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Gregory M Gressel

Karen George

Mark B Woodland

Erika Banks

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Original Article

Residents' Confidence in Performing Robotic Hysterectomy in Obstetrics and Gynecologic Training Programs

Gregory M. Gressel, MD, MSc, Karen George, MD, Mark B. Woodland, MS, MD, and Erika Banks, MD

From the Department of Obstetrics & Gynecology and Women's Health, Montefiore Medical Center, Bronx, New York (Drs. Gressel and Banks), Department of Obstetrics & Gynecology, George Washington University School of Medicine and Health Sciences, Washington, District of Columbia (Dr. George), and Department of Obstetrics & Gynecology, Reading Hospital/Tower Health, Drexel University College of Medicine, Reading, Pennsylvania (Dr. Woodland)

ABSTRACT **Study Objective:** To compare residents' perceptions of readiness to perform robotic-assisted laparoscopic hysterectomy with the perceptions of residency program directors in obstetrics and gynecology programs throughout the United States.
Design: A survey was administered to all residents taking the 2019 Council on Resident Education in Obstetrics and Gynecology Exam and concurrently to program directors in all Accreditation Council for Graduate Medical Education−accredited training programs.
Setting: The survey was designed to assess resident confidence to perform robotic hysterectomies by the time of graduation.
Patients: No patients were included in the study.
Interventions: The only intervention was administration of the survey.
Measurements and Main Results: De-identified survey data were analyzed using chi-squared and Fisher's exact tests. A total of 5473 resident respondents and 241 residency program directors were included in the study. Fifty-two percent of graduating residents reported that they felt they were given surgical autonomy to perform robotic hysterectomies, and 53.7% reported that they could perform one independently (if it was an "emergency" and they had to). By the time of graduation, only 59% of residents reported confidence performing a robotic hysterectomy, and only 56% reported they felt that it would be an important procedure for their future career. Program directors were significantly more likely to report that their residents were given autonomy to perform robotic hysterectomy by graduation (61.0% [95% confidence interval (CI), 54.3−67.3]), could perform a robotic hysterectomy independently (60.9% [95% CI, 53.9−67.6]), or could perform a robotic hysterectomy by graduation (70.2% [95% CI, 63.5−76.3]) than residents themselves (38.6% [95% CI, 37.2−40.0], 22.8% [95% CI, 21.6−24.0], 62.6% [95% CI, 61.2−64.0], respectively).
Conclusion: At the time of graduation, residents' confidence in performing robotic hysterectomy independently is lower than their confidence in performing all other approaches to hysterectomy. Journal of Minimally Invasive Gynecology (2021) 00, 1−7.

Keywords: Robotic surgery; Surgical education; Surgical confidence; Resident education

After its approval for gynecologic surgery in 2005, the role of robotic-assisted laparoscopy in our field rapidly expanded and can be commonly employed for hysterectomy, sacrocolpopexy, myomectomy, adnexal surgery, and staging of malignancy [1−3]. As the use of robotic surgery increases, so does the need for training and expertise among surgeons and trainees. The accelerated uptake of robotic hysterectomy has challenged residency programs to provide robotic training as part of surgical education [4]. The 2018−2019 Accreditation Council for Graduate Medical Education National Resident Report indicates that graduating residents perform a median of 32 (interquartile range 17−51) "Total Robotic Procedures," which accounts for almost a third of the median 108 (interquartile range 97−121) "Total Hysterectomies" performed during training [5]. Multiple reports have described how the introduction of robotic surgery has negatively impacted resident laparoscopic case volume and significantly decreased resident surgical participation [6,7]. The primary goal of this study was to assess residents' perceived confidence and readiness for

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Corresponding author: Erika Banks, MD, Department of Obstetrics, Gynecology and Women's Health, Montefiore Medical Center, Albert Einstein College of Medicine, 1695 Eastchester Rd, Bronx, NY 10461.
E-mail: ebanks@montefiore.org

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independent performance of robotic-assisted laparoscopic hysterectomy by the time of graduation. The secondary goal was to assess residency program directors' confidence that their graduating resident cohort are ready to perform robotic hysterectomies independently.

Materials and Methods

After submission to the American College of Obstetricians and Gynecologists (ACOG) Institutional Review Board, this study qualified for exemption from review as it involved the use of de-identified survey procedures. A survey was developed by the Council on Resident Education in Obstetrics and Gynecology (CREOG) Executive Council using the Delphi method [8] and was designed to assess residents' perceived readiness to perform certain obstetric and gynecologic procedures by the time of graduation (Supplemental Table 1). This survey was electronically administered to all residents taking the 2019 CREOG exam. All residents who provided consent to use their data for research purposes were included; otherwise, they were excluded from the study. Specifically, the survey asked about 1) surgical autonomy (defined as ability to operate independently with attending oversight), 2) confidence in independence (defined as ability to perform surgical procedures independently in the event of an emergency), 3) surgical preparedness by the time of residency graduation, and 4) importance for surgical procedures in one's future career after graduation. Questions were based on a 5-point Likert scale ranging from "strongly disagree" to "strongly agree." If a resident answered "neutral," "disagree," or "strongly disagree," they were considered "not prepared" to perform a particular surgical procedure. Participants were allowed to mark "prefer not to answer" or leave individual questions blank if they wished. Questions that were left blank were excluded from the analysis. Program directors were concurrently issued a similar survey by email during the same week as the CREOG exam. This survey asked program directors to evaluate their residents' abilities to perform certain obstetric and gynecologic surgeries by the time of graduation (Supplemental Table 2).

