3D-Printed Thymectomy Model for Surgical Resident Training

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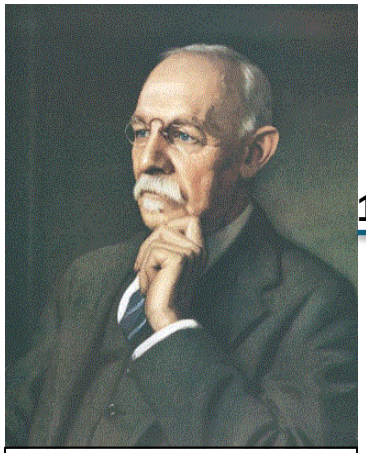
MODERN HISTORY OF SURGICAL EDUCATION



- Mentorship
- Service
- Autonomy
- Experience

1900s

Accreditation Council for Graduate Medical Education

2000s

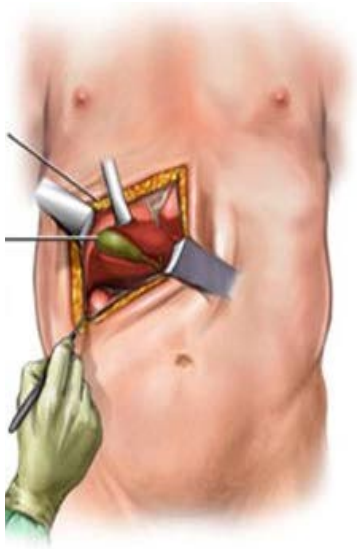
- Laparoscopy
- Robotics
- Complexity of Care
- Program Variability
- Patient Safety
- Work Hours

Surgical Council of Resident Education

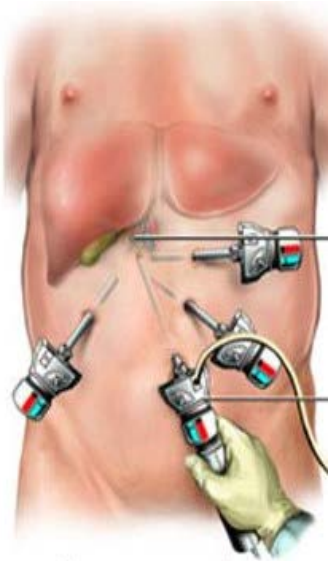
- ABS
- ASE
- APDS
- RRC-S, etc…

- Standard Curricula
- Simulation Curricula
- FLS
- FRS?

