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RESEARCH

The impact of standardized robotics course training during colorectal surgery fellowship on post-training practice: a survey of graduates

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Abstract

The Association of Program Directors for Colon and Rectal Surgery (APDCRS) has sponsored a standardized robotics course for colorectal and minimally invasive surgery fellows since 2011. The study objective was to assess the impact of the APDCRS-sponsored course on surgical approaches adopted by young colorectal surgeons before, during, and after fellowship. An internet-based survey was administered to 2014–2022 ACGME-accredited colorectal surgery program graduates. Study variables were summarized using frequencies and proportions. Survey response rate was 43.2%. Laparoscopic and robotic volumes were consistently higher than open and hand-assist laparoscopic volumes over the study period. About 70.0% of fellows performed ≥ 20 laparoscopic cases before 2017, and over 80% had experience with ≥ 20 laparoscopic cases during/after 2017. An increasing trend of performing ≥ 20 robotic colorectal cases during fellowship was observed (before 2017: 75.0%, 2018–2019: 76.9%, and 2021–2022: 84.8%). Multivariate logistic regression analysis showed that higher robotic volume (≥ 25 colorectal cases) during general surgery residency increased odds of performing ≥ 50 robotic cases during fellowship (OR: 4.38, 95% CI 0.88, 26.1). Higher robotic volumes during fellowship correlated with higher robotic volumes in the first year of post-fellowship practice. 88.6% of respondents agree (21.0%) or strongly agree (67.6%) that the APDCRS robotics training course met expectations, and 83.8% agree or strongly agree that the course prepared them for post-graduate robotics practice. The APDCRS-sponsored robotics training course met expectations and prepared colorectal surgery fellows for adopting the robotic approach after graduation, with the majority of respondents reporting that they utilize robotics in their post-graduation colorectal practice.

Keywords Colon and rectal · Colorectal · Robotic · Fellowship training

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Abbreviation

APDCRS Association of Program Directors for Colon and Rectal Surgery

Introduction

Adoption of the robotic approach in colorectal surgery has grown significantly, with nearly all colorectal trainees now gaining experience operating at the robotic console [1]. Modern surgical skills training has evolved accordingly, employing a diverse range of modalities to prepare the next generation of surgeons for independent practice. Utilization of self-directed didactic reading, online training modules, simulation, dry labs, live tissue, cadaveric and 3D printed models all support the progressive supervised real-life operative experience [2].

Historically, the integration of new technologies into colorectal fellowship training, such as transanal endoscopic

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microsurgery (TEM) and laparoscopic colorectal surgery, lacked centralized coordination and standardization critical for efficient skill acquisition and resulted in variable training value [3]. With the increased adoption of robotic surgery within the colorectal specialty, there was a need to incorporate this skillset effectively and reproducibly into colorectal surgery fellowship training [4]. This led to a partnership between the Association of Program Directors for Colon and Rectal Surgery (APDCRS) and Intuitive Surgical in 2011 to develop a unique, focused, standardized robotic colorectal surgery training curriculum designed to function as a blueprint and strategic add-on to established colorectal fellowship training methods.[5] The details of the curriculum can be found in Supplemental Fig. 1.

Previous studies have highlighted the underutilization of minimally invasive approaches in colorectal surgery, underscoring the significant impact of implementing a standardized training curriculum [5]. One previous survey study identified key barriers among young colorectal surgeons adopting the robotic surgical approach that included inadequate training and a shortage of robotic mentors [5]. This led to further refinement of the APDCRS-sponsored robotics training course, addressing these barriers through a comprehensive curriculum and in-person robotic training, aiming to equip future surgeons with the skills and confidence needed to embrace advanced surgical techniques effectively.

This study aimed to evaluate the effectiveness of a structured, specialty-wide approach to robotics training through a survey of program graduates spanning from 2014 to 2022. In addition, we sought to analyze changes in surgical modality volume during fellowship over time and investigate any correlation between these changes and the adoption of minimally invasive surgery in early professional practice.

