Review Article

Training in Esophagogastric Surgery in the Era of Minimally Invasive Procedures

Formação em Cirurgia Esofagogástrica na Era dos Procedimentos Minimamente Invasivos

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ABSTRACT

Training in esophagogastric surgery is undergoing significant change driven by the widespread adoption of minimally invasive techniques – laparoscopic, thoracoscopic and robotic. The classical Halstedian model of surgical education, based on the linear progression of "see one, do one, teach one" under a single mentor, established in 1904, is no longer sufficient given reduced resident working hours, decreased direct operative exposure, and the increasing technical complexity of modern procedures.

This article reviews the historical evolution of surgical education and examines the pillars of modern training in esophagogastric surgery: structured fellowship programs, stepwise technical training, simulation-based practice, and proctorship. The demanding learning curve of these procedures is discussed, together with a synthesis of international evidence on resident training in minimally invasive surgery, which shows increasing but uneven exposure, frequently nonstandardized curricula, and a persistent gap in readiness for independent practice at graduation. The growing role of robotic surgery, artificial intelligence and telementoring, and the importance of non-technical skills for patient safety are also addressed. The article concludes that the future of surgical training should rely on a holistic, competency-based model, integrating knowledge, technical skill and interpersonal competence, assessed through

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the framework of Entrustable Professional Activities, and supported by closer collaboration between hospitals, clinics and teaching institutions.

Keywords: Competency-Based Education; Esophagectomy; Gastrectomy; General Surgery/education; Minimally Invasive Surgical Procedures/education; Robotic Surgical Procedures/education; Simulation Training

RESUMO

A formação em cirurgia esofagogástrica atravessa um período de mudança significativa, impulsionado pela generalização das técnicas minimamente invasivas – laparoscópicas, toracoscópicas e robóticas. O modelo clássico de educação cirúrgica halstediano, baseado na progressão linear "ver um, fazer um, ensinar um" sob a orientação de um único mentor, estabelecido em 1904, deixou de ser suficiente face à redução das horas de trabalho dos internos, à diminuição da exposição operatória direta e à crescente complexidade técnica dos procedimentos atuais. Este artigo revê a evolução histórica da educação cirúrgica e analisa os pilares da formação moderna em cirurgia esofagogástrica: programas de especialização estruturados (*fellowships*), formação técnica progressiva, prática baseada em simulação e acompanhamento por *proctorship*. Discute-se a exigente curva de aprendizagem destes procedimentos, em conjunto com uma síntese da evidência internacional sobre a formação de residentes em cirurgia minimamente invasiva, que revela uma exposição crescente mas heterogénea, currículos frequentemente não padronizados e uma lacuna persistente na preparação para a prática autónoma à data da graduação. Abordam-se ainda o papel crescente da cirurgia robótica, da inteligência artificial e da telementoria, bem como a importância das competências não técnicas para a segurança do doente. Conclui-se que o futuro da formação cirúrgica deverá assentar num modelo holístico e baseado em competências, que integre conhecimento, destreza técnica e competências interpessoais, avaliado através do referencial das Atividades Profissionais Confiáveis, e sustentado por uma colaboração mais estreita entre hospitais, clínicas e instituições de ensino.

Palavras-chave: Cirurgia Geral/educação; Educação Baseada em Competências; Esofagectomia; Gastrectomia; Procedimentos Cirúrgicos Minimamente Invasivos; Procedimentos Cirúrgicos Robóticos/educação; Treino por Simulação

INTRODUCTION

The future of surgical training will involve a significant shift in the prevailing educational model. To understand the direction of this shift, it is first necessary to revisit the trajectory of surgical education, which has been marked by successive processes of continuous transformation, and to recognize how the widespread adoption of minimally invasive surgery (MIS) in the treatment of esophageal and gastric disease has progressively rendered the classical model of training inadequate.

A BRIEF HISTORICAL PERSPECTIVE ON SURGICAL EDUCATION

Between the 16th and 17th centuries, surgical training relied essentially on a practical model, in which instruction was acquired through direct observation of a mentor. There were no formal standards regarding the age of entry or the duration of training: apprenticeship typically began at 12–13 years of age and lasted between 5 and 7 years.

In 1904, William Halsted proposed a model of surgical education based on the progressive incorporation of skill and responsibility, summarized in the well-known sequence "see one, do one, teach one." This model, built on the relationship between a single mentor and a single trainee, dominated Western surgical education for most of the 20th century.

In recent decades, however, this paradigm has evolved progressively: from training centered on a single mentor and a single trainee, to pyramidal models – in which several trainees compete to progress under the guidance of one mentor – and, more recently, to holistic models, in which each trainee progresses with gradual autonomy, guided simultaneously by several mentors.