All statistical analysis was performed using Stata (Stata v.14.2; StataCorp LP., College Station, TX). Chi-squared and Fisher's exact tests were performed to assess bivariate associations between a respondent's level of postgraduate training and his or her perception of being able to complete surgical procedures by the time of graduation. Residency program directors' assessments of their residents' surgical preparedness were also compared with residents' perceptions. Data were reported as the percentage of respondents to each question along with 95% confidence intervals (CIs) and p values for chi-squared test for trend over time.

The results of the larger survey asking participants to evaluate readiness to perform obstetric procedures and minor gynecologic procedures were reported in 2020, and this study represents a subanalysis of the data regarding self-reported readiness of residents to perform robotic hysterectomy [9].

Results

The survey was administered to all 5514 United States obstetrics and gynecology residents who took the 2019 CREOG examination, and 5473 of them completed the survey, resulting in an overall response rate of 99.3%. The 336 respondents who did not provide informed consent to use their data were excluded from the study. There were also 34 (0.6%) respondents who were not resident physicians and 19 (0.4%) who did not identify their training year, and these respondents were also excluded from participation. The reported data are based on responses from 5084 resident respondents and 241 (83%) of the 292 residency program directors surveyed. Demographics of the study cohort have been reported previously [9].

Residents were asked to identify whether they were provided with surgical autonomy (allowed to operate independently with attending oversight) to perform robotic hysterectomy. They were also asked whether they felt that they would be able to perform a robotic hysterectomy by the time of graduation or independently (if it were an emergent setting and they had to). Finally, they were asked how important they thought robotic surgery would be in their future careers. These results are presented in Table 1. Residents' self-reported autonomy increased with increasing postgraduate year (PGY) (p value for trend <.01). However, only 46% of all residents in PGY4 reported being given autonomy to perform robotic hysterectomies (relative to those in PGY1, odds ratio [OR] 4.07; [95% CI, 3.39−4.89]; p <.01), and the percentage of residents feeling that they would be able to perform them independently was only slightly higher among those in PGY4 (53.7%) (relative to those in PGY1, OR 55.86; [95% CI, 36.66−85.13]; p <.01).

Fewer residents in PGY4 felt that they would be prepared to perform a robotic hysterectomy by graduation (59.0%), a significantly lower percentage than that among interns (72.3%) (OR 0.55; [95% CI, 0.46−0.66]; p <.01). A similar significant trend was seen for the importance of robotic hysterectomy in residents' future careers, with those in PGY4s being half as likely as interns to ascribe importance to this procedure (OR 0.52; [95% CI, 0.44−0.62]; p <.01). Only 56.4% of graduating residents felt that robotic hysterectomy would be important for their future career.

Respondents' results were stratified and analyzed according to their reported future career choices (Table 2). Sixty-four percent of future academic generalists felt that robotic hysterectomy would be important for their future careers, compared with 96% of future gynecologic oncologists (OR 13.51; [95% CI, 7.54−24.19]; p <.01), 87% of future female

Table 1

Residents' reported confidence performing robotic hysterectomy stratified by year of training

Survey question	Training year	Reported confidence*	OR (95% CI)†	p value for trend
Autonomy given	PGY1	248 (21.2 [18.9−23.6])	REF	<.01
	PGY2	422 (35.8 [33.0−38.6])	2.07 (1.73−2.49)	
	PGY3	533 (46.3 [43.4−49.2])	3.21 (2.67−3.85)	
	PGY4	578 (52.2 [49.2−55.2])	4.07 (3.39−4.89)	
Confidence in independence ("if it were an emergency")	PGY1	24 (2.0 [1.3−3.0])	REF	<.01
	PGY2	89 (7.6 [6.1−9.2])	3.94 (2.49−6.24)	
	PGY3	345 (30.0 [27.4−32.7])	20.67 (13.53−31.55)	
	PGY4	591 (53.7 [50.7−56.7])	55.86 (36.66−85.13)	
Graduation preparedness	PGY1	863 (72.3 [69.7−74.9])	REF	<.01
	PGY2	690 (58.7 [55.8−61.6])	0.54 (0.46−0.65)	
	PGY3	689 (60.0 [57.1−62.9])	0.57 (0.48−0.68)	
	PGY4	648 (59.0 [56.0−61.9])	0.55 (0.46−0.66)	
Importance for future career	PGY1	844 (71.3 [68.6−73.8])	REF	<.01
	PGY2	728 (62.8 [60.0−65.6])	0.68 (0.57−0.81)	
	PGY3	710 (62.6 [59.7−65.4])	0.67 (0.57−0.80)	
	PGY4	614 (56.4 [53.4−59.4])	0.52 (0.44−0.62)	

CI = confidence interval; OR = odds ratio; PGY = postgraduate year; REF = reference.

* Values reported as N (% of respondents to an individual survey item [95% CI]).