LAPAROSCOPIC AND ROBOTIC SURGERY



Open cholecystectomy



Laparoscopic cholecystectomy

BACKGROUND

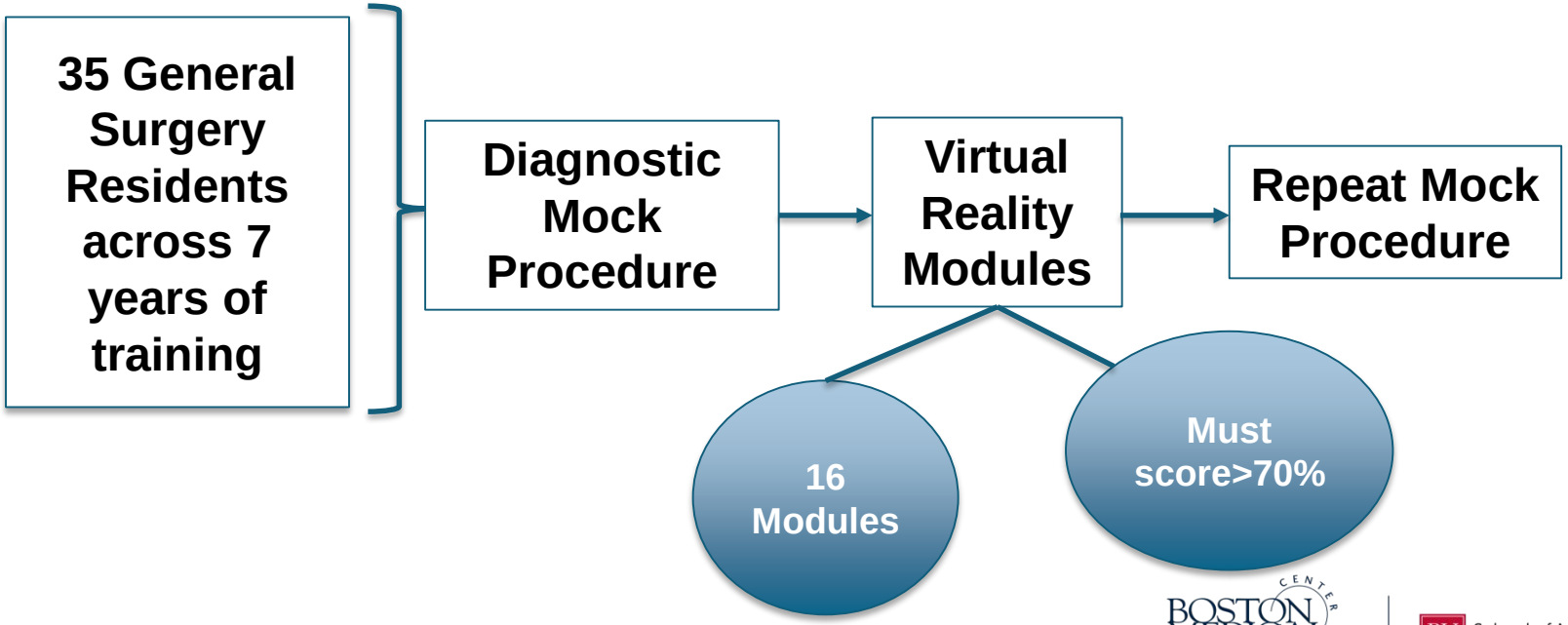
- **Increasing volume of robotic surgical cases being performed in the following fields:**
  - **General Surgery**
  - **Cardiac & Thoracic Surgery**
  - **Urologic and Gynecological Surgery**
  - **Colon and Rectal Surgery**
- **Resident training in robotic surgery lacking or inconsistent**
- **Resident confidence and basic robotic skills can be improved upon graduation**

BARRIERS TO INTRAOPERATIVE TRAINING

- Lack of a second operator console
- Inability for multiple surgeon operators
- Need for a bedside assistant
- Acuity of potential intraoperative complications

COMBINED MOCK OPERATIVE AND VIRTUAL TRAINING CURRICULUM

- Two tools available to circumvent barriers to training:
  - Virtual reality simulation
  - Anatomical model based simulation



