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Credentialing and Patient Safety in Robotic Gynecologic Surgery: Changes over the Last Eight Years

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ABSTRACT

Background and Objectives: Robotic gynecologic surgery has outpaced data showing risks and benefits related to cost, quality outcomes, and patient safety. We aimed to assess how credentialing standards and perceptions of safe use of robotic gynecologic surgery have changed over time.

Methods: An anonymous, online survey was distributed in 2013 and in 2021 to attending surgeons and trainees in accredited obstetrics and gynecology residency programs.

Results: There were 367 respondents; 265 in 2013 and 102 in 2021. There was a significant increase in robotic platform use from 2013 to 2021. Percentage of respondents who ever having performed a robotic case increased from 48% to 79% and those who performed > 50 cases increased from 25% to 59%. In 2021, a greater percentage of attending physicians reported having formalized protocol for obtaining robotic credentials (93% vs 70%, $p = 0.03$) and maintaining credentialing (90% vs 27%, $p < 0.01$). At both time points, most attendings reported requiring proctoring for 1 – 5 cases before independent use. Opinions on the number of cases needed for surgical independence changed from 2013 to 2021. There was an increase in respondents who believed > 20 cases were required (from 58% to 93% of trainees and 29% to 70% of attendings). In 2021, trainees were less likely to report their attendings lacked the skills to safely perform robotic surgery (25% to 6%, $p < 0.01$).

Discussion: Greater experience with robotic platforms and expansion of credentialing processes over time correlated with improved confidence in surgeon skills. Further work is needed to evaluate if current credentialing procedures are sufficient.

Key Words: Credentialing, Gynecologic surgery, Robotic surgery, Safety.

INTRODUCTION

Since robotic assisted surgery was approved for gynecologic procedures in 2005, its use has increased exponentially.[1–3] Studies have shown robotic surgery has clear benefits over open abdominal surgery, similar to other forms of minimally invasive surgery,[4] however without clear superiority over traditional laparoscopy and potentially at greater cost.[5–8] There is concern that the rapid adoption of robotic surgery has outpaced data showing risks and benefits related to cost, quality outcomes, and patient safety.

Mastery of robotics requires integration of a new set of skills not found in either open or conventional laparoscopic surgery, such as simultaneous management of multiple instruments, multiple energy sources, foot and hand controls, lack of haptics, and a complex patient cart. Prior studies have shown a prolonged learning curve is needed, ranging between 20 and 200 cases to achieve proficiency, and 20 to 50 cases to reduce operating time and improve cost efficiency.[9–16]

To address concerns of lack of standardized approaches to robotic training and credentialing, both the American College of Obstetricians and Gynecologists (ACOG) and the American Association of Gynecologic Laparoscopists (AAGL) have released statements recommending rigorous training and credentialing standards, minimum case numbers, proctoring, and peer case review.[5,17] Although some residency graduates have enough exposure and training

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to practice independently after graduation, residency robotic training curricula continue to vary widely,[18] calling into question the credentialing and safety of robotic practice among attending gynecologic surgeons.

The objective of this survey study was to assess how credentialing standards and perceptions of safe use of robotic surgery in gynecology have changed over time. Specifically, we sought to assess if management of and standards for robotic training and credentialing are perceived to correlate with safe incorporation of robotic surgery into practice.

METHODOLOGY

This was an anonymous, voluntary, internet-based cohort survey study conducted at two time points, 2013 and 2021. An open survey invitation was emailed to all Accreditation Council for Graduate Medical Education (ACGME) accredited obstetrics and gynecology residency program coordinators in the United States for electronic distribution to their associated attending physician and trainee (residents and fellows) listservs. At both time points, usability and technical functionality of the electronic questionnaire were tested prior to distribution. Informed consent was obtained and no personal data or identifying information was collected. Respondents entered their information directly into a SurveyMonkey (Momentive, San Mateo, CA) database for the 2013 survey and into a Qualtrics XM (Provo, UT) database for the 2021 survey. There were 22 questions for trainees and 29 questions for attending surgeons. The survey collected respondent demographic information (geographic location, surgical volume, type of cases performed), institutional credentialing protocols, and personal experience with and opinion on how robotics is being incorporated into the gynecologic surgery. All answers were included in analysis, regardless of completeness with no statistical correction such as weighting of items or propensity scores. Missing data was noted in tables, but not included in analysis or percentages.

