

Surgeons and astronauts: so close, yet so far apart

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Education is broadly defined as the process or art of “imparting knowledge, skill and judgment.”¹ This can be passed on from the educator to the learner either formally or informally. When the prefix “surgical” is added to this definition, the meaning is extrapolated to incorporate all components that relate to the practice of a surgical procedure. This includes diagnosis, preoperative preparation, intraoperative technical and decision-making strategies, postoperative care, professional ethics, interpersonal communication skills and the fundamentals of the Hippocratic Oath.

The job description of a surgeon varies tremendously depending on the subspecialty and on the chosen practice location. Whereas an academic trauma surgeon practising tertiary care may engage in a mix of clinical, teaching, research and administrative tasks, a general surgeon working in the community might limit the scope of his or her practice to clinical activities, with reduced responsibilities for research and teaching. The combinations and permutations are endless. Regardless of the practice type, the qualities of compassion, reliability, expertise, commitment, curiosity, ethics and dedication are fundamental characteristics of an excellent surgeon. Although the volume of medical training and

practice within an astronaut’s job description is minimal when compared with practising physicians (about 45 total hours for a crew medical officer, i.e., a nonphysician), the attributes listed above are ideal for astronauts as well. This commentary outlines the strikingly similar job descriptions and individual characteristics needed for both surgeons and astronauts while discussing the truly dissimilar approaches to training followed by the 2 professions.

The similarities

Although the technical nature of training surgeons and astronauts varies tremendously, the time commitment and additional skill sets of the men and women applying to these professions are not dissimilar. In North America, physicians classically complete at least one undergraduate university-level degree, as well as medical school, before applying for a surgical training position. Although applicants to most medical schools must complete prerequisite courses, a diverse background is often viewed as an asset by admissions committees. Excluding the increasingly common addition of advanced graduate degrees, the average applicant for surgical training has at least 8 years of undergraduate education.

Once training begins, it will vary from 5 to 10 additional years, depending on the degree of subspecialization the trainee chooses. This places the average graduating surgeon in the third decade of life.

Astronauts also come from varied backgrounds and have a mean age at application of 31 years. Most commonly, applicants arise from the fields of military aviation, engineering, education and, occasionally, from medicine. The selection process itself is comprehensive and takes into account the applicant’s experience, physical health, medical history, psychological profile and general demeanor. Once the process is complete (every 2 years), candidates undergo an intensive 2-year general training program that orients them to the technical and personal requirements of the position. This process is followed by designation to a specific “subspecialty” by the astronaut office of the National Aeronautics and Space Administration (NASA). These assignments can range from becoming an expert in Russian aerospace hardware to training for extravehicular activities (spacewalks) to mastering ground-orbit communication to scheduling launch and return activities for the shuttle program. These aerospace subspecialties are as diverse as those within surgery and are

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assigned on the basis of individual skill, program needs, seniority and personal desire. Although the astronaut corps is small (150), the overall service delivery model is similar for surgery and astronautics. Both professions require a workforce with high preapplication levels of education and skills and with initial broad training (medical school or general astronaut training) before selection to a subspecialization.

In addition to having comparable backgrounds with regard to skill and training, surgeons and astronauts also possess many of the same individual characteristics. Members of both professions are selected on the basis of their passion, intelligence, diligence, intensity, commitment, communication skills, ability to learn and teach and proficiency at working well within a team in times of stress. Other characteristics that make good astronauts and surgeons include technical proficiency, the ability to adapt to new and unexpected scenarios and a drive for continued learning on a professional and personal level. Both careers demand an operationally oriented mindset and an ability to function within very busy timelines. On a societal level, both professions are generally well respected and sometimes revered. Although astronauts acquire knowledge benefiting all humankind, the effect of either profession on a given individual can be life-altering.

The differences

Despite the overwhelming similarities between the job description of a surgeon and that of an astronaut, methods used to train these 2 professions are quite dissimilar. At the outset, it must be understood that the fundamental advantage astronauts have with respect to training is liberal access to sophisticated, high-fidelity simulators. This technology is central for astronauts to acquire and maintain complex procedural skills. In this respect, NASA has benefited from close ties to commercial aviation, for which

industry simulators are integral to training and safety.² The lack of advanced surgical simulators has always been a significant issue for surgical educators.³ It is still true that animal,⁴ bench-top^{5,6} and computer-based⁷ simulation plays a relatively limited role in the training of today's surgeon; however, it is likely that, with the development of more sophisticated technology such as virtual reality trainers and with the increasing use of surgical skills laboratories as adjunctive environments for training, the disparity between the educational technologies employed in these 2 professions will narrow.⁵⁻¹² Unfortunately, this evolution will demand a significant commitment in time from clinicians with a specific interest in surgical education and also a commitment in capital from hospitals, universities and government to fund expensive but clearly helpful simulation endeavours.^{13,14} Although the ability of NASA to simulate complex procedures — such as construction of the international space station in a zero-gravity environment — is limited, despite the value of training modalities such as the neutral buoyancy laboratory and parabolic flight,^{15,16} NASA has not been discouraged from incorporating these challenging settings into routine training that focuses on processes and teamwork.

