Surgical Team Training: Promoting High Reliability with Nontechnical Skills

John T. Paige, MD

The past decade has witnessed an ongoing transformation in surgical training in the United States and abroad, led in large part by the incorporation of simulation into residency educational curricula. As a result, the Halstedian apprentice-based teaching model, founded on the maxim of “See one, do one, teach one,” is steadily giving way to an objectives-based educational model centered around the triad of targeted task performance, immediate feedback, and repeated focused practice associated with Ericsson’s conceptual framework of deliberate practice. This paradigm shift in how surgery is taught has also been accompanied by an expansion in what is taught, as surgical educators have realized the importance of organization- and team-based dynamics in the care of the surgical patient. To succeed in today’s health care environment, a surgeon must be more than a masterful technician; he or she must be an expert team leader with a firm grasp of how the system in which he or she operates functions.

This article focuses on key aspects of these “nontraditional” surgical subjects of organizational structure and team interaction. First, the deficiencies in team dynamics found within the modern operating room (OR) and their resultant consequences are highlighted. Next, essential human factors concepts related to error generation, organizational culture, high reliability, and team science as applied to the OR environment are reviewed. Finally, various strategies for improving OR team function, including the use of high-fidelity simulation (HFS) in team training are discussed.

MODERN OPERATING ROOM TEAM DYNAMICS AND THEIR CONSEQUENCES

The modern OR is a highly dynamic work environment that brings together a diverse group of professionals who must work effectively together as a team to provide safe,
quality care to the surgical patient. In such a high-risk environment, each team member must draw upon his or her expert clinical knowledge as well as several distinct categories of skills (Table 1).²,³ Nontechnical skills (NTS) are the combination of those cognitive and interpersonal skills that complement each team member’s technical skills to contribute to a safe, effective operative intervention.²,⁴ They form the foundation on which team interaction and dynamics are built. Fortunately, NTS are not innately derived; instead, they can be acquired through teaching and training, much like technical skills are learned.⁵

That NTS are teachable skills is encouraging, especially given the dysfunctional status of current OR team dynamics. Indeed, the modern OR team is more appropriately characterized as a group of experts rather than an expert team.⁶ Members favor multiprofessional practice over interprofessional collaboration.⁷ The resultant “silo mentality” that each profession brings to the OR is reinforced only by its ready stereotyping of the “other” professions working on the OR team.⁸ Finally, differentials in both status and the frequency of individual traits such as motivation, competitiveness, and dominance among the various OR professions contribute to a hierarchical structure prone to interprofessional friction.⁹

This multiprofessional nature of practice within the modern OR allows each profession to harbor divergent conceptions of appropriate team interactions and norms. For example, McDonald and colleagues¹⁰ demonstrated that nurses’ reliance on adherence to written rules of conduct and standardized approaches to therapy were in direct conflict with surgeons’ beliefs in following unwritten rules of established behavior and maintaining flexibility in treatment plans. These differing attitudes related to behavior and clinical decision making negatively affected trust between the two professions. Additionally, Undre and colleagues¹¹ revealed that the definition of the term “team” itself differed among OR professions. Whereas nurses tended to view an “OR team” as a unit made up of members working together, surgeons and anesthesiologists took the more traditional view of the “OR team” as a grouping of specialists working within defined boundaries (ie, silos).

The divergent conceptions of team combine with stereotyping to distort each profession’s perception of each other and their performance in the OR. Lingard and colleagues¹² found that each profession’s self-described role on the OR team was in fact discordant with how other professions within the OR viewed that profession’s

| Table 1 |
|----------------------|------------------|
| Category             | Example          |
| Technical skills     | Endotracheal intubation Patient positioning Suturing |
| Cognitive skills     | Decision making Planning Analytical thinking |
| Interpersonal skills | Communication Assertiveness Conflict resolution |

responsibilities. Flin and colleagues\textsuperscript{13} showed that this disconnect extended to perceived leadership style. Whereas most surgeons described their leadership as consultative, a similar proportion of nurses viewed it as autocratic. Moorthy and colleagues\textsuperscript{14} and Paige and colleagues\textsuperscript{15} revealed a tendency for a profession to overestimate its self-assessed contribution to team function compared with observer- or peer-based ratings. Finally, Makary and colleagues\textsuperscript{16} demonstrated marked differences among the professions in each one’s perception of the quality of teamwork within the OR. For example, surgeons perceived teamwork with nurses within the OR as good at an almost twofold higher rate than nurses’ views of the same interaction.