We used χ^2 test and descriptive statistics to compare the distribution of responses between trainees and attendings and changes over time. A P-value of 0.05 was set to denote statistical significance. Data analysis was performed using SAS 9.4 software (SAS Institute INC, Cary, NC). The study protocol was approved by the University of North Carolina Institutional Review Board number 19–0045 for the 2021 survey and Henry Ford Health System Institutional Review Board number 7564 for the 2013 survey.

RESULTS

A total of 367 individuals including 157 attendings and 210 trainees responded to the surveys. Of these, 265 were from the 2013 cohort and 102 were from the 2021 cohort. The demographic information in 2021 (location, training year, years of practice) was different from the 2013 cohort, including a greater percentage of attendings located in the southeast U.S. (52% vs 18%) and a greater percentage of the trainees being fellows vs residents (29% vs 10%) (**Table 1**).

Case Volume

The length of time participants had at least one robotic platform at their institution significantly increased over time, with 30% of 2013 respondents reporting $>$ 5 years compared to 89% of 2021 respondents (**Table 2**). Of those that had a robotic platform at their institution, all had an Intuitive da Vinci surgical systems robotic platform. The total number of cases attending physicians performed increased over time ($P < 0.01$), with the percentage of attendings who have ever performed a robotic case increasing from 48% to 79% and the percentage of those who performed $>$ 50 cases increasing from 25% to 59%. The number of robotic cases per month per attending physician increased, with 27% performing $>$ 6 cases per month in the 2021 cohort compared to just 10% in the 2013 cohort ($P = 0.05$, **Figure 1**). There was not a significant difference between time points for robotic cases per month for trainees. Respondents reported using the robotic platform for hysterectomy, sacrocolpopexy, myomectomy, adnexal surgery, and gynecologic oncology surgery, with hysterectomy cited most commonly in all groups.

Credentialing and Training

The percentage of attendings who reported having formalized protocols for obtaining robotic credentials increased significantly from 2013 to 2021 (70% to 93%, $P = 0.03$). The number of cases attending participants reported bedside assisting prior to doing console work significantly increased ($P < 0.01$), with those reporting any cases increased from 45% to 79%. At both time points, most attendings reported requiring proctoring for 1 – 5 cases prior to independent use. The percentage of attendings who reported their department required a minimum number of robotic cases

Table 1.
Demographics of Survey Sample

	Residents/Fellows			Attendings		
	2013 Survey n = 137 (%)	2021 Survey n = 73 (%)	*P*-value	2013 Survey n = 128 (%)	2021 Survey n = 29 (%)	*P*-value
Practice Location						
Midwest	42 (31)	9 (12)	< 0.01	37 (29)	3 (10)	< 0.01
Northeast	43 (32)	36 (49)		52 (41)	9 (31)	
Southeast	24 (18)	24 (33)		23 (18)	15 (52)	
Southwest	13 (10)	3 (4)		14 (11)	2 (7)	
West	14 (10)	1 (1)		1 (1)	0	
Missing	1			1		
Training Year						
Fellow Year 1	5 (4)	4 (5)	< 0.01	–	–	
Fellow Year 2	7 (5)	10 (14)		–	–	
Fellow Year 3	1 (1)	7 (10)		–	–	
PGY1	22 (16)	7 (10)		–	–	
PGY2	28 (20)	16 (22)		–	–	
PGY3	39 (28)	14 (19)		–	–	
PGY4	35 (26)	15 (21)		–	–	
Years in Practice						
0 – 4 years	–	–		24 (19)	6 (21)	0.78
5 – 9 years	–	–		29 (23)	6 (21)	
10 – 14 years	–	–		19 (15)	6 (21)	
15+ years	–	–		56 (44)	10 (36)	
Missing	–	–			1	

Abbreviation: PGY, post graduate year.

for surgeons to maintain robotic credentials increased significantly from 27% to 90% ($P < 0.01$). Of those that knew of minimum numbers, most the attendings (76%) reported requiring 10 – 20 cases per year to maintain credentialing (only asked in the 2021 cohort). (**Table 3**).

Questions about resident/fellow training were only asked in the 2021 cohort. Fifty-four percent of trainees reported a curriculum in place to become trained in robotic hysterectomy. Sixty-eight percent of residents reported regular use of a teaching console.

Learning Curve

Attending physicians and trainees differed in their opinions of the number of cases needed to become an independent robotic surgeon at both time points, although both increased over time ($P < 0.01$). The percent that reported that number to be > 20 cases increased for trainees (58% to 93%) and for attendings (29% to 70%) (**Table 4**).

