# Fundamentals of Robotic Surgery: Outcomes Measures and Curriculum Development

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**Abstract**. To standardize the curriculum and certification of robotic surgeons, a series of consensus conferences have been used to compile the outcomes measures and curriculum that should form the basis for the Fundamentals of Robotic Surgery (FRS) program. This has resulted in the definition of 25 specific outcomes measures and the creation of curriculum for teaching those via didactic lecture, psychomotor skills labs, and team training activities. This work has been supported and/or reviewed by the leading surgical societies involved in the use of robotic surgery.

## Introduction

In 2004, the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) launched the validated Fundamentals of Laparoscopic Surgery (FLS) curriculum and, together with the American College of Surgeons (ACS), promoted the FLS as a minimum standard before a surgeon should be allowed to perform laparoscopic procedures independently [1]. In 2009, The American Board of Surgery (ABS) mandated that in addition to Advanced Cardiac Life Support (ACLS) and Advanced Trauma Life Support (ATLS) a certificate documenting the successful passing of the FLS exam be included in the application in order to be eligible to sit the examination for certification in General Surgery [2].

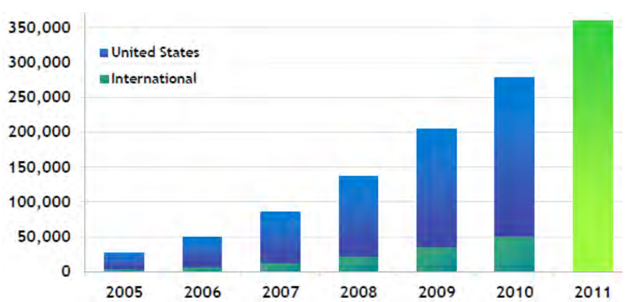


*Figure 1. Growing number of robotic surgical procedures*
*Source: Intuitive Surgical, Inc Investor Prospectus, Feb, 2012*

During the last decade, robotic surgery has transitioned through a similar evolution to laparoscopic surgery and is being recognized as an important surgical approach by multiple surgical specialties. Furthermore, it shows every sign of continuing the adoption of more diverse surgical procedures, as manifest by the fact that in calendar year 2011, approximately 350,000 robotic surgical procedures were performed (Figure 1). The number of procedures being performed by robotic surgery has been constantly rising in urology, gynecology, colorectal, pediatric and numerous other specialties. Expert robotic surgeons and numerous surgical societies and certifying organizations have advocated the need for the creation of a unified approach and standardized curriculum for basic training and certification in robotic surgery skills [3]. There have been efforts to develop a core curriculum for certifying robotic surgeons [4,5]; however, these have been fragmented, with different approaches and outcomes measures emerging from each. This has resulted in conflicting, competing and redundant curricula for the training and the assessment tools for robotic surgery. In addition, these curricula have generally lacked the human and financial resources necessary to complete the most comprehensive, multi-institutional validation that is necessary to gain acceptance at a national level.

Through the combined support of two grants, one to the Minimally Invasive Robotics Association and the other to Florida Hospital Nicholson Center, we have created a process and a group of participants which unify the previous attempts to develop a robotic curriculum and expand to a much larger foundation of surgical societies with a stake in this new technology. These grants provide the necessary funding to carry the effort through multi-institutional validation with the support of participants who represent all surgical specialties that are currently performing robotic surgery.

## Methods & Materials

Participation in this effort was invited from multiple certifying boards, professional surgical societies, and associations that represent international practitioners and regulators of various surgical specialties as well as the United States Department of Defense (DoD) and Veterans Health Administration (VHA) (Table 1). The conference participants are members of these organizations or agencies and are selected to be able to provide insight into the needs of their organizations, but they do not represent an endorsement or acceptance of the results, and participation does not imply acceptance by the societies, boards or agencies. However, the AUA, AAGL, and SAGES elected to appoint and send representatives who could officially speak for their organizations' needs for a robotic curriculum and officially accept the results of the consensus conferences. This project is an effort to provide the stakeholders with the best scientific evidence upon which to base their decisions regarding implementation of a fundamental curriculum to meet their needs while reducing redundancy, competition and duplication of effort.