Equally important to the fidelity of a given simulator is the development of an appropriate curriculum. This must be the primary step in the training of any procedure-based skill. Herein lies a major philosophical and pedagogical difference: NASA has used a competency-based curriculum that relies on meeting specific criteria before advancement to subsequent phases of learning. Typically, this progression is substantiated by strict performance-based assessments that certify competence in a specific task. In contrast, surgical training has long been time-based, not competency-based, and rarely deploys performance-based metrics to attest competence.¹⁷ Rather than using specific

stepwise and sequential tasks that culminate in the ability to complete a given procedure, we instead allow trainees to acquire various skills from a nonsequential residency experience that exposes them to a heterogeneous group of instructors over a defined period of time. Although 5 years of surgical training is considered sufficient for the acquisition of the necessary skill set, it is unclear how that constellation of abilities is either attained or evaluated. The policy adoption of “minimal technical competence” rather than an appropriate performance marker has also contributed to this issue. Certainly, both didactic and hands-on components are necessary in a milieu encompassing elements of education and service.¹⁸ In reality, this skill set appears to be a result of both the type of procedures a given educator or institution performs and the number of times a trainee is exposed. Learning by observation and osmosis is a technique that has clearly produced exceptional and dedicated surgeons over many decades. Unfortunately, the durability of this educational model is being challenged in an era of work-hour restrictions. It would be hard to argue that the surgical training ground would not benefit from a more standardized curriculum.¹⁹ It would also be difficult to disagree with the position that the operating room should remain the epicentre of learning. Moreover, because only 21% of a resident's time is spent training in this critical venue, maximizing every real-world operative experience must be a primary goal.²⁰ This is particularly difficult given reduced resident working hours,^{21,22} a reality that is just now starting to be addressed.²³

The criteria we employ to evaluate the surgical skills of our trainees also suffers from a lack of reliability and validity.¹⁸ Program directors are currently responsible to “sign off” on candidates as safe and technically acceptable surgeons. These expectations place them in a very difficult position because they are required to globally assess a trainee's technical skills with

little objective evidence. We must borrow from our NASA colleagues' more performance-based and psychometrically sound testing. Even though more sophisticated assessment tools have been recently developed and validated, dissemination into our training programs remains sporadic.

Although the individual tasks that a surgeon and an astronaut daily perform are worlds apart, they have a similar complexity and multistep nature. In both professions, technical maintenance and acquisition of new skills are significant issues. In surgery, postgraduate training courses are numerous. Many are affiliated with large surgical conferences, and others are aligned with individual clinics or surgeons. They range in duration from a few hours for short updates to days for the acquisition of complex procedures via mentorship sabbaticals. A surgeon's ability to incorporate these new skills into clinical practice is determined not only by his or her comfort level but also by hospital policies that govern operating room privileges. Unfortunately, standardized technical criteria to which a surgeon's technical competency and safety can be compared are often lacking. Similar to the airline industry, each procedure in the astronaut corps is subdivided into smaller tasks that can be evaluated repeatedly and objectively. If a given operator cannot effectively complete the task in an efficient and safe manner, training is continued or the task is transferred to another astronaut. This is fundamentally different from surgery, where a significant perioperative complication first attracts the attention of patients, supervisors and licensing bodies. In this regard, astronauts once again have a major advantage because much of their skill accrual is gained in a simulated environment, and hence, they have the opportunity to learn through a process of deliberate practise. Although the model in which a technician is able to repeat the steps of a given procedure until capability and efficiency are attained is always desir-

able, surgery is in the embryonic phase of developing these tools and venues.

Conclusion

Although the "art" of surgery and the complexity of the human body separate surgeons from astronauts, these professionals are not dissimilar. Both arise from varied, well-educated and committed backgrounds and have an intense desire to succeed on a personal and societal level. The goal of training in both professions is the ability to understand and perform complex tasks. Given that the possibility of simulating either the complexity of the human body or the zero-gravity nature of space is limited, surgery and astronautics have taken vastly different approaches to training. In part, there has been a dramatic underinvestment in surgical training, with teaching in the medical workplace being an undervalued and underpaid commodity. Finances notwithstanding, the surgical workplace must adopt some of the rigour that the world of astronautics has used in its method of training and objective approach to assessment. Further, with NASA's stated goal of returning to the moon, our methods of surgical training must adapt if we expect to play a crucial role in the inevitable care of future astronauts and extraterrestrial humans.²⁴⁻²⁶

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International surgery and the *Canadian Journal of Surgery*

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Several years ago, the *Canadian Journal of Surgery (CJS)* initiated a section on international surgery. This decision was motivated by an understanding that *CJS* readers are interested in surgery in low-income countries and that the inclusion of articles about surgical care and research in low-income countries is part of the mandate of any truly international surgical journal.

What is the role of the *CJS* international surgery section? Consistent with the journal's overall mandate, it encourages the publication of high-quality original research and review articles. It differs from other parts of the journal in its focus on work performed in under-resourced environments within low-income countries. Mentorship is another objective of

this section.¹ The content of the international articles should equal that of contributions in other sections, but editorial assistance to ensure that important contributions are not rejected because of writing skill or style is considered appropriate. Recently, the *CJS* editors were asked to post "Surgery in Africa,"² an electronic seminar, on the *CJS* website. The editorial board felt this was a reasonable request but that that "Surgery in Africa" must first be reviewed to assure the seminar's quality before it is posted. Maintaining standards increases the credibility of international surgery as a legitimate academic and clinical discipline.

Does a readership for this section exist within Canada? The Canadian Network for International Surgery,^{3,4} the Office for International Surgery

at the University of Toronto⁵ and the Canadian Association of General Surgeons Committee for International Surgery⁶ have been active for more than 10 years, with expanding Canadian membership, budgets and international activities. The Bethune Round Table on International Surgery, a well-attended annual meeting in Canada, has been growing in popularity and scientific rigour since its commencement 8 years ago.⁷ In 2005, a summary of the Bethune presentations was published in the *CJS*.⁸

Progress is being made. Published in this issue are the individual abstracts from the May 2008 Bethune Round Table. Initiated by the Office of International Surgery at the University of Toronto, "ownership" of this meeting has become

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