Communication suffers in the OR multiprofessional practice model as well. Lingard and colleagues\textsuperscript{17} discovered that up to one-third of all communications within the OR fail in their purpose. The reasons for these breakdowns are manifold, ranging from poor timing of the communication to exclusion of key team members from the communication. Such ineffective communication naturally can lead to increased tension within the OR.\textsuperscript{18} Finally, the poor communication is likely magnified by an OR culture that discourages members from alerting each other regarding potential threats within the environment\textsuperscript{19} and the poor interpersonal skills of other members on the OR team.\textsuperscript{20}

The silo mentality, divergent perceptions of team-based roles and performance, and poor communication among the professions within the modern OR negatively affect team function as well as surgical patient care. Rosenstein and O’Daniel\textsuperscript{21} discovered that disruptive behavior such as yelling and the use of abusive language is unfortunately commonplace, increasing frustration and stress within the OR. More telling, it further stifles communication and interprofessional collaboration, leading many OR team members to link such behavior with decreased patient safety and quality of care. Christian and colleagues\textsuperscript{22} established an even stronger link between team dysfunction and quality of care by revealing that difficulties with workload distribution and communication in complex surgical cases have the potential of negatively affecting patient safety. Finally, Mishra and colleagues\textsuperscript{23} linked breakdowns in NTS with increased rates of error in technical skills within the OR.

Most importantly, impaired team dynamics in the modern OR is responsible for both adverse events and poor outcomes. Communication breakdowns have been linked to wrong-site surgery\textsuperscript{24,25} as well as other adverse events.\textsuperscript{26} Mazzocco and colleagues\textsuperscript{27} have even shown that poor teamwork in the OR results in higher postoperative morbidity (ie, complication rates) and mortality. Clearly, improving team dynamics in the OR should be a priority and has the potential to improve processes and outcomes of surgical care.

\textbf{THE OPERATING ROOM TEAM FROM A HUMAN FACTORS PERSPECTIVE}

Human factors, or ergonomics, is the study of the interaction of humans with their environment. As such, it strives to understand the physical and psychological factors at play when humans interface with machines, systems, or other humans to create safe work environments that maximize efficiency. A central tenet of the field is the \textit{inevitability of error} occurring in any system designed or operated by humans because of the innate \textit{fallibility of humans}.\textsuperscript{28} Consequently, an understanding of the \textit{conditions} under which humans work within a complex system is paramount for designing layers of defense, so-called \textit{defenses-in-depth}, to trap and mitigate the impact of errors within that system.\textsuperscript{29,30} Even so, each layer within a series of defenses-in-depth is susceptible to dynamic defects that, when they become aligned with defects within
all the other layers, create a “window of opportunity” for catastrophic failure. Defects typically arise from one of two sources: (1) active failures occurring at the “sharp-end” of the human-system interface that have immediate but short-lived impacts and (2) latent conditions occurring at the organizational level that lie dormant within a system until a confluence of local circumstances reveal them. Within this context, the OR team can be a dual source of weakness. It can contribute to the formation of a defect within the defenses-in-depth of a system via active failure by members working at the “sharp-end” of care or as a latent condition owing to the dysfunctional nature of team dynamics.

The OR can be considered one of many clinical microsystems dedicated to a common patient care purpose that help make up the organizational structure of a health care entity. As such, it operates within the cultural climate of the larger institution of which it is a part. Westrum defined three main types of organizational cultures with distinct responses to failure: (1) the power-oriented pathologic culture that attempts to find scapegoats and suppress the problem; (2) the rules-oriented bureaucratic culture that focuses on meting out justice and providing local fixes; and (3) the performance-oriented generative culture that embraces failure as an opportunity for improvement and searches for its root causes. Understanding the way in which an organizational culture processes information and responds to error is critical in developing an effective approach to improving OR team dynamics within a particular health care system, especially because the best way to support cultural change is by addressing real problems in ways that will promote participation and successfully shift assumptions to tilt the organizational culture in the desired direction.

A generative organizational culture is characteristic of high-reliability organizations (HROs). These organizations promote a culture of safety in which safety becomes the organization’s primary priority. Because HROs recognize as an illusion the possibility of becoming completely safe, they maintain a constant preoccupation with failure. As a result, they pay particularly close attention to frontline operations in an effort to find weaknesses in their defenses. In HROs, expertise trumps rank, safety becomes everyone’s responsibility, and resilience in the face of failure allows for systems to function in times of crisis. HROs, however, cannot exist without highly reliable teams (HRTs) functioning within them. In this context, improving the function of the OR team takes on even more urgency, as HRO status is unattainable without it.