MOCK THYMECTOMY MODEL

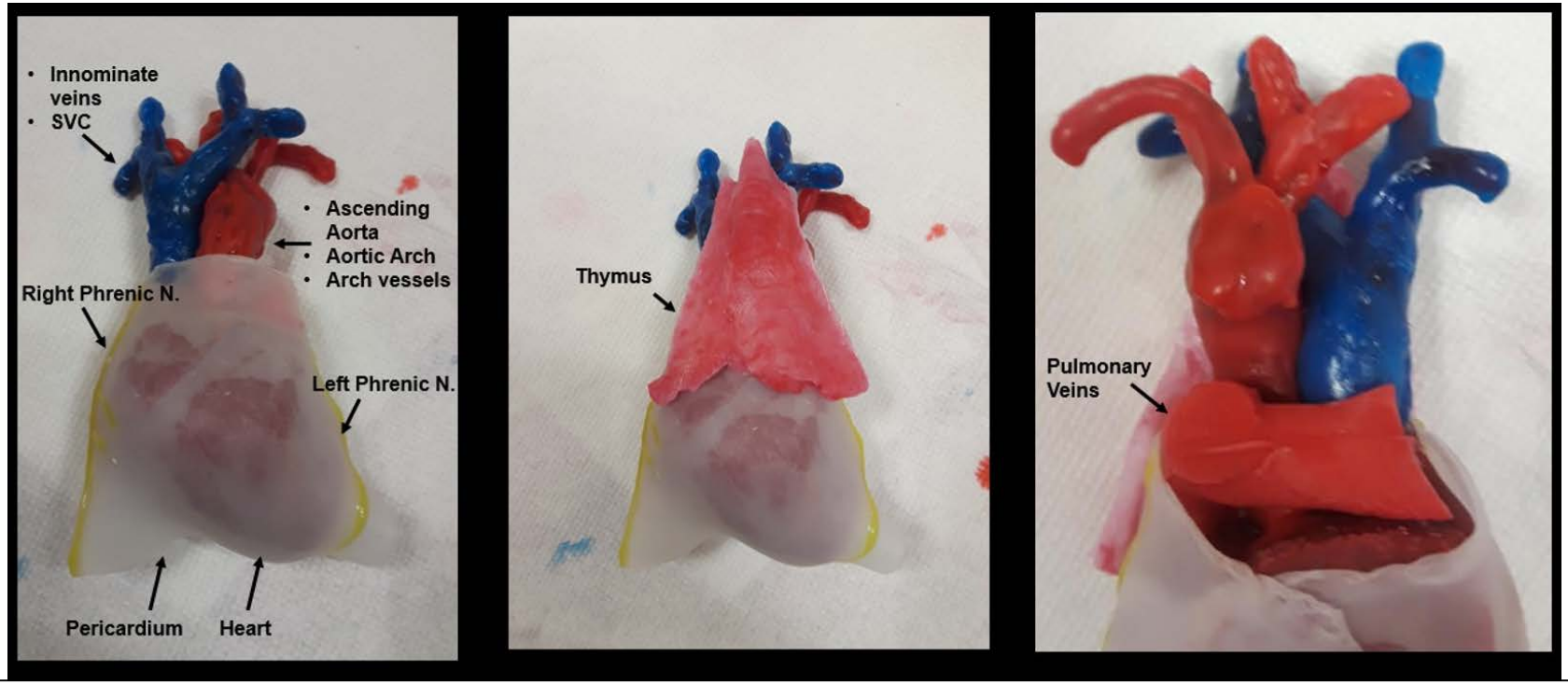
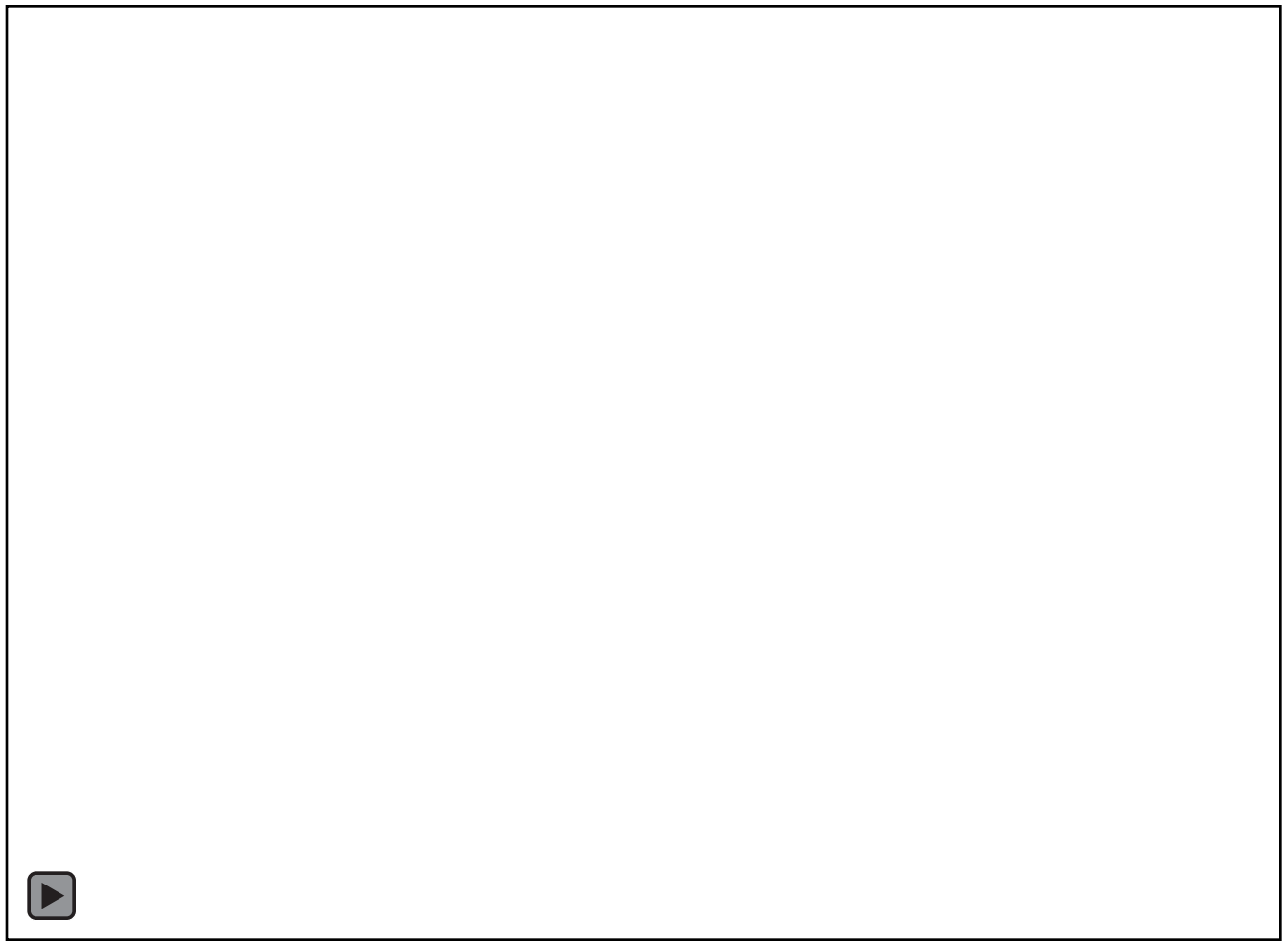