WHY TRAINING HAS TO CHANGE

Minimally invasive surgery – including laparoscopic, thoracoscopic and robotic techniques – has profoundly transformed esophageal and gastric surgery. These approaches have become widespread because they reduce postoperative complications and length of hospital stay, and improve functional recovery and patients' quality of life. On the other hand, they are technically demanding, require advanced skills and meticulous perioperative management, which makes their acquisition particularly sensitive to the training model used.

To this technical demand are added constraints specific to contemporary surgical training: reduced resident working hours, driven by legal and institutional restrictions, translate into less time available for practice and study; reduced operative exposure, resulting from restricted time allocated to the operating room, decreases opportunities for supervised hands-on training; the growing technical complexity of procedures demands greater efficiency within a shorter training period; and burnout during surgical residency reflects the imbalance between clinical workload and time available for training.

The future of surgical education therefore depends on recognizing that training requires the rapid assimilation of a vast body of knowledge and multiple competencies within an intensive, accelerated period. Trainees must develop simultaneously across multiple domains, moving beyond the linear "see, do, teach" model.

COMPETENCY BY DESIGN: COMPETENCY-BASED LEARNING

The Competency by Design (CBD) model seeks to address these limitations through teaching structures that are practical and feasible, without overburdening supervisors or compromising clinical workflow. A central principle of this model is the recognition that repetition and time spent in practice do not, by themselves, guarantee competence: the role of "supervisor and observer," combined with immediate and constructive debriefing, forms the actual basis of learning.

CBD rests on five core pillars: planning the acquisition of technical skills and medical knowledge; valuing continuous self-reflection and feedback; strengthening specialized certification; encouraging the development of non-technical skills; and transitioning from an evaluation based on time and case numbers toward a holistic assessment of the surgeon's essential competencies.[1]

ESSENTIAL COMPONENTS OF MODERN TRAINING

Modern surgical training in esophagogastric surgery rests on three complementary pillars: structured specialization programs, supervised simulation, and progressive direct supervision.

STRUCTURED SPECIALIZATION PROGRAMS

Most surgeons dedicated to esophageal and gastric pathology are currently trained through fellowship programs, which should combine operative activity, outpatient consultation, research and teaching, with active participation in clinical decision-making and multidisciplinary care. These programs ensure systematic exposure to esophageal and gastric disease and allow progressive development of competence in laparoscopic and robotic gastrectomy, esophagectomy, and antireflux and hiatal hernia surgery.

PROGRESSIVE TECHNICAL TRAINING

Technical training should follow a stepwise progression, beginning with basic competencies in minimally invasive surgery – camera navigation, suturing, and tissue handling – advancing to procedure-specific training (esophageal hiatus, gastrectomy, esophagectomy), and culminating in advanced techniques, namely robotic surgery and complex reconstruction. This pathway is typically supported by a three-phase capacity-building process: participation in live or recorded surgical demonstrations; structured video-based discussion, to deepen understanding of operative steps and best practices; and hands-on laboratory training, in a controlled environment, to develop effective manual dexterity.

SIMULATION AND HANDS-ON TRAINING

Simulation centers – whether virtual, synthetic-model based, animal-based, or cadaver laboratories – allow techniques to be trained safely, technical errors to be identified early, and dexterity to be improved before operating on real patients. Each modality presents distinct advantages and limitations: box trainers are more accessible but useful only for basic maneuvers; virtual reality simulators can reproduce a complete surgical procedure but are expensive and provide limited tactile feedback; and animal and cadaveric models, although more faithful to real anatomy, raise ethical concerns and involve significant costs.

Simulation provides well-established advantages in the literature: cost reduction, by allowing training without the need for real materials or dedicated physical space; safety, by enabling the practice of risky or delicate procedures without exposing patients; repeatability, with the possibility of repeating the same experience as many times as needed for improvement; and flexibility, as it can be adapted to different scenarios and training needs.[2]

It should be emphasized, however, that simulators are a double-edged sword: in the absence of adequate supervision, they may favor the acquisition of incorrect technical habits. Simulation complements surgical training but cannot replace it. The main difficulties in its widespread implementation lie in the lack of a homogeneous simulation curriculum across institutions, and in the acquisition and maintenance costs of the equipment. Even so, simulation remains an excellent and useful teaching tool and should be part of the curriculum of every surgical trainee.

PROCTORSHIP AND SUPERVISION

The central element of hands-on training remains supervised progression: experienced surgeons accompany and directly guide trainees during the first cases of a new procedure and during complex procedures, simultaneously ensuring technical learning and patient safety.