Perception of Safety

Over time, both trainees and attending physicians had more confidence in the robotic surgeons in their departments. More respondents reported that attending gynecologic robotic surgeons are always fully independent and competent (52% to 69% for trainees, 51% to 68% for attendings), but this change was not significant for either group (**Figures 2** and **3**). Similarly, the percentage of trainees and attendings who felt there were people doing robotic cases who lacked the skills to do so safely decreased for both groups, although only significantly for trainees (25% to 6% for trainees, $P < 0.01$, 30% to 21% for attendings, P = 0.32). The percentage of trainees who

Table 2.
Robotic Case Volume

	Residents/Fellows			Attendings		
	2013 Survey n = 137 (%)	2021 Survey n = 73 (%)	*P*-value	2013 Survey n = 128 (%)	2021 Survey n = 29 (%)	*P*-value
How long has your institution had the robotic platform?						
< 1 year	2 (2)	0	< 0.01	2 (2)	0	< 0.01
1 – 2 years	10 (8)	0		12 (10)	0	
3 – 5 years	42 (33)	6 (8)		63 (51)	0	
6 – 10 years	31 (24)	13 (18)		22 (18)	6 (21)	
> 10 years	2 (2)	15 (21)		4 (3)	13 (45)	
I don't know	41 (32)	39 (53)		20 (16)	10 (34)	
Missing	9	0		4		
How many robotics cases do you participate in per month?						
0 cases	21 (16)	14 (19)	0.42	72 (58)	12 (41)	0.05
1 – 5 cases	70 (55)	32 (44)		40 (32)	9 (31)	
6 – 10 cases	24 (19)	16 (22)		7 (6)	4 (14)	
11 – 20 cases	11 (9)	8 (11)		5 (4)	3 (10)	
21 – 50 cases	1 (1)	3 (4)		0	1 (3)	
> 50 cases	1 (1)	0		0	0	
Missing	9	0		4		
The total number of robotic GYN cases I have completed at the console as an attending is						
0 cases	–	–		64 (52)	6 (21)	< 0.01
1 – 5 cases	–	–		5 (4)	0	
6 – 10 cases	–	–		5 (4)	2 (7)	
11 – 20 cases	–	–		6 (5)	3 (10)	
21 – 50 cases	–	–		11 (9)	1 (3)	
> 50 cases		–		31 (25)	17 (59)	
Missing	–	–		6	0	

ever wished someone more expert was in the room during robotic cases decreased, with trends towards significance (67% to 48%, $P = 0.06$). For attending physicians, this percentage increased, but there was not a significant difference between time points (46% to 67% $P = 0.11$). Similarly, the percentage of trainees who felt cases were ever booked above their attendings' skill level decreased (69% to 56%, $P < 0.01$) while the percentage of attendings who reported this about themselves increased, although not significantly (31% to 50%, $P = 0.16$) (**Table 5**).

Institutional Application of Robotic Surgery

Trainees were significantly more likely to agree that the robot is being utilized in a way that consistently improves quality of patient care in 2021 compared to 2013 (90% vs 66%, $P < 0.01$). While there was also an increase in this metric for attending surgeons, this change was not significant (55% to 66%, $P = 0.46$). However, both groups had a significant increase in respondents who agreed that the robot was being chosen for appropriate cases on a consistent basis (67% to 100% of trainees, $P < 0.01$; 59% to 96% for attending surgeons, $P < 0.01$). The slight majority of trainees at both time points agreed that their institution wanted more gynecologists to become trained in robotics (59% and 58%), while the minority of attending respondents agreed with this statement, and this decreased overtime (46% to 21%, $P = 0.02$). Most trainee and attending respondents at both time points believed that the robotic platform makes minimally invasive surgery more accessible