Figure 1. <u>Thymectomy prototype</u>. Thymus shown in pink. Heart is covered with a thin layer of pericardium (white) with phrenic nerves running vertically (yellow). The vessels are fluid-filled such that injury can be detected.

MOCK OPERATIVE MODEL AT WORK



MOCK PROCEDURE ASSESSMENT TOOL

A. Thymectomy

1) Appropriate port placements	/3
2) Identification/protection of ipsilateral phrenic nerve a. Identification (0/2) b. Protection (0/3)	/5
3) Identification/protection of contralateral phrenic nerve a. Identification (0/2) b. Protection (0/3)	/5
4) Identification/protection of superior vena cava (SVC) a. Identification (0/2) b. Protection (0/3)	/5
5) Identification/protection of SVC/innominate vein junction a. Identification (0/2) b. Protection (0/3)	/5
6) Identification/protection of Innominate vein a. Identification (0/2) b. Protection (0/3)	/5
7) Injury to pericardium avoided	/3
8) Completeness of thymectomy	/3
9) Camera navigation	/3
10) Hand position/equipment safety	/3
	/40

USE OF VIRTUAL REALITY SIMULATION

Training Module	Skill Focus
Camera Targeting	Camera Control
Energy Switching 1	Camera Control & Clutching, Energy Control
Energy Dissection 1	Endowrist Manipulation, Dissection, Energy Control
Matchboard 3	Endowrist Manipulation, Fourth Arm Control
Needle Targeting	Endowrist Manipulation, Needle Control
Ring Walk 2	Endowrist Manipulation, Camera Control
Dots and Needles 1	Needle Control, Basic Needle Driving
Suture Sponge 1	Endowrist Manipulation, Needle Control, Basic Needle Driving
Thread the Needle	Endowrist Manipulation, Camera Control, Needle Control
Tubes	Endowrist Manipulation, Camera Control & Clutching, Needle Control

Residents progress through an organized curriculum composed of 16 modules (Table 2) from the robotic skills simulator, requiring a score of >70% based on 20 simulation metrics