THE LEARNING CURVE IN MINIMALLY INVASIVE ESOPHAGOGASTRIC SURGERY

Minimally invasive esophagogastric surgery presents a particularly demanding learning curve, which reinforces the importance of structured programs and training in high-volume surgical centers. Reported figures suggest that basic competence in robotic hiatal hernia repair is reached after approximately 20–30 cases, with 30–50 or more cases required to optimize outcomes, while basic competence in minimally invasive esophagectomy is achieved between 40 and 60 cases, with consolidated proficiency requiring approximately 60–100 cases.[3,4] This demand is corroborated by a two-decade review of ACGME operative logs, which documented a sustained increase in general surgery residents' exposure to minimally invasive procedures over time, although this exposure remains unevenly distributed across programs and procedure types.[5-7]

This demand is directly related to well-described cognitive phenomena in the psychological literature, namely the Dunning-Kruger effect, according to which the trainee's self-confidence reaches an early peak – the "peak of Mount Stupid" – followed by a phase of reduced confidence as experience reveals the real extent of one's own limitations (the "valley of despair"), before a gradual progression toward the "plateau of sustainable competence" characteristic of the experienced specialist.[5] Recognition of this pattern by trainers is important for appropriately calibrating the autonomy granted to trainees at each stage of their learning curve.

INTERNATIONAL EVIDENCE ON RESIDENT TRAINING IN MINIMALLY INVASIVE SURGERY

A synthesis of evidence published in recent years, across different specialties and healthcare systems, confirms the direction of the change described above: resident exposure to MIS has been increasing consistently, but training remains heterogeneous, frequently nonstandardized, and in many cases insufficient to guarantee independent practice by the end of residency.[8-20] This finding is consistent across different national contexts and surgical specialties, reflecting the fact that MIS requires psychomotor skills distinct from those of open surgery, longer learning curves, and simultaneous competence across open, laparoscopic, and robotic platforms.[9,18,19]

The available evidence is particularly consistent in three areas. First, structured simulation curricula measurably improve residents' technical performance in MIS and are increasingly regarded as an essential, rather than merely complementary, component of surgical training.[9,21,22] Second, evidence consistently shows that clinical exposure alone (the traditional apprenticeship model) does not, by itself, ensure adequate preparation for MIS, with many programs lacking standardized curricula, dedicated rotations, or sufficient case exposure.[13,18,20] Third, the creation of dedicated robotic training pathways appears to increase resident participation and to favor broader adoption of MIS, although the curricular content of, and access to, these pathways remain highly variable across institutions.[9,11,14]

A particularly relevant issue concerns the relationship between simulation and readiness for independent practice. In at least one prospective program, a substantial improvement in residents' technical performance was observed over the course of training, yet the large majority did not feel fully prepared to perform low-complexity laparoscopic procedures unsupervised by the end of the program.[8] This dissociation between performance demonstrated in simulated settings and the perceived readiness for clinical autonomy is consistent with recent reviews in colorectal, spinal, and emergency digestive surgery, which converge on recommending a multistep training model – early simulation, validated skill assessments, structured expert feedback, mentored operating-room experience, and benchmark-based progression, always under direct supervision.[10,16,17]

The main gap identified in the international literature is, precisely, preparation for independent practice: several studies document meaningful gains in simulated or supervised performance, but evidence that residents truly complete training ready for autonomous MIS practice, consistently across different clinical settings, remains clearly scarcer.[8,10,20] This gap is particularly marked in emergency digestive surgery and minimally invasive spine surgery, areas in which the training methods described are heterogeneous, resident training is poorly documented, and the question of how to ensure sufficient exposure to these procedures remains, to a large extent, unresolved.[10,17]

Among the main challenges identified are: case volume, which is frequently lower than considered necessary for the acquisition of MIS competence[18]; uneven access to structured training, with only a minority of programs reporting, in one survey, the existence of dedicated MIS rotations[22]; insufficient early exposure in some healthcare systems, as illustrated by a national survey in China that identified low training rates among junior residents[13]; and the persistent shortage of simulation infrastructure and qualified faculty/mentors, particularly in resource-limited settings.[12,15]

Taken together, this evidence suggests that training programs achieve better results when they teach MIS early, deliberately, and across technological platforms, systematically linking simulation to supervised clinical autonomy. The central question that remains without a definitive answer is not whether residents can progress and improve their performance – which the evidence consistently demonstrates – but whether current training systems can consistently produce, by the time of graduation, a sufficient number of minimally invasive surgeons who are truly ready for independent practice.

