Understanding safety and performance in the cardiac operating room: from 'sharp end' to 'blunt end'

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Successful surgery requires a patient with an accurate diagnosis, a treatment plan with an acceptable chance of success, a skilled surgeon and supporting team, a range of equipment, drugs and disposable items to support complex surgical tasks, a follow-up care team to ensure appropriate postoperative recovery and discharge, and an organisation that supports the people and helps to coordinate the delivery of all aspects of care. The tragic consequences that can ensue from failures across this broad range of system components came to light in the case of paediatric cardiac surgery some 15 years ago. Incidents in Winnipeg, Canada,[1] and Bristol, UK,[2] led to inquiries into surgical deaths that were among the first to highlight the complex range of systemic influences on surgical performance. These thorough analyses revealed a huge range of 'blunt end' system problems: surgical volumes, leadership and organisational issues, dysfunctional communication between teams and departments, and the basic predisposition to error imposed by the complex amalgam of team, task, process and technical ability within the surgery itself.

Emerging partly from those events was perhaps the seminal observational multidisciplinary study in surgical care conducted by Carthey and de Leval *et al*.[3] They demonstrated that even successful operations were often fraught with large numbers of potential problems that arose as a result of systems issues. More importantly for outcomes-based research, they found that enough of these minor problems in one operation could contribute to increased morbidity and mortality.[4] Furthermore, the actions of the team in recovering from these problems could make the difference between a good and a poor outcome.[5] This study was therefore critical in making direct inferential links between surgical outcomes, human factors and systems issues.

Subsequent research developed these observational techniques and a suggested model for understanding error causation in surgery.[6] Videotaping operations produced transcripts of errors as they happened,[7] thus allowing identification of the mechanisms by which minor problems escalate into major ones,[8] and the influence of potentially trainable teamwork skills on that escalation. These findings were replicated and further developed in a later set of studies in identical surgeries in The Netherlands,[9 10] as well as being extended into other surgical domains.[11 12]

At about the same time, similar results were also being reported in adult cardiac surgery, again employing direct observation by multidisciplinary teams consisting of clinicians and human factors professionals. In a sequence of studies at the Mayo Clinic, Wiegmann and colleagues identified similar minor problems, which they usefully called flow disruptions. It was possible to relate these directly to surgical errors.[13] This work also began to refine the observational methods required to obtain this type of information reliably,[14] examining the practical constraints of observation in surgery and moving from the unstructured note-taking and checklists of the early observations to more structured data collection. Other groups were also developing and deploying direct observational methods to understand teamwork and process across a variety of procedures demonstrating a range of causes of turbulence in surgery.[15 16] The underlying principle that was being developed and expounded through 'sharp end' observational studies was that the influences on surgical performance and outcome went well beyond simply the skills of the surgeon or the wellness of the patient, even for successful operations.

One common feature of all this work was the close interrelationship between teamwork, technology and task in surgical success and failure,[7] confirming the view that it is the people that held together the otherwise unsafe system, and that human errors and systems problems were frequent.[17] This led naturally to experiments with team-based interventions, such as training,[18 19] checklists[20 21] and briefings.[22] A subsequent challenge was then to identify higher-order sources of hazards in the operating environment that might lead to solutions that go beyond training or teamwork. Various methods have been offered to structure the analysis of behavioural observations to assist in the identification and correction not just of hazardous behaviours at the 'sharp

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end,'[23] but of latent systems problems (at the 'blunt end') that were causing those hazards.[24–26]

The research presented by Gurses *et al*[27] in this issue is perhaps the next phase in that evolution of understanding through direct observation and analysis of work processes. As with previous studies, their research seeks to look deeper into the systems of care in cardiac surgery. Their special contribution to this body of literature is that they do not focus directly on teamwork or task-related behaviour, but rather on the predisposition to error through equipment, environmental, workspace and organisational factors, which they identify through physical and behavioural artifacts within the operating rooms they visited. This is particularly valuable where, for example, traditional methods focus on the design of one piece of equipment in isolation, without effectively taking into account interactions between them. Thus, it opens up the possibility of a deeper systems analysis and the generation of a wider range of solutions to safety and quality problems.

Though extremely broad-ranging and time-intensive (and thus costly) to conduct, such behaviourally oriented, richly representational, direct observations analyse work 'as performed' rather than 'as imagined'. The observations and analyses tell us what really happens rather than what we might speculate happens or what 'should' happen. This methodology not only provides the keenest context specificity and face validity, but also generates data with richness of detail not available by any other means. Incident reporting, for example, not only notoriously under-captures events of interest,[28] but also tends to lack many contextual details that can prove to be important in understanding safety.

The ability to provide a detailed understanding of 'normal' systems state is particularly valuable given the tendency for systems to immediately change following a serious event, and for hindsight bias to cloud judgement in understanding what really happened. Indeed, since this approach is prospective, it helps to identify and remove problems before they accumulate in sufficient numbers to cause adverse events. Another key feature of this work is its interdisciplinary nature. Employing clinical expertise (surgeons, nurses, anaesthetists) and non-clinical expertise (human factors, systems analysts) is extremely powerful, and distinctly advantageous given neither type of expert may fully understand all the implications of their observations[12 29 30] The multidisciplinary nature of the work has also benefited both types of experts. It has helped clinicians recognise the importance of human factors in achieving optimal patient outcomes, and helped human factors experts understand the unique demands of healthcare, and recognise where approaches from other industries (such as aviation) require adaptation.[31]

Direct, prospective observation and systems analysis methods have demonstrated the value of looking deeper into complex error-prone systems to develop higher-level quality improvement initiatives. This identification of a broad range of system problems has facilitated a better understanding of human abilities and has afforded greater opportunities to help clinicians avoid and deal with error. It has also led to the development of new systems of work to reduce workload and encourage smoother workflows. The evolution of human factors work in surgical safety reflected in the work reported by Gurses *et al* (this issue)[27] illustrates the growing interest in design and a complete systems approach that encompasses, yet goes beyond teamwork, training and checklists. While there is a clear need to understand and address the issues they identify, there also is the well-recognised need to understand how best to bring about desired changes in healthcare systems. There is also the perennial problem of how to measure the effects of combinations of interventions in complex systems.

The legacy of Bristol, Winnipeg and the safety movement is that of moving our understanding of error from the 'sharp end' to the 'blunt end', and of clinical success from outcomes to process. As a result, we are becoming increasingly knowledgeable about how to improve, support and develop human performance in surgery; the role of teamwork and communication in generating or recovering from errors; how to begin to make change; and how to continually improve. Starting in high-risk surgery, where patient outcomes were clearly observable, and moving to more detailed techniques in lower risk but more common surgeries, the value and depth of direct observational methods have been established. This research emphasised, in particular, the complexity and tightly coupled nature of cardiac surgery,[32] and the value of the human factors perspective—which embraces the complex relationship between people, equipment, processes and organisations—in understanding safety in both high-risk and lower-risk surgery. With the new understanding provided in this issue (Ref Gurses, this issue)[27] we can begin to understand how the workspace can be developed to improve all these aspects of healthcare delivery. Now, more than ever, we need good designs, a systems approach to improvement, and we need to measure the impact that this work is having on outcomes.

Funding Dr KC and Dr WD are supported by grant funding from the United States Department of Defense, Telemedicine and Advanced Technology Research Center (TATRC) of the US Army Medical Research and Material Command.

Competing interests None.

Provenance and peer review Commissioned; internally peer reviewed.

BMJ Qual Saf 2012;**21**:807–809.
doi:10.1136/bmjqs-2012-001135

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