*Table 1. Invited Organizational Representation in Fundamentals of Robotic Surgery.*

American Association Gynecologic Laparoscopy (AAGL) *
American College of Surgeons (ACS)
American Congress of Obstetrics and-Gynecology (ACOG)
American Urologic Association (AUA) *
American Academy of Orthopedic Surgeons (AAOA)
American Association of Thoracic Surgeons (AATS)
American Association of Colo-rectal Surgeons (ASCRS)
Minimally Invasive Robotic Association (MIRA) †
Society for Robotic Surgery (SRS)
Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) *
American Board of Surgery (ABS)
Accreditation Council of Graduate Medical Education (ACGME)
Association of Surgical Educators (ASE)
Residency Review Committee (RRC) – Surgery
Royal College of Surgeons-Ireland (RCSI)
Royal College of Surgeons-London (RCSL)
Royal College of Surgeons-Australia (RCSA)
U.S. Department of Defense (DoD) †
U.S. Department of Veterans Health Affairs (VHA)

* : Official Representative Participation
† : Funding organizations.

Each consensus conference was conducted over a two-day period using a modified Delphi method [6]. This methodology consisted of a facilitator who captured the input and guidance of the participants. This input was then analyzed for common concepts to create a list of critical items in robotic surgery. Previously published material from a single institution's curriculum was used as a template for initial idea generation [7,8]. The individual outcomes measures and curriculum materials were itemized and votes taken on their importance according to each participant. This method led to a composite ranking which was captured in a draft report. The report containing the first group ratings was then sent to each participant for their private deliberation. Each participant then submitted a second set of scores which were informed by the first composite scores, but anonymous to other group members. This modified Delphi Method led to a higher level of consensus around the measures and the curriculum. It also identified those items for which there was little group support. Those items were removed from the list of outcomes measures and from the outline of the curriculum.

The first conference on outcomes measures was attended by 20 participants that included surgeons, scientists, educators, and facilitators. The ranking of the tasks identified was done by a subset of nine experienced surgeons. Participants who were not surgeons abstained from the scoring process.

The second conference on curriculum development was attended by 38 surgeons, scientists, educators, and facilitators. This group reviewed and became familiar with the material from the first conference. Thereupon, they were divided into three working groups to develop curriculum that focused on didactic and knowledge-based information, psychomotor skills, and team training and communications. Similarly, the actual ranking of the material developed was limited to experienced surgeons within the group.

**Results**

The first consensus conference resulted in a list of 25 outcomes measures which the group agreed should be mastered by a surgeon seeking privileges in robotics. These included 8 pre-operative, 15 intra-operative and 2 post–operative tasks which are shown in Figure 2. The resulting report also provides detailed definitions, descriptions, errors, outcomes and metrics for each of these tasks [9].

**FRS Outcomes Measures**

| Pre-Operative | Intra-Operative | Post-Operative |
|---|---|---|
| System Settings | Energy Sources | Transition to Bedside Asst |
| Ergonomic Positioning | Camera Control | Undocking |
| Docking | Clutching | |
| Robotic Trocars | Instrument Exchange | |
| OR Set-up | Foreign Body Management | |
| Situation Awareness | Multi-arm Control | |
| Closed Loop Comms | Eye-hand Instrument Coord | |
| Respond to System Errors | Wrist Articulation | |
| | Atraumatic Tissue Handling | |
| | Dissection – Fine & Blunt | |
| | Cutting | |
| | Needle Driving | |
| | Suture Handling | |
| | Knot Tying | |
| | Safety of Operative Field | |

*Figure 2. FRS Outcomes Measures.*

The second consensus conference on curriculum development resulted in outlines and principles for the creation of a curriculum to teach the previously identified list of tasks and knowledge (Figure 3).

*Didactic and Knowledge.* The didactic and knowledge working group created an outline of the material which should be taught in lecture format. This will include:

1. Introduction to robotic surgical devices.
2. Pre-operative set-up of equipment and positioning of staff.
3. Intra-operative use of a robot, surgeon ergonomics, visual field control, and necessary instruments and supplies.
4. Post-operative steps for removing a robot and transitioning to bedside control.

