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BRIEF REPORT

Developing a Standardized Curriculum for Robotic Colorectal Surgery for General Surgery Residents: Experience from a Tertiary Center

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ABSTRACT

Robotic platforms are being adopted in surgery at an increasingly rapid pace, with implications for the field of general surgery and residency training. This evolution has prompted discussion on the ideal methods used to train current surgical residents in the use of robotic platforms.

The colorectal surgery department at our institution has implemented a standardized robotic surgery curriculum designed to establish clear expectations for residents' progression, autonomy, and the skills that should be acquired by the conclusion of their training. The curriculum outlines key surgical objectives, representing essential steps that require distinct skills and anatomical knowledge, organized by postgraduate year level as a general guide to the resident's ability.

The goals of this standardized curriculum include increasing resident engagement in acquiring robotic skills, dividing complete procedures into manageable steps and objectives, and promoting faculty participation to allow residents to operate independently, within defined competency levels. Upon completion of the curriculum, residents report confidence in performing common robotic colorectal surgeries.

We aim to expand the implementation of this curriculum model to other departments within our institution and encourage the adoption of similar standardized robotic training by other academic centers in this new era of robotic surgery.

To underscore the benefits and importance of a standardized robotic surgery curriculum for residents with our experience in the division of colorectal surgery.

Keywords: Surgical education, robotic surgery, robotic curriculum, standardized curriculum

Introduction

Over the last decade, the field of general surgery has adopted robotic platforms at a remarkably rapid pace. According to a 2019 cohort study of 72 hospitals, the use of robots in general surgery procedures increased from 1.8% to 15.1% between 2012 and 2018.[1] Consequently, general surgery residents have experienced substantial changes in the types of cases they are exposed to and in the skills required to become proficient surgeons in a changing landscape. This shift has sparked discussion regarding the most effective methods to prepare and train surgical residents in robotic skills.

In 2024, a working group of minimally invasive surgeons and robotic educators was formed to develop recommendations for a standardized, transferable curriculum that could be implemented in residency programs across the US[2] The group's recommendations included preliminary simulator practice and hands-on experience with bedside assistance and console operation, with an emphasis on well-defined tiers based on

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specific objectives that residents must meet to progress.

At our institution, we developed a standardized robotic curriculum that is distributed to residents at the beginning of their training to establish clear expectations for their progression, autonomy, and the skills to be mastered by the conclusion of their training. The goals of this curriculum include increasing resident engagement in acquiring robotic skills, breaking up specific full procedures into manageable steps and objectives, and increasing faculty engagement to allow residents to operate independently, provided there is a mutual understanding of the resident's "level" or achieved objectives. We believe that residents should be able to participate in appropriate portions of procedures based on their level of training.

This philosophy has permeated the entire department, and colorectal surgery rotations are now highly regarded by residents at all levels due to the clear expectations and operative autonomy. To facilitate understanding of the cases and individual steps, residents are granted access to case recordings from all robotic cases across services. This initiative allows them to better prepare for specific cases and attending surgeons and to improve their skills by analyzing their intraoperative performance.

Methods and Curriculum Development

The robotic curriculum was developed by faculty and residents within the department of colorectal surgery. No informed consent was required for this process.

Outlined below is our standardized robotic curriculum for common colorectal procedures, including right and left colectomy, low anterior resection, and Hartmann's reversal (Table 1). Each operation includes objectives representing key steps of the surgery that require distinct skills and anatomical knowledge. These objectives are organized by postgraduate year (PGY) level, which serves as a general guide for the resident's skill level. However, residents may work on objectives above or below their PGY level depending on their prior exposure to the operation or their overall skill level.