† Odds ratios refer to the odds of a resident within each training year reporting surgical preparedness to perform robotic hysterectomy relative to PGY1 respondents.

pelvic medicine and reconstructive surgeons (OR 3.59; [95% CI, 2.27−5.65]; p <.01), and 89% of future minimally invasive surgery specialists (OR 4.46; [95% CI, 2.81−7.06]; p <.01). In contrast, only 35% of participants who planned to go into "other" subspecialties (defined as reproductive endocrinology and infertility, maternal fetal medicine, family planning, or pediatric and adolescent gynecology) ascribed importance to robotic hysterectomy for their future career

Table 2

Residents' self-reported assessment of surgical preparedness for robotic surgery stratified by future career choice

Survey question	Career choice*	Residents prepared N = 5084†	OR (95% CI)‡	p value
Autonomy	Academic generalist	1086 (41.3 [39.4−43.2])	REF	<.01
	Gynecologic oncologist	131 (42.1 [36.5−47.8])	1.03 (0.82−1.31)	
	FPMRS	80 (46.8 [39.1−54.6])	1.25 (0.92−1.70)	
	MIS	64 (32.5 [26.0−39.5])	0.68 (0.50−0.93)	
	Other	256 (31.4 [28.2−34.7])	0.65 (0.55−0.77)	
Independence	Academic generalist	655(24.9 [23.3−26.6])	RE	<.01
	Gynecologic oncologist	93 (29.7 [24.7−35.1])	1.27 (0.98−1.65)	
	FPMRS	48 (28.6 [21.9−36.0])	1.20 (0.85−1.70)	
	MIS	40 (20.3 [14.9−26.6])	0.77 (0.54−1.10)	
	Other	134 (16.5 [13.9−19.2])	0.59 (0.48−0.73)	
Graduation	Academic generalist	1720 (65.2 [63.3−67.0])	REF	<.01
	Gynecologic oncologist	234 (74.5 [69.3−79.2])	1.56 (1.20−2.04)	
	FPMRS	117 (69.2 [61.7−76.1])	1.20 (0.86−1.68)	
	MIS	115 (59.3 [52.0−66.3])	0.78 (0.57−1.05)	
	Other	416 (50.9 [47.4−54.3])	0.55 (0.47−0.65)	
Importance	Academic generalist	1695 (64.8 [62.9−66.6])	REF	<.01
	Gynecologic oncologist	298 (96.1 [93.3−98.0])	13.51 (7.54−24.19)	
	FPMRS	145 (86.8 [80.7−91.6])	3.59 (2.27−5.65)	
	MIS	172 (89.1 [83.8−93.1])	4.46 (2.81−7.06)	
	Other	279 (34.9 [31.6−38.3])	0.29 (0.25−0.34)	

CI = confidence interval; FPMRS = female pelvic medicine and reconstructive surgery; MIS = minimally invasive surgery; OR = odds ratio; Other = respondents who reported future plans to pursue reproductive endocrinology and infertility, maternal fetal medicine, family planning, or pediatric and adolescent gynecology; REF = reference.

* REF - Reference.

† Values reported as N (% of respondents to an individual survey item [95% CI]).

‡ Odds ratios refer to the odds of a respondent reporting surgical preparedness for robotic hysterectomy based on their future career choice relative to respondents reporting a future career as an academic generalist.

Table 3

PGY4 residents' self-reported assessment of surgical preparedness for each route of hysterectomy compared with robotic approach stratified by survey question

Survey question	Surgical procedure	PGY4 residents' prepared N = 1187*	OR (95% CI)†	p value
Autonomy	Robotic	578 (52.2 [49.3−55.2])	REF	REF
	Abdominal	906 (81.8 [79.4−84.1])	6.43 (4.39−9.41)	<.01
	Vaginal	830 (75.0 [72.3−77.5])	5.66 (4.13−7.76)	<.01
	Laparoscopic	920 (83.0 [80.7−85.2])	9.83 (6.33−15.29)	<.01
Independence	Robotic	591 (53.7 [50.7−56.7])	REF	REF
	Abdominal	997 (90.5 [88.6−92.1])	4.41 (2.75−7.07)	<.01
	Vaginal	758 (68.9 [66.0−71.6])	3.52 (2.69−4.62)	<.01
	Laparoscopic	953 (86.2 [84.1−88.2])	5.32 (3.52−8.02)	<.01
Graduation	Robotic	648 (59.0 [56.0−61.9])	REF	REF
	Abdominal	1046 (95.1 [93.6−96.3])	4.92 (2.61−9.30)	< .01
	Vaginal	875 (79.4 [76.9−81.8])	3.62 (2.66−4.93)	< .01
	Laparoscopic	1021 (92.5 [90.8−94.0])	8.20 (4.55−15.77)	< .01
Importance	Robotic	614 (56.4 [53.4−59.4])	REF	REF
	Abdominal	1010 (92.5 [90.8−94.0])	5.83 (3.32−10.23)	< .01
	Vaginal	837 (76.8 [74.2−79.3])	4.57 (3.36−6.22)	< .01
	Laparoscopic	940 (86.2 [84.0−88.2])	25.50 (13.24−49.11)	< .01

CI = confidence interval; OR = odds ratio; PGY = postgraduate year; REF = reference.

* Values reported as N [% of respondents to an individual survey item (95% CI)].

† Odds ratios refer to the odds of a PGY4 respondent reporting surgical preparedness to perform a hysterectomy via different routes relative to reporting surgical preparedness for robotic hysterectomy.

and were 71% less likely to report importance compared with future academic generalists (OR 0.29; [95% CI, 0.25−0.34]; p <.01). Respondents who reported "other" future careers were also significantly less likely to report surgical autonomy (OR 0.65; [95% CI, 0.55−0.77]; p <.01), independence (OR 0.59; [95% CI, 0.48−0.73]; p <.01), and graduation preparedness (OR 0.55; [95% CI, 0.47−0.65]; p <.01), compared with future academic generalists.