Each of these included an explicit list of errors that can occur in the process.

**FRS Curriculum Outline**

| Didactic & Cognitive | Psychomotor Skills | Team Training |
|---|---|---|
| **Lecture-based** | **Principle-based** | **Checklist-based** |
| Intro to Robotic System | Based on Physical Models (Virtual Models are Derivative) | #1: WHO Pre-Op |
| Pre-Operative Activity | 3D Exam Tools | #2: Robotic Specific |
| Intra-Operative Activity | Use Tasks that have Evidence of Validity | #3: Undocking & Debriefing |
| Post-Operative Activity | Multiple Outcomes Measured per Exercise | #4 Crisis Scenarios |
| Each Activity includes: Goals, Conditions, Metrics, Errors, Standards | Cost Effective Solution | |
| | High Fidelity for Testing, Lower Fidelity for Training | |
| | IRR Requires Ease of Administration | |

*Figure 3. FRS Curriculum Outline and Principles.*

*Psychomotor.* The psychomotor skills working group prefaced their work with seven principles that should be applied in selecting or designing a skills device for robotic surgery. Those principles were:

1. The tasks should be 3 dimensional in nature.
2. The tasks designed for testing should be such that they have multiple learning objectives that incorporate multiple tasks from the first conference report. The tasks designed for training will have more focused learning objectives.
3. Implementation of the tasks and the resultant method for teaching should be cost effective.
4. High fidelity models should be used for testing. Training can use lower fidelity devices or methods.
5. Tasks should be easy to administer to ensure Inter-Rater Reliability (IRR).
6. The tasks should be designed for implementation with physical objects and devices. Future implementation in VR with a simulator would be derivative of the physical model.
7. Preference should be given to tasks that have existing evidence of validity

The group then identified 16 of the 25 tasks which contained psychomotor features. To address these, they proposed ten tasks which could be used to measure these skills. Three tasks were drawn from FLS, others were selected from existing educational programs, and designs for new task devices were proposed.

1. FLS peg transfer
2. FLS suturing
3. FLS pattern cutting
4. Running Suture
5. Dome with four towers
6. Vessel dissection and clipping
7. UTSW 4$^{th}$ arm retraction and cutting
8. Energy and mechanical cutting
9. Docking task (new design)
10. Trocar insertion task (new design)

For each of these the group also identified the associated task description, conditions, metrics, and errors.

*Team Training and Communications.* The team training and communications working group prefaced their work by defining the importance of team training in a robotic environment. They identified the following principles as essential to successful team-based operations and training.

1. Inclusion
2. Empowerment
3. Person specific
4. Reiterative
5. 'Just in time'
6. Ownership
7. Risk management/quality improvement- closed loop

They stated that existing programs like TeamSTEPPS can be applied to robotic teams. Their curriculum follows a checklist format and is conceptually derived from the standard WHO checklist. For robotic training they recommended the following checklists:

1. Pre-operative. Addressing General situation, surgeon, anesthetist, nurse/OPD, and surgical site infection.
2. Robotic Docking. Addressing anesthesia, patient, bedside assist, procedure-specific checks, and trouble shooting.
3. Intra-operative. Addressing the communication that occurs within a team throughout the operation.
4. Undocking and Debriefing.

A third consensus conference is scheduled for August 2012 to write the detailed material that will be included in the didactic and team training sections of the curriculum; and where specific psychomotor skills devices will be identified, designed and selected.

**Conclusions & Discussion**

Two consensus conference involving members from major stakeholder organizations in surgical training, governance, and certification across multiple specialties have been conducted to arrive at a consensus regarding the most important outcome measures for the safe conduct of robotic surgery and the curriculum to teach those skills and knowledge. The development of FRS is multi-specialty, system agnostic and follows decades of experience in other industries at developing such education and training platforms. Using the curriculum for training and assessment should result in a surgeon who has proficiency in basic robotic surgery skills and is capable of passing the requirements of high stakes testing and evaluation. At some future time, this testing and evaluation would be administered by an appropriate independent, objective and authoritative organization, which would adopt the materials developed through this consensus process.

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