Table 1. Robotic surgery curriculum

Right colectomy/ileocolic resection
1. **PGY5:** Isolate and ligate the ileocolic vessels (when applicable) using clips, stapler, or energy device.
2. **PGY3+:** Perform medial to lateral dissection: use sharp and blunt dissection to separate the colon mesentery from the retroperitoneum; identify and dissect the duodenum.
3. **PGY3+:** Perform inferior to superior dissection (alternate technique): use sharp and blunt dissection to separate the colon mesentery from the retroperitoneum; identify and dissect the duodenum.
4. **PGY1+:** Perform lateral takedown of the white line of Toldt and hepatic flexure takedown.
5. **PGY3+:** Staple robotically across the colon and ileum.
6. **PGY5+:** Perform the side-to-side anastomosis.
7. **PGY3+:** Oversew the resulting enterotomy (two-layer closure); PGY1 may perform the outer layer closure.
8. **PGY1+:** Extract the specimen using an Alexis wound protector; close the fascia.
9. **PGY1+:** Provide bedside assistance as indicated (suction, exposure, retraction).
Left colectomy/sigmoidectomy
1. **PGY5:** Isolate and ligate the inferior mesenteric vessels (IMA and IMV, when applicable) using clips, stapler, or energy device.
2. **PGY3+:** Perform medial to lateral dissection: use sharp and blunt dissection to separate the colon mesentery from the retroperitoneum.
3. **PGY5:** Identify and protect the ureter.
4. **PGY1+:** Perform lateral takedown of the white line of Toldt.
5. **PGY3+:** Mobilize the splenic flexure (enter the lesser sac, take down the gastrocolic ligament, and separate from the lower edge of the pancreas).
6. **PGY3+:** Staple robotically across the colon.
7. **PGY1+:** Extract the specimen through the extraction site (Pfannenstiel).
8. **PGY1+:** Secure the anvil to the colon extracorporeally.
9. **PGY3+:** Perform the colorectal anastomosis.
10. **PGY1+:** Manipulate and deploy the EEA stapler.
11. **PGY1+:** Perform the air leak test/flexible sigmoidoscopy.
12. **PGY1+:** Provide bedside assistance as indicated (suction, exposure, retraction).

Table 1. Continued

Right colectomy/ileocolic resection
Low anterior resection
1. **Steps 1-12 as described for the left colectomy/sigmoidectomy.**
2. **PGY5:** Perform the pelvic dissection (total mesorectal excision).
3. **PGY5:** Transect the rectum distal to the level of the tumor.
Hartmann reversal
1. **PGY1+:** Take down the colostomy to the level of the fascia.
2. **PGY5:** Isolate and ligate the inferior mesenteric vessels (IMA and IMV, when applicable) using clips, stapler, or energy device.
3. **PGY3+:** Mobilize the splenic flexure (enter the lesser sac, take down the gastrocolic ligament, and separate from the lower edge of the pancreas).
4. **PGY3+:** Transect the sigmoid stump (when applicable).
5. **PGY1+:** Secure the anvil to the colon extracorporeally.
6. **PGY3+:** Perform the colorectal anastomosis.
7. **PGY1+:** Manipulate and deploy the EEA stapler.
8. **PGY1+:** Perform the air leak test/flexible sigmoidoscopy.
9. **PGY1+:** Provide bedside assistance as indicated (suction, exposure, retraction).

PGY: Postgraduate year

Discussion

It has been over a year since the implementation of our standardized curriculum. Residents have expressed high satisfaction with the opportunity to acquire progressively advanced skills and perform increasingly complex portions of colorectal operations.

The Cognitive Load Theory, developed by John Sweller in 1988, describes how the brain's working memory can be easily overwhelmed, leading to decreased information retention once capacity is exceeded. Effective strategies to reduce cognitive load include breaking down larger, more intimidating tasks into smaller steps and building upon prior knowledge. For this reason, our robotic curriculum was designed to provide digestible, concrete objectives that learners can build upon to achieve their ultimate goal.

Other institutions, such as the University of Illinois College of Medicine at Peoria, have developed robotics curricula that combine simulation and hands-on training for small groups of participants. During the hands-on portion, residents began with the simplest operative tasks and then progressed to increasingly complex ones. Their study showed improved resident performance with higher numbers of procedures performed in this sequential manner and, as they stated, underscores the importance of a "methodical, stepwise robotics curriculum".[3]

Feedback from both residents and faculty at our institution has been extremely positive. Residents report that they have been able to progress rapidly through the outlined colorectal procedures, with more time spent on the console in the operating room. They have reported that attending surgeons are more comfortable letting them perform increasingly complex steps of the procedure, knowing that they have progressed adequately through the curriculum. However, the most demonstrative fact may be that at the end of their general surgery training, our residents can confidently perform complex robotic colorectal operations.

Conclusion

We have developed a standardized robotic curriculum specific to the colorectal surgery department at our institution. This curriculum incorporates small operative steps organized by PGY level, representing tasks of increasing complexity that ultimately build into the completion of a procedure. This is a time-efficient, goal-oriented, and competency-based method that has contributed to our surgical training program being recognized as providing one of the most rewarding and formative operative experiences in the country.

Upon completion of the curriculum, residents report feeling confident in performing common robotic colorectal surgeries. Future steps include continued development of an online video database to supplement hands-on training and provide learners with visual demonstrations of curriculum objectives prior to performing them. Additionally, we aim to implement similar curricula in other departments within our institution and encourage other academic centers to consider adopting their own standardized robotic learning in this new era of robotic surgery.

Footnotes

Authorship Contributions

Concept: B.C., E.E., C.A., Design: B.C., E.E., C.A., Data Collection or Processing: B.C., E.E., Analysis or Interpretation: B.C., E.E., C.A., Literature Search: B.C., E.E., Writing: B.C., E.E., C.A.

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