TECHNOLOGY IN THE OPERATING ROOM AND DATA COLLECTION

Technology in the operating room has enabled global data collection and real-time monitoring of surgical performance, contributing to risk mitigation, accident review, and the development of strategies to prevent future events. The standardization of objective metrics, through wall-mounted cameras, microphones, and video feeds from laparoscopic instruments, has revealed relevant data for training: on average, 20 errors per case are identified, occurring predominantly during dissection and reconstruction, together with an average of 138 auditory distractions per case. These data reinforce the need to combine clinical training, simulation, and systematic video review as an integrated strategy for continuous improvement.

In the operating room, the most effective teaching strategies integrate three complementary moments: briefing, in which the expectations for the case, the anatomy, and the critical steps are discussed before skin incision; the intraoperative period, in which guided discovery is favored – through questions about anatomy and technique – without compromising patient safety; and debriefing, in which the case is reviewed to highlight what worked well and to identify areas for improvement. These strategies are complemented by promoting progressive autonomy, active trainee involvement in preoperative preparation, and a consistent focus on fundamentals, such as patient positioning and correct instrument handling.

EMERGING TRENDS IN TRAINING

Robotic surgery, owing to the greater precision and three-dimensional visualization it provides, is increasingly integrated into training programs, although it requires dedicated, procedure-specific curricula.[9,11,14] In parallel, advanced teaching technologies are being progressively incorporated, namely artificial intelligence applied to surgical support, telementoring – enabling remote guidance by experienced surgeons – and virtual and augmented reality applied to technical training.

There is also a clear trend toward the standardization of technique, with emphasis on reproducible operative steps, structured perioperative protocols, and systematic quality assessment through outcome indicators ("textbook outcomes"), with direct benefits for the learning curve, patient safety, team efficiency, and cost predictability. Finally, a multidisciplinary approach is increasingly central to the training of the esophagogastric surgeon, who must learn to work in an integrated manner with oncology, gastroenterology, radiology, and pathology.

These trends are not without challenges: the high technical complexity of the procedures, reduced case exposure in low-volume centers, safeguarding patient safety during the learning process itself, and the costs associated with robotic surgery together constitute the main obstacles to the widespread implementation of these training models.

THE IMPORTANCE OF NON-TECHNICAL SKILLS

The patient-centered model recognizes the central importance of Non-Technical Skills (NTS) for the "professional" surgeon, distributed across three domains: cognitive skills (decision-making, situational awareness), interpersonal skills (communication, teamwork, leadership), and personal skills (burnout prevention, fatigue management). It is now recognized that most surgical complications result from failures in NTS, rather than primarily from technical errors, which justifies the need for formal training and validated assessment of these competencies within the surgical training curriculum. NTS are expected to become, over the next decade, a fundamental and formalized part of surgical training.[6]

A PARADIGM SHIFT IN ASSESSMENT

General surgery residents must now master open, laparoscopic, and robotic surgery simultaneously, combining an expanding knowledge base with the development of leadership and communication skills. Training time and case numbers are, by themselves, no longer sufficient to assess a trainee's dexterity and autonomy. Assessment of the "future surgeon" must therefore holistically integrate knowledge, technique, and interpersonal competence, which has driven the progressive transition toward the Entrustable Professional Activities (EPA) framework as the reference standard for assessing surgical competence.

REFLECTION

The increasing demand for technical competence necessarily entails more learning and verification procedures. There is, however, no standardization regarding when different certifications should be completed, nor regarding the composition of each trainee's simulation curriculum. Familiarity with simulation predicts better initial performance but does not, by itself, guarantee surgical mastery; simulation does not replace the real experience acquired in laparoscopic or robotic procedures. It is therefore necessary to systematically combine simulation with actual operative practice, so as to ensure genuine and sustained technical competence – a conclusion fully consistent with the international evidence described above.

CONCLUSION

Training in esophagogastric surgery is evolving from a model centered on a single mentor and a linear progression of responsibility, toward structured, holistic, competency-based models, in which simulation and supervised practice play a fundamental and complementary role. The learning curve for these procedures is long and demanding, and international evidence confirms that, despite increasing resident exposure to minimally invasive surgery, a significant gap persists in ensuring independent practice by the time of graduation. Robotic surgery, artificial intelligence, and simulation are irreversibly transforming contemporary surgical education.

Reduced resident working hours make it harder, by themselves, to guarantee sufficient experience and competence, which reinforces the need to strengthen mentorship – encouraging more experienced surgeons to supervise trainees with appropriate recognition and compensation – and to expand collaboration between hospitals, clinics, and teaching institutions, so as to ensure more real opportunities for practice. It is equally necessary to value general surgery as a specialty and to actively address the economic challenges associated with the profession.

It is our responsibility, as a surgical community, to continuously critique and rethink the way we train surgeons, drawing lessons from the past to improve surgical education in the future.

ETHICAL DISCLOSURES

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