Resident responses regarding preparedness to perform robotic hysterectomy were compared with responses regarding other surgical approaches (Table 3). Whereas 95%, 79%, and 93% of residents felt they could perform abdominal, vaginal, and laparoscopic hysterectomies, respectively, by the time of graduation, only 59% felt they could perform a robotic hysterectomy (p <.01). Residents also reported significantly less autonomy (52%) and independence (53.7%) for robotic hysterectomy compared with abdominal (82% and 91%), vaginal (75% and 79%), and laparoscopic (83% and 86%) approaches (p <.01 for all comparisons). Residents ascribed less importance to robotic hysterectomy (56%) for their future careers than all other approaches (93%, 77%, and 86% for abdominal, vaginal, and laparoscopic, respectively [p <.01 for all comparisons]).

Residency program directors were asked similar questions designed to assess the readiness of their residents to perform robotic hysterectomy (Table 4). Program directors

Table 4

Residents' self-reported assessment of surgical preparedness compared with residency program director assessment of resident surgical preparedness to perform robotic hysterectomy

Survey question	Residents Prepared N = 5084*	Program directors Prepared N = 241*	OR (95% CI)†	p value
Autonomy given	1781 (38.6 [37.2−40.0])	139 (61.0 [54.3−67.3])	2.48 (1.89−3.26)	<.01
Confidence in independence	1049 (22.8 [21.6−24.0])	126 (60.9 [53.9−67.6])	5.28 (3.96−7.04)	<.01
Graduation	2890 (62.6 [61.2−64.0])	146 (70.2 [63.5−76.3])	1.40 (1.04−1.90)	<.01
Importance	2896 (63.4 [62.0−64.8])	100 (47.9 [40.9−54.8])	0.53 (0.40−0.70)	<.01

CI = confidence interval; OR = odds ratio.

* Values reported as N (% of respondents to an individual survey item [95% CI]).

† Odds ratios refer to the odds of a program director reporting surgical preparedness of their residents to perform robotic hysterectomy relative to resident respondents themselves.

Table 5

PGY4 residents' self-reported assessment of surgical preparedness compared with residency program director assessment of resident surgical preparedness to complete hysterectomies via all approaches

Surgical procedure	PGY4 residents Survey question	Program directors Prepared N = 1187*	Prepared N = 241*	OR (95% CI)†	p-value
Robotic hysterectomy	Autonomy	578 (52.2 [49.3−55.2])	139 (61.0 [54.3−67.3])	1.43 (1.07−1.91)	.02
	Independence	591 (53.7 [50.7−56.7])	126 (60.9 [53.9−67.6])	1.34 (0.99−1.82)	.06
	Graduation	648 (59.0 [56.0−61.9])	146 (70.2 [63.5−76.3])	1.64 (1.19−2.25)	<.01
	Importance	614 (56.4 [53.4−59.4])	100 (47.9 [40.9−54.8])	0.71 (0.53−0.95)	.02
Total abdominal hysterectomy	Autonomy	906 (81.8 [79.4−84.1])	203 (86.8 [81.7−90.8])	1.45 (0.97−2.18)	.07
	Independence	997 (90.5 [88.6−92.1])	200 (94.3 [90.3−97.0])	1.76 (0.95−3.25)	.07
	Graduation	1046 (95.1 [93.6−96.3])	205 (96.7 [93.3−98.7])	1.51 (0.68−3.37)	.31
	Importance	1010 (92.5 [90.8−94.0])	207 (98.1 [95.2−99.5])	4.20 (1.52−11.59)	<.01
Vaginal hysterectomy	Autonomy	830 (75.0 (72.3−77.5))	188 (80.7 [75.0−85.6])	1.40 (0.98−1.98)	.06
	Independence	758 (68.9 [66.0−71.6])	158 (74.5 [68.1−80.2])	1.32 (0.95−1.85)	.10
	Graduation	875 (79.4 [76.9−81.8])	191 (90.1 [85.3−93.8])	2.36 (1.47−3.79)	<.01
	Importance	837 (76.8 [74.2−79.3])	199 (93.9 [89.7−96.7])	4.63 (2.59−8.25)	<.01
Laparoscopic hysterectomy	Autonomy	920 (83.0 [80.7−85.2])	202 (86.7 [81.6−90.8])	1.33 (0.88−2.01)	.17
	Independence	953 (86.2 [84.1−88.2])	189 (89.2 [84.2−93.0])	1.31 (0.82−2.09)	.25
	Graduation	1021 (92.5 [90.8−94.0])	205 (96.7 [93.3−98.7])	2.38 (1.09−5.22)	.03
	Importance	940 (86.2 [84.0−88.2])	207 (98.1 [95.2−99.5])	8.31 (3.05−22.69)	<.01

CI = confidence interval; OR = odds ratio; PGY = postgraduate year.

* Values reported as N (% of respondents to an individual survey item [95% CI]).

† Odds ratios refer to the odds of a program director reporting surgical preparedness of their residents to perform hysterectomy relative to resident respondents themselves.

were significantly more likely than residents themselves to believe that their residents were given surgical autonomy (61.0% vs 38.6%; OR 2.48; [95% CI, 1.89−3.26]; p <.01), would be able to perform robotic hysterectomy independently (if they had to) (60.9% vs 22.8%; OR 5.28; [95% CI, 3.96−7.04]; p <.01), or would be able to perform robotic hysterectomy independently by the time of graduation (70.2% vs 62.6%; OR 1.40; [95% CI, 1.04−1.90]; p <.01). In contrast, program directors were less likely than their residents to report that robotic hysterectomies were important for their residents' future careers [47.9% vs 63.4%; OR 0.53; [95% CI, 0.40−0.70]; p <.01).