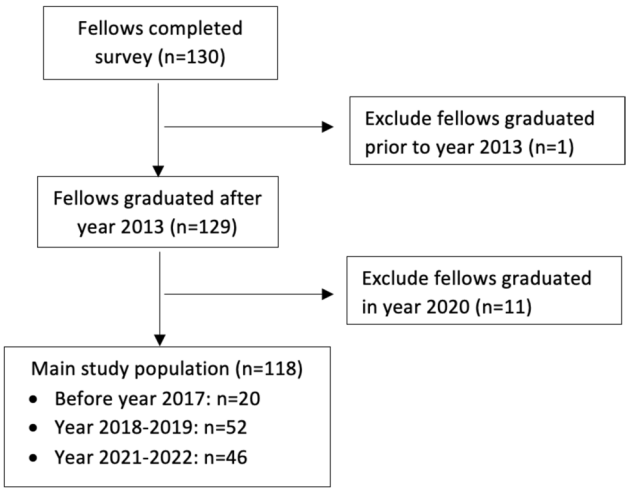

Fig. 1 APDCRS survey study algorithm

Methods

Study design

An anonymous, internet-based survey was sent via Qualtrics® to colorectal surgeons who graduated from ACGME-accredited colorectal surgery programs between 2014 and 2022. An initial email with a brief introduction, contact information, and a link to the survey was sent to all eligible graduates in September 2022 and a follow-up email invitation was sent 2 weeks after the initial email.

The survey consisted of 33 questions (Supplemental Fig. 2) designed to describe the APDCRS fellowship training experience and evaluate the impact of the APDCRS-sponsored course on surgical practice of young colorectal surgeons during and after fellowship training. No personal identifiers were collected in the survey. IRB exemption was obtained from the WIRB-Copernicus Group (WCG).

Statistical analysis

All study variables were summarized using frequencies and proportions to describe overview of fellowship training experience. APDCRS fellows who graduated in 2020 were excluded from the main analyses due to the impact of COVID on surgical education, training course, and clinical practice that might lead to experiences different than graduates of other years, but they were included in the sensitivity analyses. In addition to presenting aggregated results for all the eligible graduates, stratified analyses by time periods of completing fellowship and APDCRS-sponsored training (prior to 2017, 2018 to 2019, 2021 to 2022) were performed to identify any possible temporal changes. Multivariate logistic regression was used to evaluate factors impacting higher robotic case volumes during the APDCRS fellowship. Odds ratio (OR) and 95% confidence intervals (CI) were presented. All analyses were performed using R 4.2.2.

Results

A total of 43.2% (159 of 368) of ACGME-accredited colorectal surgery program graduates responded to the survey. We excluded 29 fellows who did not complete all the questions and 1 fellow who graduated prior to 2013, leaving a sample of 129 eligible respondents. In the main analysis, we further excluded 11 fellow respondents who graduated in 2020 due to the impact of COVID, thereby reporting data from 118 fellows (Fig. 1). Survey outcomes for the 129

responding fellows graduating from 2014 to 2022 are shown in Supplemental Fig. 2.

Of the 118 fellows included in the main analysis, the majority of them ($n = 114$, 96.6%) participated in the robotic training course and received a robotic training equivalency certificate either during their general surgery residency (28.8%) or colorectal fellowship (65.3%). Considering the different components of the APDCRS robotic training curriculum, most had completed the APDCRS-sponsored in-person robotic training lab (89.0%), 5 da Vinci cases as console surgeon (81.4%), the da Vinci training modules (76.3%), da Vinci simulation (68.6%) and da Vinci in-service (63.6%). Only 31.4% attended the faculty-led webinars (began in 2020 during COVID restrictions). A little more than one-third (34.7%) received further robotic training after completing fellowship. Graduated fellows are currently practicing across community (50.0%), university (23.7%), and non-university academic (20.3%) practices (Table 1 and Supplemental Table 1).

Respondents indicated that the most desired areas for more exposure during fellowship training were intracorporeal anastomosis (61.0%), ventral rectopexy (55.9%), inflammatory bowel disease (IBD) indications (41.5%), deep pelvic dissection (35.6%), and rectal cancer (22.0%) (Table 2 and Supplemental Table 2).