VIRTUAL REALITY PRELIMINARY RESULTS

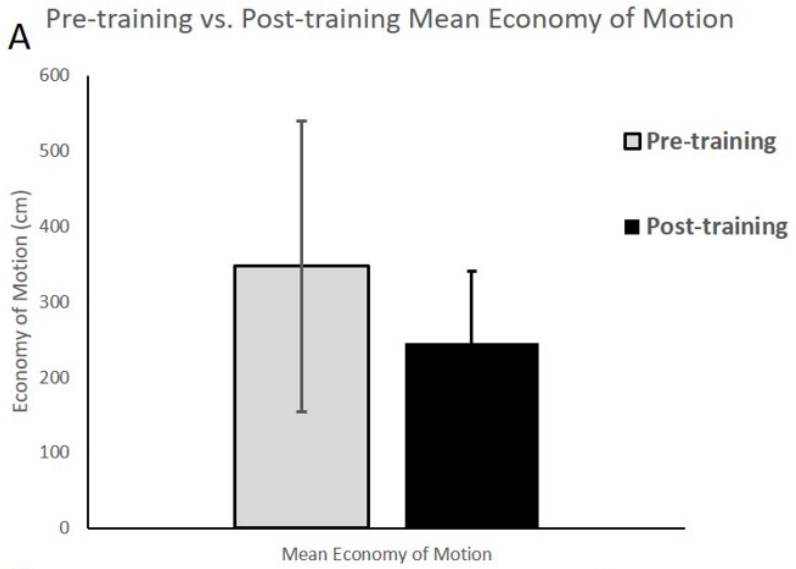
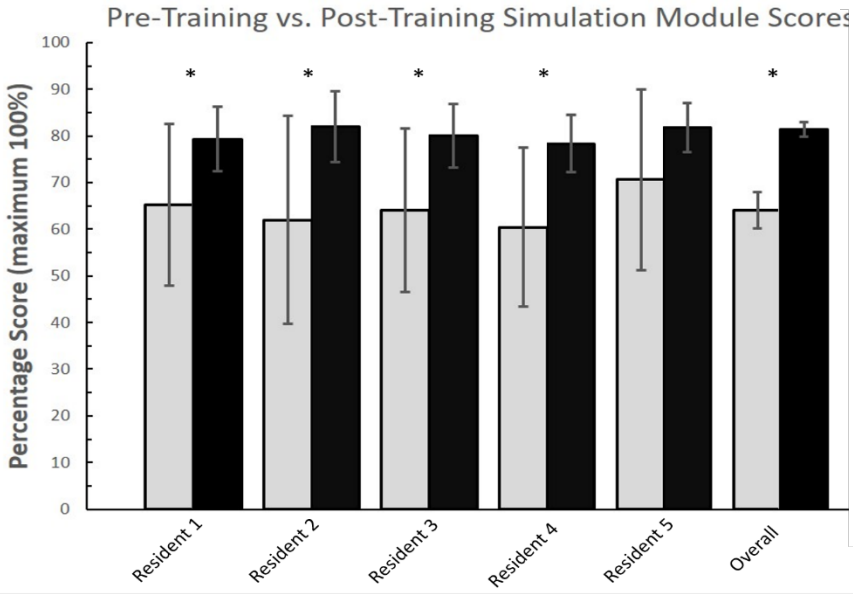
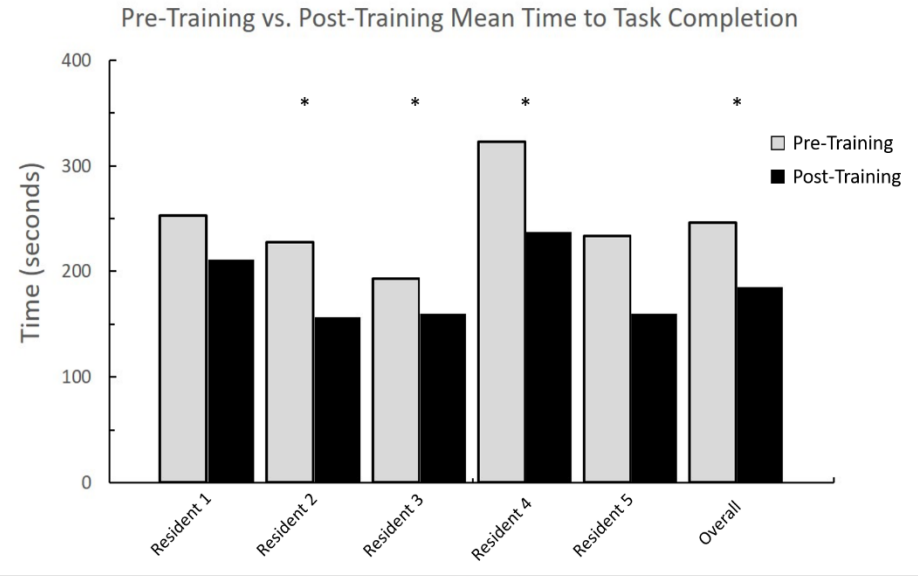


Figure 1. Comparison of overall Pre-training and Post-training VR simulation scores. **(A)** Pre-training vs. Post-training mean 'economy of motion' for five residents after completion of all simulation modules measured in centimeters (p=0.0056). **(B)** Pre-training vs. Post-training mean 'time to task completion' for five residents after completion of all simulation modules measured in seconds (p=0.0046). **(C)** Pre-training vs. Post-training mean total score after completion of all modules by five residents.