When this analysis was limited only to graduating residents, these differences became less significant (Table 5). Program directors (61.0%) were still significantly more likely to believe that their residents were given the autonomy to perform robotic surgery compared with residents in PGY4 (52.2%) (OR 1.43; [95% CI, 1.07−1.91]; p = .02). There was no significant difference in the assessment of residents in PGY4 (53.7%) and that of program directors (60.9%) on their residents' ability to perform a robotic hysterectomy independently (if they had to) (OR 1.34; [95% CI, 0.99 −1.82]; p = .06). However, program directors were significantly more likely than residents to report that their residents would be prepared by graduation (70.2% vs 59.0% respectively; OR 1.64; [95% CI, 1.19−2.25]; p <.01) and significantly less likely to report the importance of robotic hysterectomy for their residents' future careers (47.9% vs 56.4 respectively; OR 0.71; [95% CI, 0.53−0.95, p = .02).

Discussion

Residents are performing fewer hysterectomies than in the past, and more of them are now being performed robotically [4]. As educational and clinical leaders in our field decide which surgical skills are essential for the practice of obstetrician and gynecologist specialists, the evidence supporting a robotic approach in benign gynecology should be evaluated. The results of our study demonstrate that only 59% of graduating residents feel that they are "robot ready" and can competently complete a robotic hysterectomy by the time of graduation. Compared with recently published data from the same survey reported in this manuscript, robotic hysterectomy is the procedure that graduating residents felt least confident performing (reported confidence in performing cesarean delivery, 99.6%; vacuum delivery, 96.5%; total abdominal hysterectomy, 95.1%; vaginal hysterectomy, 79.4%; laparoscopic hysterectomy, 92.5%; operative hysteroscopy, 99.6%) [9]. Decreased confidence in performing robotic surgery may be associated with the degree of involvement that residents have in performing these procedures, which varies by resident seniority, attending surgeon, and institution. In some situations, a resident may only be allowed to assist at the bedside during robotic surgery. Furthermore, in contrast to laparoscopic surgery, where 2 assisting surgeons must work together simultaneously, during robotic surgery, it may be relatively easy for an attending surgeon to take over the console if difficulty is encountered. This information was not assessed in

this survey study but would be interesting to examine using real-time data collection in the operating room.

The lack of clarity regarding the importance of robotic surgical training during residency is supported by the fact that in our study, only approximately half of graduating residents (56.4%) and their program directors (47.9%) ascribed importance to robotic hysterectomy for their future careers. An analysis of the 2007−2012 National (Nationwide) Inpatient Sample database identified that robotic assistance was reported in 45% of all laparoscopic surgeries, including 39.5% of all benign laparoscopic cases and 72.3% of malignant hysterectomies, which is consistent with the resident perception of the importance of robotic surgery to their future careers [10]. Our data suggest that this is likely driven by planned future career choices: relative to future academic generalists, future gynecologic oncologists, female pelvic medicine and reconstructive surgeons, and minimally invasive surgeons ascribed significantly more importance to robotic hysterectomy. In contrast, residents who planned to go into maternal fetal medicine, reproductive endocrinology, family planning, or pediatric and adolescent gynecology ascribed 71% less importance to robotic hysterectomy in their future careers. Perhaps even more interestingly, residents who plan to pursue these other subspecialties reported less autonomy and surgical independence than future academic generalists, gynecologic oncologists, urogynecologists, and minimally invasive surgeons. This suggests that perhaps attending surgeons let residents who have chosen "non-robotic" future careers participate to a lesser extent in robotic surgeries than residents who might need robotic skills in the future.

These data corroborate the findings of other studies evaluating resident readiness to perform robotic surgery. In 2011, Gobern et al [11] performed an online survey of 83 residency program directors at Accreditation Council for Graduate Medical Education accredited institutions. Robotic surgical systems were present at 78% of the institutions surveyed, but robotic surgery training was present in only 58% of those institutions. Less than a third of program directors felt that they had a curriculum in place that they believed was "effective" or "very effective." [11] In a recent survey conducted by the American College of Obstetrics and Gynecologic Simulations Working Group, only 19 of 36 (53%) residents surveyed felt that they could perform robotic surgery independently by graduation, whereas 69 of 99 (70%) program directors felt that their graduating residents could perform robotic surgery independently [12]. This suggests that either the program directors have an inflated sense of their residents' abilities or of the autonomy that their residents are being provided in these cases, or residents are underestimating their true level of skill. Further, data suggest that only about half of residents felt that robotic surgery would be important for their future careers. In a similar survey study of 193 general surgery residents, 46% felt that the presence of a robot in a case interfered with their participation in the surgical procedure. Forty percent stated that they were not sure whether they would use robotics in their future practice, and 19% stated that they probably or definitely would not use robotics in practice [13]. The fact that program directors were less likely to ascribe importance to robotic surgery in future practice than residents themselves may also be indicative of a generational effect.