Before becoming an HRT, the multiprofessional practice of the OR must become a team. Currently, it is a working group of siloed individuals who, in the best circumstances, act as a potential team and, in the worse situations, function more like a pseudo-team. By definition, teams in health care possess five key attributes: (1) they consist of two or more individuals; (2) they consist of members with specific roles and tasks who interact to achieve a common goal; (3) they have the ability to make decisions; (4) they have specialized knowledge and skill for use in a high workload environment; and (5) they have collective action arising from task interdependency. According to LePine and colleagues, team actions and activities can be divided into three specific second-order processes that are themselves governed by an overall team third-order process. These second-order processes include actions conducted between performances (ie, transition processes), actions that occur as the team works toward a goal (ie, action processes), and actions focusing on the management of interpersonal relations (ie, interpersonal processes). Team effectiveness and member satisfaction are equally related to each of these three processes. In other words, all three second-order processes of team activities are each important in providing wanted outcomes and creating a sense of fulfillment among members.
How do HRTs effectively implement these second-order team processes? Decades of research into the characteristics of HRTs has spawned multiple models for team behavior and performance.41 The Salas and colleagues42 concept of The Big Five Model of Teamwork is particularly useful for identifying the key competencies needed to promote highly reliable team function. In it, they have identified five core individual-based behaviors common to HRTs that are successfully implemented using three key coordinating behaviors (Table 2).5,39,41–43 These behaviors in turn can be categorized into team-based knowledge, skills, and attitudes (KSAs).39 Additionally, Wilson and colleagues43 mapped how these eight essential components relate to critical components of HROs, facilitating the development of effective training methods for creating HRTs and promoting a culture of safety within the team structure and organization.

What team-based competencies are applicable to the OR team? Clearly, the Big five core components and their coordinating mechanisms would play a role in any attempt to create HRTs within the OR. Nonetheless, each profession’s particular roles and responsibilities in the OR might favor particular behaviors (ie, NTS) over others for effective team interaction. Fortunately, work from the Industrial Psychology Research Center at the University of Aberdeen has identified those key behavioral markers of NTS that are required by each profession in the OR for HRT performance (Table 3).2,41,44–46 Although slightly different from the Big five behaviors, they can be roughly aligned. By identifying those NTS related to each profession in the OR, the development of targeted rating systems is possible for assessment of each profession.46,47 Finally, by using the conceptual framework of the Big Five Model of Teamwork, accurate performance measures can be developed for assessing the effectiveness of training interventions.41

Approaching the OR team from the human factors perspective, therefore, reveals that it has the potential to be either a huge liability or an invaluable asset to the clinical microsystem and larger health care organization within which it functions. According to the University of Texas Medical Threat and Error Management Model proposed by Helmreich and Sexton,48 the OR, like any clinical microsystem, should be viewed as an environment filled with both external threats (ie, unexpected events like an equipment failure) as well as latent threats (ie, overemphasis on case throughput) that, if not successfully identified and mitigated by the OR team, can lead to adverse events. Within this threat-filled environment work humans whose individual-based weaknesses (ie, limited memory, finite mental processing capacity, and susceptibility to stress or fatigue) predispose them to error production. In addition, group-based deficits such as flawed teamwork or negative cultural influences contribute to the generation of errors. To counteract such threats and errors, Helmreich and Sexton48 have emphasized the development of a carefully designed program for change process, including training to improve teamwork. The challenge then becomes developing effective strategies for a surgical team training program.