VIRTUAL REALITY TRAINING RESULTS





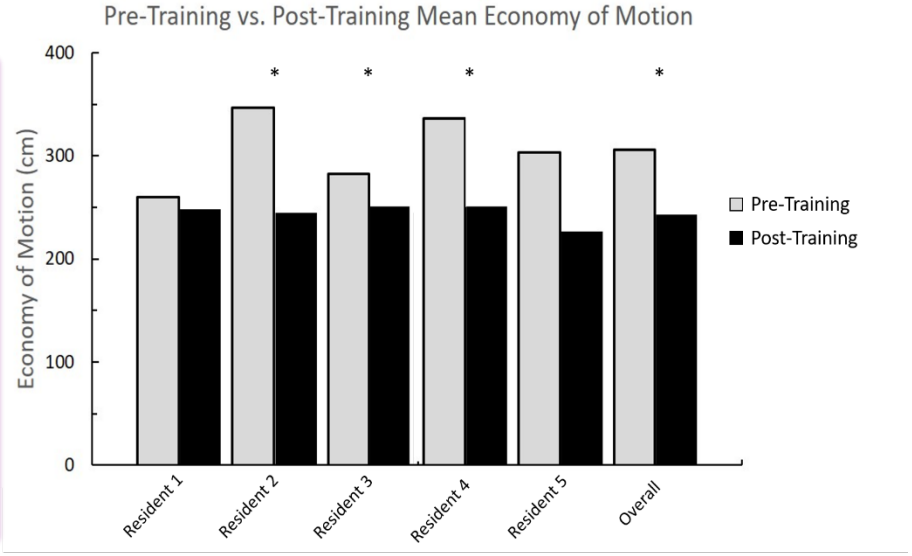


Figure 2: Individual results for each of the 5 residents who completed the assigned simulation module training (n=16 modules). Asterisk (*) indicates $p<0.05$ (A) Significant improvements in simulation scores were observed in 4 out of 5 residents (B) Significant improvements in time to task completion were observed in 3 out of 5 residents (C) Significant improvements in mean economy of motion were observed in 3 out of 5 resident

CONCLUSION & FUTURE DIRECTION

- **VR simulation alone - residents were able to improve performance in multiple metrics measured across all simulation modules, including ‘economy of motion’ and ‘time to task completion’**
- **Performance, extinguishment was not measured**
- **There have been no studies to assess validity of 3D printed models**
- **Improvements to the 3D printed robotic model should be incorporated to more closely emulate operation**
- **The 3D print concept can be applied to other robotic procedures, including:**
    - **Pelvis model for low anterior resection**
    - **Ventral hernia model**
    - **Pulmonary lobectomy model**

REFERENCES

1. Foell K, Finelli A, Yasufuku K, et al. Robotic surgery basic skills training: Evaluation of a pilot multidisciplinary simulation-based curriculum. *Can Urol Assoc J.* 2013;7(11-12):430-434.
2. Zhong W, Mancuso P. Utilization and Surgical Skill Transferability of the Simulator Robot to the Clinical Robot for Urology Surgery. *Urol Int.* 2017;98(1):1-6.
3. Siddiqui NY, Tarr ME, Geller EJ, et al. Establishing Benchmarks For Minimum Competence With Dry Lab Robotic Surgery Drills. *J Minim Invasive Gynecol.* 2016;23(4):633-638.
4. Siddiqui NY, Galloway ML, Geller EJ, et al. Validity and reliability of the robotic Objective Structured Assessment of Technical Skills. *Obstet Gynecol.* 2014;123(6):1193-1199.
5. Hogg ME, Tam V, Zenati M, et al. Mastery-Based Virtual Reality Robotic Simulation Curriculum: The First Step Toward Operative Robotic Proficiency. *J Surg Educ.* 2016.
6. Farivar BS, Flannagan M, Leitman IM. General surgery residents' perception of robot-assisted procedures during surgical training. *J Surg Educ.* 2015;72(2):235-242.
7. Davoudi M, Osann K, Colt HG. Validation of two instruments to assess technical bronchoscopic skill using virtual reality simulation. *Respiration.* 2008;76(1):92-101.

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