Hospital systems, surgical residency programs, and patients are now inquiring about surgical proficiency in robotics. Evaluating residents' competence to perform robotic surgery is limited by the overall lack of validated metrics to monitor proficiency in robotic surgical education. Gobern et al [11] reported that the most common method to assess residents' competency in robotic surgery was operating room performance (75%), which can be a subjective and variable way of determining competency. A potential way to address this issue would be to employ procedure-specific scoring algorithms, but such scoring systems have not been widely validated or implemented [14,15]. Simulation is another option, but it remains unclear which platforms are best and when and how frequently they should be used. The American Board of Obstetrics and Gynecology now requires Fundamentals of Laparoscopic Surgery certification to be eligible for Obstetrics and Gynecologic board certification [16]. Although this program is validated to assess laparoscopic surgical techniques, it does not assess robotic surgical skills and is not specific to gynecology. Despite increased robotic surgical practice on a national level, robotic simulation has received less emphasis than simulation for other obstetrics and gynecologic procedures [12]. ACOG recently published a committee opinion acknowledging that the quality of data supporting robotic-assisted surgery for noncancerous conditions is low to moderate compared with conventional laparoscopy [17]. Further research is needed to understand variation in training and early career performance of robotics surgery after training to better inform training needs in robotic surgery skills.

Our study may have implications for credentialing and privileging in robotic surgery. The credentialing of robotic surgeons is currently limited to the standards set by individual institutions. The recent ACOG Committee Opinion on Guiding Principles for Privileging of Innovative Procedures in Gynecologic Surgery states, "The number of cases needed will be variable depending on inherent skill level, previous relevant experience, simulation experience, frequency of cases, complexity of cases and availability of peer-supported training systems" [18]. Without clear national guidelines for privileging requirements, hospitals are left to decide for themselves whether surgeons are being trained and credentialed in robotic surgical skills. In 2012, Erickson et al [19] performed a review of credentialing requirements for robotic surgery in hospitals in Alabama. Of the 15 hospitals surveyed, only 9 (60%) had a separate pathway to credentialing new graduates with recent residency training in robotic surgery, and only 3 (20%) required new physicians to be proctored before granting privileges [19]. Credentialing often involves submission of an affidavit signed by a graduating

resident's program director asserting that the trainee is competent in robotic surgery. As our study reports, only 52% of program directors, and an even smaller percentage of their residents, feel that graduates are ready to perform robotic hysterectomies autonomously.

One of the strengths of our study is its large sample size. Our study population includes all United States obstetrics and gynecology residents within the purview of CREOG, and we achieved a high (>99%) response rate. Whereas our survey tool was not validated per se, it was developed using the Delphi method, which is a rigorous and validated approach to instrument development [8]. Our study carries the typical limitations of survey studies, including recall bias, survey fatigue, and nonresponse. Although the data were collected anonymously, respondents may not have felt comfortable providing answers that present themselves in an unfavorable manner. Because the study was administered on the same day as the CREOG examination, it is possible respondents may have felt fatigued or nervous and may have therefore responded inaccurately. Our study is limited in that it is able only to assess residents' and program directors' perception of their confidence in performing robotic hysterectomy and does not include any surgical performance evaluation. However, we believe that these data suggest that now is an important time to consider the evidenced-based role of robotic surgery in benign gynecology and to elucidate its importance for graduating residents in the practice of the specialist in general obstetrics and gynecology. This would help to clarify the need for a comprehensive and standardized national curriculum for robotic surgical education in obstetrics and gynecology training programs.

References

1. Committee opinion no. 628: robotic surgery in gynecology. *Obstet Gynecol*. 2015;125:760–767.
2. Advincula AP, Wang K. Evolving role and current state of robotics in minimally invasive gynecologic surgery. *J Minim Invasive Gynecol*. 2009;16:291–301.
3. Aarts JW, Nieboer TE, Johnson N, et al. Surgical approach to hysterectomy for benign gynaecological disease. *Cochrane Database Syst Rev*. 2015(8):CD003677.
4. Gressel GM, Potts JR 3rd, Cha S, Valea FA, Banks E. Hysterectomy route and numbers reported by graduating residents in obstetrics and gynecology training programs. *Obstet Gynecol*. 2020;135:268–273.
5. Accreditation Council for Graduate Medical Education. Data collection systems. Available at: https://acgme.org/Data-Collection-Systems/Case-Logs-Statistical-Reports 2019. Accesed February 1, 2020.
6. Brenot K, Goyert GL. Impact of robotic surgery on obstetric-gynecologic resident training. *J Reprod Med*. 2009;54:675–677.
7. Mehaffey JH, Michaels AD, Mullen MG, et al. Adoption of robotics in a general surgery residency program: at what cost? *J Surg Res*. 2017;213:269–273.
8. McMillan SS, King M, Tully MP. How to use the nominal group and Delphi techniques. *Int J Clin Pharm*. 2016;38:655–662.
9. Banks E, Gressel GM, George K, Woodland MB. Resident and program director confidence in resident surgical preparedness in obstetrics and gynecologic training programs. *Obstet Gynecol*. 2020;136:369–376.
10. Desai VB, Guo XM, Fan L, Wright JD, Xu X. Inpatient laparoscopic hysterectomy in the United States: trends and factors associated with approach selection. *J Minim Invasive Gynecol*. 2017;24.151−158.e1.
11. Gobern JM, Novak CM, Lockrow EG. Survey of robotic surgery training in obstetrics and gynecology residency. *J Minim Invasive Gynecol*. 2011;18:755–760.
12. DeStephano CC, Nitsche JF, Heckman MG, Banks E, Hur HC. ACOG Simulation Working Group: a needs assessment of simulation training in OB/GYN residencies and recommendations for future research. *J Surg Educ*. 2020;77:661–670.
13. Farivar BS, Flannagan M, Leitman IM. General surgery residents' perception of robot-assisted procedures during surgical training. *J Surg Educ*. 2015;72:235–242.
14. Frederick PJ, Szender JB, Hussein AA, et al. Surgical competency for robot-assisted hysterectomy: development and validation of a robotic hysterectomy assessment score (RHAS). *J Minim Invasive Gynecol*. 2017;24:55–61.
15. Ismail A, Wood M, Ind T, Gul N, Moss E. The development of a robotic gynaecological surgery training curriculum and results of a Delphi study. *BMC Med Educ*. 2020;20:66.
16. Fundamentals of Laparoscopic Surgery. ABOG announces new eligibility requirement for board certification. Available at: https://www.flsprogram.org/news/abog-announces-new-eligibility-requirement-board-certification/#:~:text=The%20American%20Board%20of%20Obstetrics,of%20obstetrics%20and%20gynecology%20(OB-%2018. Accessed February 1, 2020.
17. Robot-assisted surgery for noncancerous gynecologic conditions: ACOG COMMITTEE OPINION, Number 810. *Obstet Gynecol*. 2020;136:e22–e30.
18. Committee opinion no. 674: guiding principles for privileging of innovative procedures in gynecologic surgery. *Obstet Gynecol*. 2016;128:e85–e88.
19. Erickson BK, Gleason JL, Huh WK, Richter HE. Survey of robotic surgery credentialing requirements for physicians completing OB/GYN residency. *J Minim Invasive Gynecol*. 2012;19:589–592.