Most fellows strongly agreed (67.6%) or somewhat agreed (21.0%) that the APDCRS robotics training course met their expectations, and strongly agreed (45.7%) or somewhat agreed (38.1%) that the course prepared them for postgraduate practice. Over 94% of fellows thought the training was balanced in didactics and laboratory course components (Table 3 and Supplemental Table 3).

Figure 2 shows the temporal trends of open, laparoscopic, hand-assist laparoscopic, and robotic colorectal case volumes during the APDCRS fellowship. The proportion of fellows performing more than 20 open colorectal cases during their fellowship increased over time (before 2017: 55.0%, 2018–2019: 73.1%, and 2021–2022: 80.4%) (Fig. 2).

Most fellows had performed less than 20 hand-assist laparoscopic colorectal cases during their fellowship and no obvious temporal change was observed (Fig. 3).

Laparoscopic and robotic volumes were consistently higher than open and hand-assist volumes over the study period (Figs. 4 and 5).

For laparoscopic volumes, a slight increase was observed after 2018. About 70.0% of fellows performed more than 20 laparoscopic cases prior to 2017, while over 80% had experience with over 20 laparoscopic cases from 2018 and onward (Fig. 4). An increasing trend of performing more than 20 robotic colorectal cases during the fellowship was also observed (before 2017: 75.0%, 2018–2019: 76.9%, and 2021–2022: 84.8%) (Fig. 5). For open, laparoscopic, and robotic cases, fellows graduating in 2018–2019 had the

Table 1 Characteristics of APDCRS fellows

Characteristics	$N = 118$[a]
Years completed training	
Before year 2017	20 (16.9%)
Year 2018	24 (20.3%)
Year 2019	28 (23.7%)
Year 2021	25 (21.2%)
Year 2022	21 (17.8%)
Type of fellowship training program	
Colon and rectal surgery (CRS) residency (fellowship)	112 (94.9%)
Minimally invasive surgery fellowship	1 (0.8%)
Both	5 (4.2%)
Participated robotic training course	114 (96.6%)
Completed APDCRS robotics training modules	
APDCRS-sponsored in-person robotic training lab	105 (89.0%)
Participated in 5 da Vinci cases as console surgeon	96 (81.4%)
da Vinci training modules	90 (76.3%)
da Vinci Simulation	81 (68.6%)
da Vinci in-service	75 (63.6%)
Faculty-led webinars	37 (31.4%)
Received robotic training equivalency certificate	
During general surgery residency	34 (28.8%)
During fellowship	77 (65.3%)
Did not receive equivalency certificate	7 (5.9%)
APDCRS training is first robotic course	
Yes	74 (62.7%)
No	31 (26.3%)
Unknown	13 (11.0%)
Received further RAS training after fellowship	41 (34.7%)
Current hospital type	
Community	59 (50.0%)
University	28 (23.7%)
Non-university academic	24 (20.3%)
Others	7 (5.9%)

[a]n (%)

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Table 2 Desired areas for more exposure in fellowship

	Overall, $N = 118$[a]
Intracorporeal anastomosis	72 (61.0%)
Ventral rectopexy	66 (55.9%)
IBD indications	49 (41.5%)
Deep pelvic dissection	42 (35.6%)
Rectal cancer	26 (22.0%)
Right colectomy	16 (13.6%)
Diverticulitis	12 (10.2%)

[a]n (%)

IBD inflammatory bowel disease

Table 3 Satisfaction of APDCRS-sponsored in-person robotics training

	Overall, $N = 118$[a]
Met my expectation	
Strongly agree	71 (67.6%)
Somewhat agree	22 (21.0%)
Neither agree nor disagree	7 (6.7%)
Strongly disagree	4 (3.8%)
Somewhat disagree	1 (1.0%)
Unknown	13
Prepared me for post-graduate practice	
Strongly agree	48 (45.7%)
Somewhat agree	40 (38.1%)
Neither agree nor disagree	12 (11.4%)
Somewhat disagree	3 (2.9%)
Strongly disagree	2 (1.9%)
Unknown	13
Balanced in didactics/lab course	
Balance was appropriate	99 (94.3%)
Too much didactics	5 (4.8%)
Too much lab	1 (1.0%)
Unknown	13

[a]n (%)

APDCRS Association of Program Directors for Colon and Rectal Surgery

highest proportions of performing more than 50 cases for each of the three surgical approaches (Figs. 2, 3, and 5). More granular volume data by surgical approach and years of graduation during the APDCRS fellowship year and during 1-year post-fellowship are presented in Supplemental Tables 4 and 5, respectively.

