial intelligence-enabled video analysis holds promise for transformative advancements in surgery, promising reduced errors, improved patient care, and enriched professional growth for clinicians. The integration of computer vision and machine learning in automating operative phase detection is paving the way for real-time clinical decision support systems, revolutionising surgical safety and quality[4].

Nevertheless, individual proficiency alone does not guarantee consistent success. A significant portion of surgical outcomes hinges on team dynamics, communication, situational awareness, adaptability, and decision-making. Consequently, emerging sabermetric-like capabilities for team performance analysis are gradually finding application in surgery. Crowd-sourced video platforms equipped with taxonomies for assessing technical and non-technical skills across surgical teams, including surgeons, anaesthetists, and scrub practitioners, are harnessing embedded artificial intelligence to uncover previously unseen practice patterns, signalling an imminent revolution in surgical sabermetrics.

Improving your own non-technical skills

Several options are available to surgeons at all career levels who are interested in enhancing performance through dedicated non-technical skills training:

1. **Simulation-based training:** This offers surgeons a safe environment to practice and refine their non-technical skills. Through realistic scenarios that mimic surgical situations, all trainees can enhance their communication, teamwork, and situation awareness. Senior trainees and consultants can hone decision-making, and leadership abilities. These simulations may involve virtual reality platforms, high-fidelity mannequins, or standardised patients. By immersing themselves in simulated surgical experiences, learners can develop confidence, practice new skills, improve performance, and learn how to navigate challenging situations. Instructors provide structured feedback and debriefing sessions after each simulation, offering valuable insights and allowing learners to identify strategies for continual improvement.

2. **Structured debriefing:** Debriefing sessions are a critical component of both simulation-based training and real clinical experiences. Structured debriefing involves a systematic review of the simulation or clinical encounter, focusing on both technical and non-technical aspects of performance. Trainees reflect on their actions, decisions, and communication strategies during the scenario. Facilitators guide the discussion, encouraging trainees to identify strengths, weaknesses, and areas for development. Through open dialogue and constructive feedback, trainees gain valuable insights into their non-technical skills and learn how to apply lessons learned to future practice.

3. **Peer observation and feedback:** This is a strategy that can be enacted without any equipment or technology, providing trainee surgeons with an opportunity to learn from their colleagues and receive valuable insights into their non-technical skills. Trainees can observe each other during simulations, surgeries, or clinical interactions, paying attention to communication patterns, teamwork dynamics, and leadership behaviours using a validated framework such as the NOTSS taxonomy[5]. Afterwards, peers provide feedback on observed strengths and areas for improvement. This reciprocal process promotes a culture of continuous learning and collaboration, fostering mutual support and professional growth. Instructors also often learn new strategies from participants which can be passed on to others, enriching the learning experience.

4. **Surgical coaching:** Mentorship relationships often extend beyond technical proficiency to encompass broader professional development and career guidance, further enriching the learning experience for trainee surgeons. This is different from surgical coaching, a recently adopted method for skill enhancement and patient safety improvement, drawing from business and sports coaching techniques that emphasise adult learning principles. Unlike teaching and mentorship, it prioritises surgeons becoming agents of change. Various coaching programmes for surgeons exist worldwide, such as the Surgical Coaching for Operative Performance Enhancement (SCOPE) programme from Ariadne Labs in Boston[6]. SCOPE defines coaching as a collaborative partnership between two surgeons aimed at pursuing self-identified goals through joint analysis, feedback, and peer learning support. It focuses on continuous development of intra-operative performance, covering technical skills (e.g. tissue respect, exposure, instrument handling) and non-technical skills (e.g. situation awareness, decision-making, communication). The programme follows four principles: self-identified goals, collaborative analysis, constructive feedback, and peer learning support. Current questions regarding how best to train peer coaches, coach-coachee matching mechanisms, and optimal metrics for evaluating surgical coaching are being investigated. As surgical coaching evolves, it presents an avenue to enhance skills and patient safety throughout surgeons' careers.

The technological future of surgical performance

As we look ahead to the future of surgery, the convergence of advanced technologies and innovative methodologies promises a new era of excellence and precision in patient care. With continued integration of artificial intelligence, virtual reality, and augmented reality into surgical practice, surgeons could have access to real-time feedback, personalised training, and predictive analytics, revolutionising the way surgeries are performed and outcomes are optimised. As surgical sabermetrics and data science become increasingly sophisticated, the operating room of tomorrow will be a dynamic ecosystem where decisions and action are informed by data-driven insight, ensuring that every patient continues to receive the highest standard of care, every time. ■

References

1. Yule S, Gupta A, Gazarian D, Geraghty A, Smink DS, Beard J, *et al*. Construct and criterion validity testing of the Non-Technical Skills for Surgeons (NOTSS) behaviour assessment tool using videos of simulated operations. *Br J Surg*. 2018;105(6):719-27.

2. Howie EE, Ambler O, Gunn EG, Dias RD, Wigmore SJ, Skipworth RJ, *et al*. Surgical Sabermetrics: A Scoping Review of Technology-Enhanced Assessment of Non-Technical Skills in the Operating Room. *Ann Surg*. 2024 Jan 23; [Online ahead of print].

3. Birkmeyer JD, Finks JF, O'Reilly A, Oerline M, Carlin AM, Nunn AR, *et al*. Surgical skill and complication rates after bariatric surgery. *N Engl J Med*. 2013;369(15):1434-42.

4. Hashimoto DA, Rosman G, Witkowski ER, Stafford C, Navarette-Welton AJ, Rattner DW, *et al*. Computer Vision Analysis of Intraoperative Video: Automated Recognition of Operative Steps in Laparoscopic Sleeve Gastrectomy. *Ann Surg*. 2019;270(3):414–21.

5. The Royal College of Surgeons of Edinburgh [Internet]. [cited 2024 May 12]. Non-Technical Skills for Surgeons (NOTSS). Available from: www.rcsed.ac.uk/professional-support-development-resources/learning-resources/non-technical-skills-for-surgeons-notss.

6. Pradarelli JC, Yule S, Panda N, Lowery KW, *et al*. Surgeons' coaching techniques in the Surgical Coaching for Operative Performance Enhancement (SCOPE) program. *Ann Surg*. 2022;275(1):e91-e98.