2019 CREOG Exam Survey Demographics

1. Current year of residency (optional)
a. PGY1
b. PGY2
c. PGY3
d. PGY4
e. Not listed (please specify) _____
2. Gender Identification (optional)
a. Male
b. Female
c. Transgender Female
d. Transgender Male
e. Gender Variant/Non-Conforming
f. Not listed (please specify) _____
g. Prefer not to answer
3. Are you Hispanic, Latino or of Spanish origin? (optional)
a. Yes
b. No
c. Prefer not to answer
4. How would you describe yourself? (optional):
a. American Indian or Alaska Native
b. Asian
c. Black or African American
d. Native Hawaiian or Other Pacific Islander
e. White
f. Two or more races
g. Not listed (please specify) _____
h. Prefer not to answer
5. In which CREOG Region is your residency program?
a. Region 1 (CT, MA, ME, NH, NY, RI, VT, Newfoundland, Nova Scotia, Quebec)
b. Region 2 (DE, IN, KY, MI, NJ, OH, PA, Ontario)
c. Region 3 (DC, FL, GA, MD, NC, SC, VA, WV, Puerto Rico)
d. Region 4 (AL, AR, IL, IA, KS, LA, MN, MS, MO, NE, OK, TN, TX, WI, Saskatchewan, Manitoba)
e. Region 5 (Armed Forces, AZ, CA, CO, HI, NV, NM, OR, UT, WA, Alberta, British Columbia)
6. Is your residency program primarily?
a. University-based
b. Community-based
c. Military
d. Both University and Community based
7. After graduation I anticipate practicing as a:
i. Specialist in General OB/GYN
ii. Reproductive Endocrinology and Infertility (REI)
iii. Maternal-Fetal Medicine (MFM)
iv. Gynecologic Oncology
v. Female Pelvic Medicine & Reconstructive Surgery (FPMRS)
vi. Family Planning
vii. Pediatric and Adolescent OB/GYN
viii. Other _____

2019 CREOG Exam Survey on Surgical Experience

In my program, I am given surgical autonomy (allowed to operate independently with attending oversight) to perform:	Strongly Agree	Agree	Neutral	Disagree	Strong Disagree
Operative Hysteroscopy					
Total Abdominal Hysterectomy (TAH)					
Vaginal Hysterectomy (VH)					
Laparoscopic Hysterectomy (Non-robotic Laparoscopic Assisted Vaginal Hysterectomy (LAVH) or Total Laparoscopic Hysterectomy (TLH))					
Robotic Hysterectomy					
Cesarean Section					
Forceps Operative Vaginal Delivery					
Vacuum Operative Vaginal Delivery					

In an emergency, I think I could perform these procedures independently:	Strongly Agree	Agree	Neutral	Disagree	Strong Disagree
Operative Hysteroscopy					
Total Abdominal Hysterectomy (TAH)					
Vaginal Hysterectomy (VH)					
Laparoscopic Hysterectomy (Non-robotic Laparoscopic Assisted Vaginal Hysterectomy (LAVH) or Total Laparoscopic Hysterectomy (TLH))					
Robotic Hysterectomy					
Cesarean Section					
Forceps Operative Vaginal Delivery					
Vacuum Operative Vaginal Delivery					

By graduation, I think I will be able to comfortably perform these procedures independently:	Strongly Agree	Agree	Neutral	Disagree	Strong Disagree
Operative Hysteroscopy					
Total Abdominal Hysterectomy (TAH)					
Vaginal Hysterectomy (VH)					
Laparoscopic Hysterectomy (Non-robotic Laparoscopic Assisted Vaginal Hysterectomy (LAVH) or Total Laparoscopic Hysterectomy (TLH))					
Robotic Hysterectomy					
Cesarean Section					
Forceps Operative Vaginal Delivery					
Vacuum Operative Vaginal Delivery					

I think the following procedures will be important for my clinical practice after graduation:	Strongly Agree	Agree	Neutral	Disagree	Strong Disagree
Operative Hysteroscopy					
Total Abdominal Hysterectomy (TAH)					
Vaginal Hysterectomy (VH)					
Laparoscopic Hysterectomy (Non-robotic Laparoscopic Assisted Vaginal Hysterectomy (LAVH) or Total Laparoscopic Hysterectomy (TLH))					
Robotic Hysterectomy					
Cesarean Section					
Forceps Operative Vaginal Delivery					
Vacuum Operative Vaginal Delivery					