In multivariate logistic regression analysis, higher robotic volume (≥ 25 colorectal cases) during general surgery residency tended to increase the odds of performing more than 50 robotic cases during the fellowship (OR: 4.38, 95% CI 0.88, 26.1) (Table 4). Higher robotic volumes during fellowship were also observed to be correlated with higher robotic volumes in the first-year post-fellowship practice (Table 5).

Discussion

This study utilized an anonymous online survey of colorectal fellowship graduates to assess their experience with the APDCRS-sponsored standardized robotic colorectal surgery curriculum. The majority of survey respondents indicated that the curriculum successfully met their expectations and prepared them for post-graduate robotic colorectal surgery. Most were also able to achieve an Equivalency Certificate that allows them to begin their post-fellowship career certified to perform robotic surgery.

The proportion of graduates who reported they were able to complete more than 20 robotic cases during fellowship increased over time. This trend parallels the national

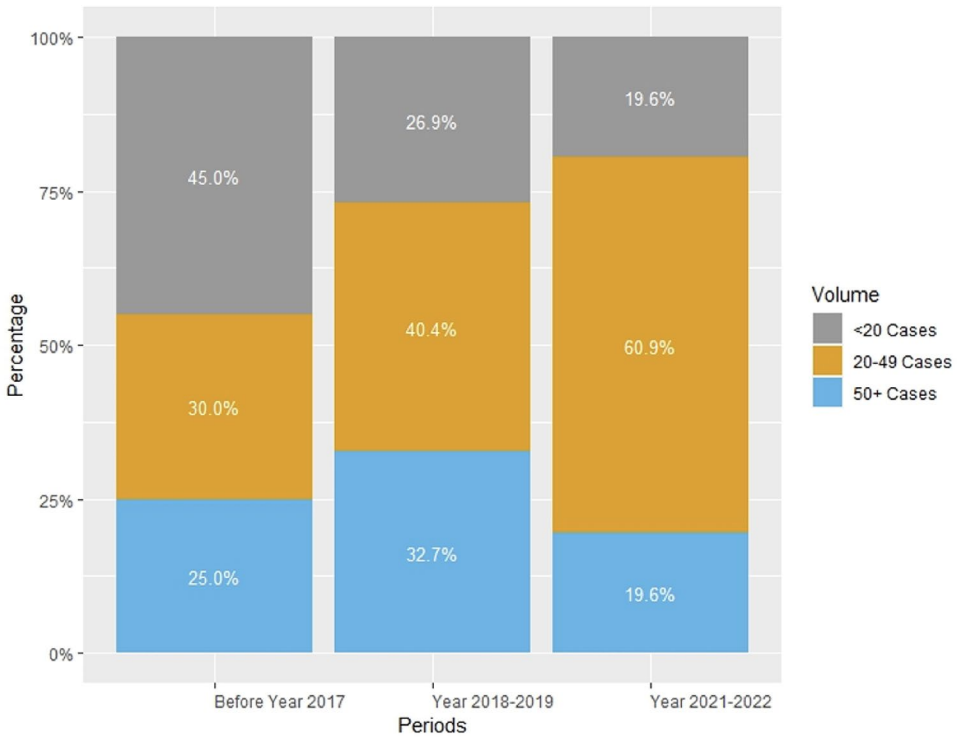

Fig. 2 Open colorectal case volumes during fellowship

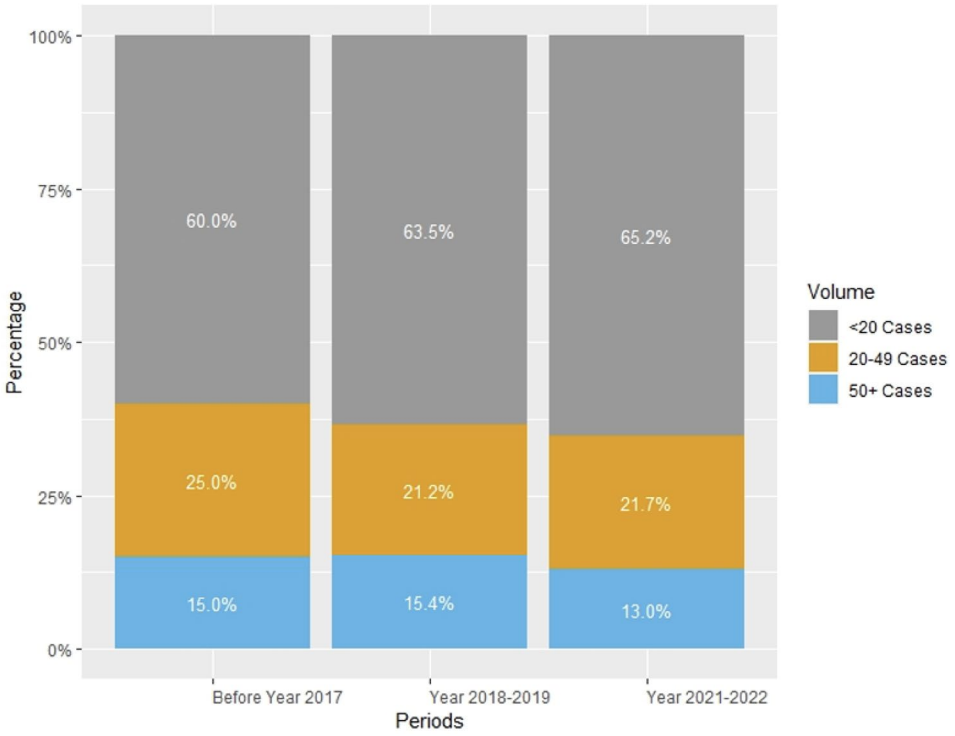

Fig. 3 Hand-assist laparoscopic colorectal case volumes during fellowship

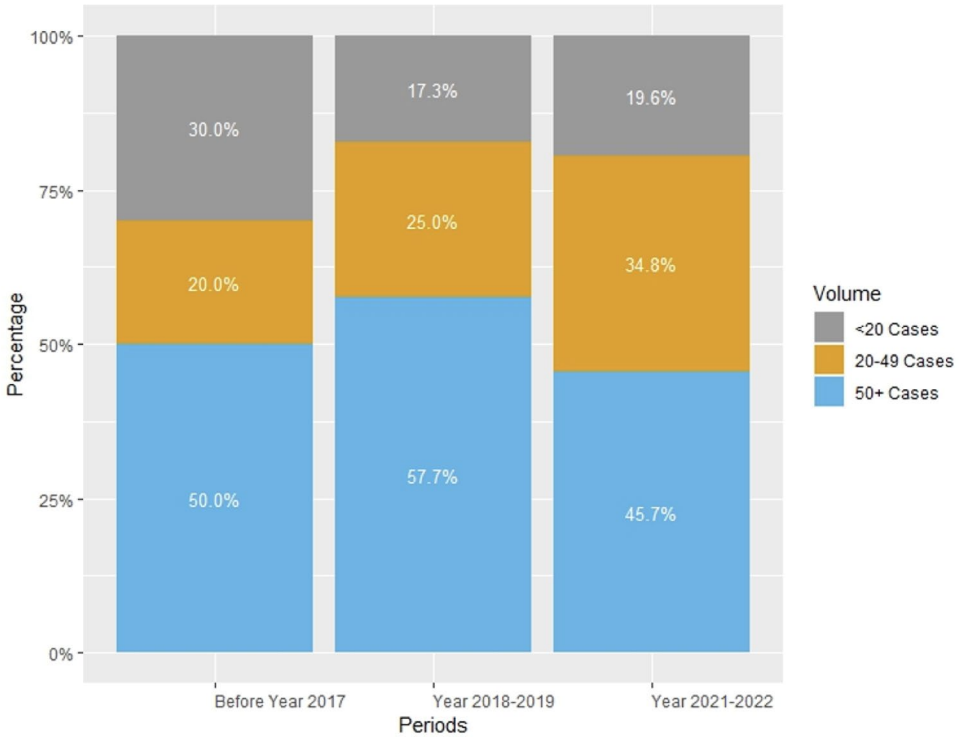

Fig. 4 Laparoscopic colorectal case volumes during fellowship