STRATEGIES FOR SURGICAL TEAM TRAINING

Like any educational endeavor, developing an effective surgical team training program begins with the creation of a robust objectives-driven curriculum derived from targeted team-based KSAs (ie, competencies) identified through a thorough needs analysis of the learner group.49,50 Clearly, content geared toward creating and promoting HRTs is desirable.43 It should also use a human factors approach to error generation and team function as well as include training in behavioral countermeasures to threat and error (eg, inquiry, conflict resolution, and fatigue management).48 Finally, the curricular content should attempt to introduce established tools for improving team
<table>
<thead>
<tr>
<th>Category</th>
<th>Team-based Competency</th>
<th>Definition</th>
<th>Competency Type</th>
<th>Example</th>
<th>HRO Trait Equivalent(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big 5 core components</td>
<td>Team leadership</td>
<td>Promotion of coordinated team performance through social problem solving and facilitation of goal definition and attainment</td>
<td>Skill</td>
<td>Assignment of roles to team members</td>
<td>Deference to expertise; reluctance to simplify</td>
</tr>
<tr>
<td></td>
<td>Mutual performance monitoring</td>
<td>Keeping track of other members’ work while performing own work</td>
<td>Skill</td>
<td>Providing feedback to promote self-correction</td>
<td>Commitment to resilience</td>
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<tr>
<td></td>
<td>Back-up behavior</td>
<td>Shifting of workload among members in discretionary fashion to achieve balance</td>
<td>Skill</td>
<td>Completion of task by other team members with task saturation of an individual</td>
<td>Commitment to resilience</td>
</tr>
<tr>
<td></td>
<td>Adaptability</td>
<td>Recognizing and appropriately responding to unexpected events or needs</td>
<td>Skill</td>
<td>Maintaining vigilance regarding cues of change in the course of events</td>
<td>Reluctance to simplify; preoccupation with failure</td>
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<td></td>
<td>Team orientation</td>
<td>Belief in the importance of the team’s goals over individual goals</td>
<td>Attitude</td>
<td>Taking into account other team members’ input</td>
<td>Deference to expertise; preoccupation with failure</td>
</tr>
<tr>
<td>Coordinating mechanisms</td>
<td>Shared mental model</td>
<td>A shared understanding of the situation and team goals for accomplishing objective</td>
<td>Knowledge</td>
<td>Implicit task coordination during high-workload situation</td>
<td>Commitment to resilience; reluctance to simplify; sensitivity to operations</td>
</tr>
<tr>
<td></td>
<td>Mutual trust</td>
<td>Belief that team members will perform goals and protect each others’ interests</td>
<td>Attitude</td>
<td>Admitting mistakes and accepting feedback regarding improvement</td>
<td>Deference to expertise; preoccupation with failure</td>
</tr>
<tr>
<td></td>
<td>Communication</td>
<td>Exchange of information between sender and receiver</td>
<td>Skill</td>
<td>Initiation of message by sender, acknowledgment by receiver, follow-up by sender</td>
<td>Sensitivity to operations</td>
</tr>
</tbody>
</table>

Data from Refs. 5,39,41–43
function (eg, standardized briefings, debriefing techniques, establishment of critical language, and assertiveness measures).

Once created, a team training curriculum can then be implemented using a variety of instructional formats. Although a lecture-style format for mass distribution can be successfully implemented, using a simulation-based training (SBT) format involving smaller groups of learners is best suited for ensuring transfer of team-based competencies to the actual clinical setting. Ideally, SBT should target and involve the entire team unit to foster both cultural change within the organization and HRT function within the team itself.

SBT can run the gamut of methodologies, each with varying levels of fidelity, cost, and optimal learner capacity. In addition, it can use a variety of instructional strategies to maximize training effectiveness and HRT function. Of the various SBT methodologies, team-centered HFS is particularly attractive because it creates a realistic and safe learning environment for practicing skills, managing rare events (eg, malignant hyperthermia), and revealing the consequences of team actions (eg, the natural course of an adverse event). In HFS, fidelity is best achieved through mimicking the look and feel of the work system (ie, establishing equipment fidelity), re-creating the sensory cues of that system (ie, maintaining environment fidelity), and, most importantly, convincing the participants to “suspend disbelief” (ie, creating psychological fidelity).

Like other forms of SBT, HFS is well suited for using a scenario-based training strategy for teaching team-based competencies. Rosen and colleagues proposed using the event-based approach to training (EBAT) for such scenario development to create a standardized, structured learning experience for evaluating overall team and individual member performance. Key components of EBAT include defining specific learning objectives related to targeted teamwork competencies, framing the scenario development within a chosen clinical context, identifying KSAs related to the learning objectives, defining critical events and targeted responses related to the KSAs, creating appropriate measurement tools based on the targeted responses, and developing a scenario script.

Although robust scenario development using a structured methodology like EBAT is important, the debriefing is the critical teaching component of any HFS session. As a facilitative discussion among participants, it should focus on the strengths and