2019 CREOG Exam Program Director Survey
Demographics

1. Years as PD (optional)
a. < 2
b. 2-5
c. 6-10
d. 11-15
e. >15
2. Gender Identification (optional)
a. Male
b. Female
c. Transgender Female
d. Transgender Male
e. Gender Variant/Non-Conforming
f. Not listed (please specify) _____
g. Prefer not to answer
3. Are you Hispanic, Latino or of Spanish origin? (optional)
a. Yes
b. No
c. Prefer not to answer
4. How would you describe yourself? (optional):
a. American Indian or Alaska Native
b. Asian
c. Black or African American
d. Native Hawaiian or Other Pacific Islander
e. White
f. Two or more races
g. Not listed (please specify) _____
h. Prefer not to answer
5. In which CREOG Region is your residency program?
a. Region 1 (CT, MA, ME, NH, NY, RI, VT, Newfoundland, Nova Scotia, Quebec)
b. Region 2 (DE, IN, KY, MI, NJ, OH, PA, Ontario)
c. Region 3 (DC, FL, GA, MD, NC, SC, VA, WV, Puerto Rico)
d. Region 4 (AL, AR, IL, IA, KS, LA, MN, MS, MO, NE, OK, TN, TX, WI, Saskatchewan, Manitoba)
e. Region 5 (Armed Forces, AZ, CA, CO, HI, NV, NM, OR, UT, WA, Alberta, British Columbia)
6. Is your residency program primarily?
a. University-based
b. Community-based
c. Military
d. Both University and Community based
7. In the past year (3 years?) after graduation what percentage of your residents go on to:
i. Specialist in General OB/GYN
ii. Reproductive Endocrinology and Infertility (REI) Fellowship
iii. Maternal-Fetal Medicine (MFM) Fellowship
iv. Gynecologic Oncology Fellowship
v. Female Pelvic Medicine & Reconstructive Surgery (FPMRS) Fellowship
vi. Family Planning Fellowship
vii. Pediatric and Adolescent OB/GYN Fellowship
viii. Minimally Invasive Gynecology Fellowship

2019 CREOG Exam Program Director Survey on Surgical Experience

In my program, my residents when ready are given surgical autonomy (truly allowed to operate independently with only attending oversight) to perform:	Strongly Agree	Agree	Neutral	Disagree	Strong Disagree
Operative Hysteroscopy					
Total Abdominal Hysterectomy (TAH)					
Vaginal Hysterectomy (VH)					
Laparoscopic Hysterectomy (Non-robotic Laparoscopic Assisted Vaginal Hysterectomy (LAVH) or Total Laparoscopic Hysterectomy (TLH))					
Robotic Hysterectomy					
Cesarean Section					
Forceps Operative Vaginal Delivery					
Vacuum Operative Vaginal Delivery					

By year, I think my residents **can** perform these procedures independently (with only attending oversight)	PGY1	PGY2	PGY3	PGY4	Need "hands on" supervision (or more)
Operative Hysteroscopy					
Total Abdominal Hysterectomy (TAH)					
Vaginal Hysterectomy (VH)					
Laparoscopic Hysterectomy (Non-robotic Laparoscopic Assisted Vaginal Hysterectomy (LAVH) or Total Laparoscopic Hysterectomy (TLH))					
Robotic Hysterectomy					
Cesarean Section					
Forceps Operative Vaginal Delivery					
Vacuum Operative Vaginal Delivery					

In an emergency, I think my residents could perform these procedures independently:	Strongly Agree	Agree	Neutral	Disagree	Strong Disagree
Operative Hysteroscopy					
Total Abdominal Hysterectomy (TAH)					
Vaginal Hysterectomy (VH)					
Laparoscopic Hysterectomy (Non-robotic Laparoscopic Assisted Vaginal Hysterectomy (LAVH) or Total Laparoscopic Hysterectomy (TLH))					
Robotic Hysterectomy					
Cesarean Section					
Forceps Operative Vaginal Delivery					
Vacuum Operative Vaginal Delivery					

By graduation, I think my residency graduates are truly able to comfortably perform these procedures independently:	Strongly Agree	Agree	Neutral	Disagree	Strong Disagree
Operative Hysteroscopy					
Total Abdominal Hysterectomy (TAH)					
Vaginal Hysterectomy (VH)					
Laparoscopic Hysterectomy (Non-robotic Laparoscopic Assisted Vaginal Hysterectomy (LAVH) or Total Laparoscopic Hysterectomy (TLH))					
Robotic Hysterectomy					
Cesarean Section					
Forceps Operative Vaginal Delivery					
Vacuum Operative Vaginal Delivery					

I think the following procedures will be important for the clinical practices of my residents that do not do fellowships after graduation:	Strongly Agree	Agree	Neutral	Disagree	Strong Disagree
Operative Hysteroscopy					
Total Abdominal Hysterectomy (TAH)					
Vaginal Hysterectomy (VH)					
Laparoscopic Hysterectomy (Non-robotic Laparoscopic Assisted Vaginal Hysterectomy (LAVH) or Total Laparoscopic Hysterectomy (TLH))					
Robotic Hysterectomy					
Cesarean Section					
Forceps Operative Vaginal Delivery					
Vacuum Operative Vaginal Delivery					

I have considered reducing my resident complement to meet the new minimum numbers of minimally invasive hysterectomies (70)

Strongly Agree	Agree	Neutral	Disagree	Strong Disagree