increase in robotic general surgery cases observed during general surgery residency training [6]. This may reflect growing interest in the robotic approach to colorectal surgery, increased adoption by colorectal surgery faculty mentors, and favorable evidence-based patient outcomes with the robotic approach, especially lower conversion-to-open rates [7, 8]. In addition, the introduction of the da Vinci Xi surgical system with multi-quadrant access likely increased adoption of the robotic approach by general

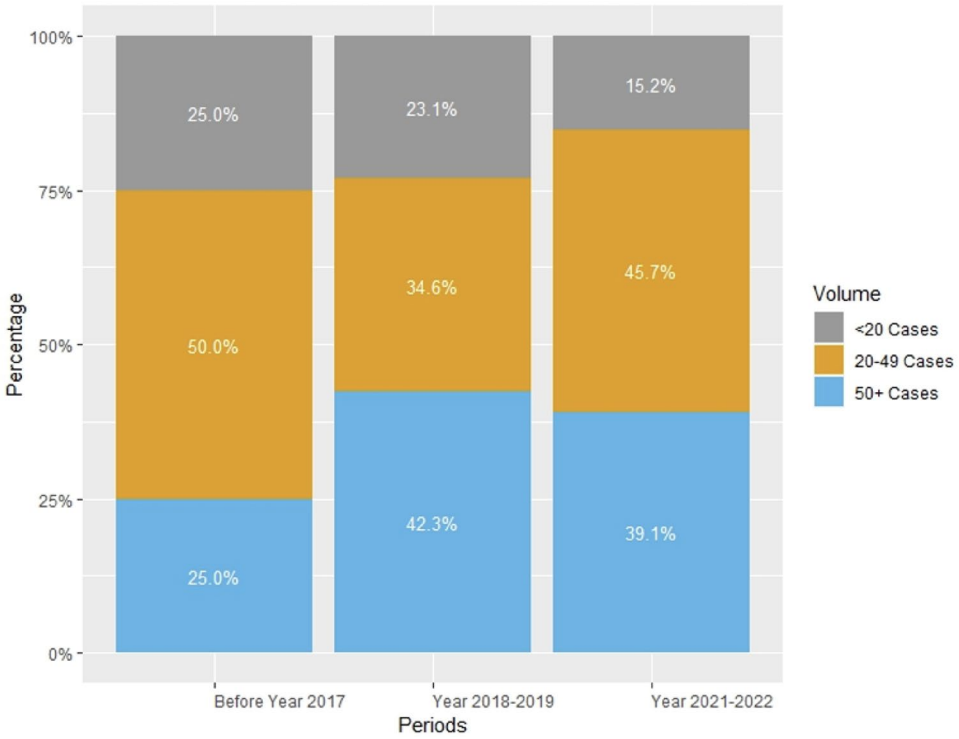

Fig. 5 Robotic colorectal case volumes during fellowship

Table 4 Univariate and multivariate logistic regression model for high robotic volume (50 cases +) during fellowship