<table>
<thead>
<tr>
<th>Skill Type</th>
<th>Nontechnical Skill</th>
<th>Profession</th>
<th>Proposed Big 5 Counterpart(s)</th>
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<tbody>
<tr>
<td>Cognitive</td>
<td>Situation awareness</td>
<td>Surgery</td>
<td>Shared mental model</td>
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<tr>
<td></td>
<td></td>
<td>Anesthesia</td>
<td>Mutual performance monitoring</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nursing</td>
<td>Adaptability</td>
</tr>
<tr>
<td>Decision making</td>
<td></td>
<td>Surgery</td>
<td>Adaptability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anesthesia</td>
<td></td>
</tr>
<tr>
<td>Task management</td>
<td></td>
<td>Surgery</td>
<td>Adaptability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anesthesia</td>
<td>Mutual performance monitoring</td>
</tr>
<tr>
<td>Interpersonal</td>
<td>Leadership</td>
<td>Surgery</td>
<td>Team Leadership</td>
</tr>
<tr>
<td></td>
<td>Communication</td>
<td>Surgery</td>
<td>Communication</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nursing</td>
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<tr>
<td>Teamwork</td>
<td></td>
<td>Surgery</td>
<td>Team orientation</td>
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<td>Anesthesia</td>
<td>Mutual trust</td>
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<tr>
<td></td>
<td></td>
<td>Nursing</td>
<td>Back-up behavior</td>
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Table 3
Profession-based behavioral markers of nontechnical skills (NTS) in the operating room

Data from Refs.2,41,44–46
weaknesses of both the team and system that are revealed during the HFS scenario training. An emphasis on “what is right” over “who is right” is critical in this setting of immediate feedback because it helps participants become more aware of patient care hazards and gives them the opportunity to help find solutions. A debriefing facilitator capable of creating a safe environment in which learning objectives are met and in which participants focus on such processes as team communication and coordination is critical.

Even though HFS-based team training is expensive and labor intensive, it can benefit learners at every point along the professional education continuum (ie, as student, resident, and practitioner). Interprofessional HFS OR team training began in the 1990s in Basel, Switzerland, when clinicians from the OR departments at the Kantonsspital teamed up with investigators from the Human Factors Research Project at the University of Texas at Austin to create Team-Oriented Medical Simulation (TOMS). Although this program is no longer functioning, interprofessional HFS OR team training has grown in popularity and has now been successfully implemented within specialized simulation centers and at the point of care. Distributed training of interprofessional OR teams using HFS has a demonstrated utility in reinforcing and expanding participants’ positive attitudinal changes toward team-based competencies.

Implementing an HFS-based training program can at first seem a rather daunting challenge. Developing a systematic approach to marshalling support, resources,
and personnel is crucial for success. Paige\(^{69}\) has proposed the “5P” approach, which attempts to group potential challenges into 5 major categories: finding a *patron*, developing a *plan*, locating a *place*, assembling the appropriate *people*, and choosing effective *products*. Both strategic and tactical solutions are then formulated to each one of these challenges. For example, developing a plan would entail the strategic creation of a robust curriculum as well as the tactical determination of such logistics as the scheduling of participants and the timing of sessions.

Does team training work? Salas and colleagues\(^{57}\) remarked that, in general, all the previously mentioned team training strategies have been demonstrated to be effective in improving team cognitive, affective, process, and performance outcomes (see Table 4).\(^{43,50,57}\) Cross training appears less effective than team coordination and guided self-correction training. Finally, every training strategy has been shown to have a positive influence on team functioning.

How effective is surgical team training? The introduction and adoption of something as simple as a preoperative protocol briefing has been demonstrated to positively affect team-based behaviors,\(^{70,71}\) patient care process measures,\(^{72}\) retention of personnel,\(^{51}\) and surgical outcomes.\(^{73}\) More structured didactic programs have demonstrated improved teamwork climate,\(^{7}\) better communication among team members,\(^{74}\) and more positive perceptions regarding teamwork.\(^{75}\) HFS-based OR team training has been demonstrated to improve team-based attitudes among participants\(^{67}\) as well as team-based behaviors within the actual OR.\(^{76}\) It has also been successfully used to evaluate differences in team-based NTS among OR personnel\(^{62}\) as well as “seasoned” and younger surgeons.\(^{77}\) Such findings indicate that surgical team training is an effective modality for improving teamwork as well as the quality of patient care.

**SUMMARY**

Within today’s complex, dynamic systems of health care, surgeons must draw on more than their technical skills to succeed. Instead, they must bring key NTS to bear to promote team-based competencies within the OR team and to ensure its
cohesive function. By endorsing a human factors perspective to organizational culture, error generation, and team-based science, surgeons can identify and adopt effective surgical team training strategies for incorporation into an objectives-driven training program based on key team-based competencies. In this manner, they will assist in the transformation of the dysfunctional OR teams of the present into the highly reliable OR teams of the future.

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56. Frankel AS, Leonard MW, Denham CR. Fair and just culture, team behavior, and leadership engagement: the tools to achieve high reliability. Health Serv Res 2006;41:1691–709.