	Univariable				Multivariable		
	High robotic volume	OR[a]	95% CI[a]	*p* value	OR[a]	95% CI[a]	*p* value
Periods							
Before year 2017	5/20 (25%)	–	–		–	–	
Year 2018–2019	22/52 (42%)	2.20	0.73, 7.59	0.2	2.02	0.62, 7.42	0.26
Year 2021–2022	18/46 (39%)	1.93	0.62, 6.76	0.3	1.08	0.28, 4.39	0.91
Robotic volume during residency							
0	13/45 (29%)	–	–		–	–	
1–24	26/64 (41%)	1.68	0.75, 3.88	0.2	1.50	0.58, 3.93	0.40
25 +	6/9 (67%)	4.92	1.13, 26.2	**0.041**	4.38	0.88, 26.1	0.080
Robotic training equivalency certificate							
During general surgery residency	18/34 (53%)	–	–		–	–	
During fellowship	25/77 (32%)	0.43	0.19, 0.97	**0.043**	0.47	0.18, 1.18	0.11
Did not receive equivalency certificate	2/7 (29%)	0.36	0.05, 1.90	0.3	0.39	0.05, 2.38	0.33

Bold values are statistically significant values with p<0.05

[a]*OR* odds ratio, *CI* confidence interval

and colorectal surgeons who train residents[1] and fellows, increased the growth in number and quality of publications showing favorable clinical outcomes, and pushed faculty early adopters further along their learning curve [4, 9].

The development of standardized robotic training curriculum has increased in recent years and taken on various approaches [10–14]. A robotic curriculum for novice residents in training was implemented in a German university hospital in 2020 with outcome measures that included surgical competency, nontechnical skills, progression, organizational, and patient aspects. The authors found that this

[1] Though technically ACGME-accredited colorectal surgery positions are "residents", they are commonly referred to as "fellows". To avoid confusion with general surgery residents, we have referred to colorectal surgery residents as "fellows" in this manuscript.

Table 5 correlation of robotic volumes during fellowship and 1-year post-fellowship

	Robotic volume 1-year post-fellowship		
	< 10, $N=24$[a]	10–24, $N=33$[a]	25 + , $N=40$[a]
Robotic volume during fellowship			
< 20	12 (57.1%)	5 (23.8%)	4 (19.0%)
20–49	6 (15.4%)	17 (43.6%)	16 (41.0%)
50 +	6 (16.2%)	11 (29.7%)	20 (54.1%)

[a]n (%)

curriculum met the needs of young surgeons in training [10]. Another university hospital reported on the development of a formal institutional thoracic surgery curriculum characterized by simulation, video review, and coaching. These authors suggested that their curriculum has expedited surgical training at their institution leading to more advanced robotic thoracic surgery skill sets prior to fellowship graduation [11]. In contrast to these valuable intuitional training programs, our APDCRS-sponsored colorectal surgery robotic training program was designed to offer national standardized training relevant for all colorectal surgery fellowship programs that are currently 73 in number.

We observed a shift toward higher proportion of robotic equivalency certificates awarded to trainees during general surgery residency in more recent years. Those fellows with higher general surgery robotic experience tended to perform more robotic cases during their fellowship year [14]. This may represent a bidirectional self-selection of interested residents and high-volume programs as a mutual fit of individuals with an interest and aptitude for robotic surgery. It also indicates that less basic and more advanced robotic training during fellowship is needed for many fellows who can build on their general surgery residency training experience.

Those fellows who reported high robotic experience in fellowship also reported high robotic volume in practice after graduation. This may reflect self-selection of those who have an interest in robotic colorectal surgery. It further demonstrates the national trend of increasing institutional access to the robotic platform that enables higher volumes by robotic surgeons and increased adoption by surgeons interested in the robotic approach. Numerous studies have shown that higher volumes in a surgical approach result in more favorable clinical outcomes [15, 16].

This APDCRS curriculum has demonstrated the ability to enhance exposure to robotic colorectal training in fellowship while preparing fellows for the transition into independent practice. However, there remain opportunities to continue guiding future improvements and course modifications based on fellow feedback. The respondents identified the desire for exposure to several other skills and techniques during fellowship year. This feedback has been incorporated into the next iteration of the curriculum to include the robotic approach to ventral mesh rectopexy and lateral pelvic lymph node dissection, beginning in 2024. Furthermore, recent changes in accreditation policies, such as the separate logging of laparoscopic and robotic cases by both the Fellowship Council accrediting body for non-ACGME surgical specialties and the ACGME-accredited colorectal specialty, signify the evolving recognition of the role of robotics in resident and fellow education. These changes aim to provide trainees with more comprehensive surgical skillsets and experience as they transition into independent practice.

Trainees have requested more robotic experience during training years and there are several factors that make adoption of robotics during residency and fellowship years an attractive option rather than waiting until practice as an attending surgeon [17]. The process of training as an attending surgeon requires significant time and resource investment that includes traveling to a robotic training course, pursuing independent simulation training, and completing hands-on skills development. Executing this process efficiently can be challenging, particularly for a young surgeon transitioning into independent practice. In addition, when adopting robotics as an attending surgeon, much of the learning curve is experienced independently rather than under the supervision of an expert. A previous survey study showed that CRS residents largely valued mentorship and learning from expert faculty more so than rapid development of autonomy [17]. These are significant influencers of the robotic learning curve that highlight the importance and value of a society-sponsored standardized robotics fellowship curriculum.

Our study is limited by small sample size and by recall bias of respondents. Due to travel restrictions and constraints created by COVID-19, the 2020 fellowship course was unable to be implemented in its entirety. We elected to omit the 2020 cohort from our primary analysis because of the impact of COVID on trainee experience. An additional potential study limitation is the variation in robotic curriculum and variation in opportunities experienced by colorectal fellows during their general surgery residency with some general surgery residents starting colorectal fellowship with no robotic experience [1]. With the expansion of 4th generation robotic systems, the accessibility to robotic surgery increased throughout the study period and this may have contributed to increased numbers of cases for those in the later study years, Colorectal fellows graduate and move on to varied university and non-university practice settings and this may also impact the number of cases performed beyond course training.

Operative skills and surgical decision training extend beyond preparation for and participation in an in-person laboratory. Our current curriculum depends on the fellow gaining post-course systematic progressive experience

at their training institution and continued development after completing fellowship training. Continued evaluation and supplemental additions to the training paradigm will be imperative for further effective skill set development following fellowship training. In-person and remote monitored simulation, post-case video review, mentorship, and surgical coaching are examples of post-course training options implemented by thoracic surgery that warrant evaluation by colorectal surgery and other disciplines [11]. Surgical educational applications that include virtual case and topic presentations and expertly performed case videos are valuable additions to robotic education. We currently use SurgeOn®, an application that includes a colorectal surgery community equipped with video review and case presentations, to provide mandatory virtual APDCRS-sponsored course preparation prior to attending the procedure-specific in-person lab course component. Data capturing methods built into the robotic system may soon add to skill assessment and require formal evaluation for educational value. Should artificial intelligence gain clinical application in robotic surgery, the future role in resident and fellowship training will likely warrant assessment [13, 14].

Conclusion

This study shows that the structured and standardized APDCRS-sponsored robotic colorectal surgery curriculum has successfully matched the needs of fellowship trainees and prepared them for post-graduate careers. Future studies should investigate the impact of curriculum changes related to the incorporation of advanced robotic procedures and the impact of general surgery residency robotic experience on preparation for colorectal surgery fellowship training.

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Author contribution ALB, HB, IFS, YL, MS, RKC made substantial contributions to the conception or design of the work. HB, IFS, YL contributed to acquisition of data. ALB, HB, IFS, YL, MS, RKC contributed to analysis and interpretation of data. ALB, HB, RKC drafted the work. ALB, HB, IFS, YL, MS, RKC revised it critically for important intellectual content. ALB, HB, IFS, YL, MS, RKC approved the version to be published. ALB, HB, IFS, YL, MS, RKC agree to be accountable for all aspects of the work ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Data availability No datasets were generated or analyzed during the current study.

Declarations

Conflict of interest Amir L Bastawrous MD has received honoraria from Intuitive Surgical, Inc for educational speaking. Hannah Bossie MS is a full time employee of Intuitive Surgical, Inc. I-Fan Shih PhD is a full time employee of Intuitive Surgical, Inc. Yanli Li PhD is a full time employee of Intuitive Surgical, Inc. Mark Soliman MD has received honoraria from Intuitive Surgical, Inc for educational speaking and is Founder/CEO of Surgery Unified, Inc. Robert K Cleary has received honoraria from Intuitive Surgical, Inc for educational speaking.

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