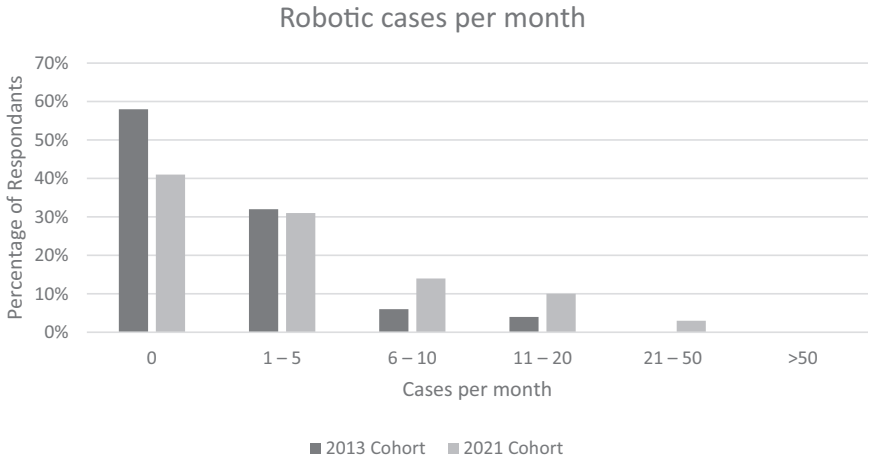

Figure 1. Change in robotic case volume for gynecologic surgeons from 2013 to 2021.

to those lacking straight stick laparoscopic skills; however, this decreased for trainees (69% to 53%, $P = 0.03$) and increased for attending physicians (59% to 79%, $P = 0.05$) (**Table 6**).

DISCUSSION

This study sought to explore and compare the learning curve, credentialing process, and the safe and efficient application of robotic gynecologic surgery across two time points, including both trainees and attending surgeons. In each survey we evaluated how credentialing programs related to confidence of independent case completion, and personal beliefs on how the use of robotics affects patient safety and outcomes. Given the two time points, we were able to report on how these factors may have changed over time, with better development and implementation of robotics training at individual institutions.

Case Volume, Credentialing, Training, and Learning Curve

As expected, in 2021 participants reported performing a greater number of robotic cases and having better access to robotic platforms at their institution for more years. This follows reports from with other national studies showing increasing numbers for robotic gynecologic procedures being performed.[1–3]

Aligned with the increased use of robotics across institutions, formal credentialing processes also increased from 70% to 93% from 2013 to 2021. A call for the standardization of robotic credentialing to demonstrate proficiency, ensure patients safety, and provide reproducible results has been recommended by professional organization position statements.[5,17,19]

Defining robotic proficiency is challenging; previous studies have found a set number of cases completed cannot sufficiently substitute individual appraisal of operative skill, given that the learning curve for each individual will vary.[17,20] Additionally, most obstetrics and gynecology residencies now include training on the robotic platform, although curricula vary greatly. In our study, we found most attending physicians reported a requirement of 1 – 5 proctored cases prior to credentialing, similar in 2013 and 2021. It remains unclear if this is referring to surgeons who already reached robotic proficiency and were new to an institution or those who were newly trained in robotic surgery. This number is similar to survey results obtained from the second World Robotic Gynecology Congress in 2010 in which surgeons reported on average being proctored in 3.29 cases prior to independent practice.[20] Similarly, one study of multiple hospitals found that a median of 5 cases performed in residency was sufficient for credentialing, with most hospitals not requiring any proctored cases if a case list and note from a program director were provided.[21,22] Given that published literature previously established a learning curve of at least 20 cases[9–16] and the findings in our study that most trainees and attendings in 2021 agreed that at least 20 cases are needed to be a safe and efficient independent robotic surgeon, then 5 cases may not be sufficient for someone who is new to robotic surgery. It should be questioned whether surgeons who have performed robotic cases independently only 1 – 5 times in a monitored environment have sufficient training and comfort to implement this complicated technology in clinical practice.

Table 3.
Information About Robotic Platform Credentialing and Training from Attending Physicians

	2013 Survey n = 128 (%)	2021 Survey n = 29 (%)	*P*-value
My institution has a formalized protocol for gaining credentials as a robotic surgeon			
True	87 (70)	27 (93)	0.03
False	10 (8)	0	
I don't know	28 (22)	2 (7)	
Missing	3	0	
The total number of robotic cases I bedside assisted prior to EVER doing console work was			
0 cases	65 (55)	6 (21)	< 0.01
1 – 5 cases	29 (25)	6 (21)	
6 – 10 cases	9 (8)	5 (17)	
11 – 20 cases	9 (8)	3 (10)	
> 20 cases	6 (5)	9 (31)	
Missing	10	0	
Before completing cases independently, my institution requires proctoring in			
1 – 5 cases	64 (52)	10 (34)	< 0.01
6 – 9 cases	9 (7)	1 (3)	
10 – 20 cases	6 (5)	3 (10)	
21 – 50 cases	1 (1)	0	
> 50 cases	0	0	
Does not require if documentation/experience provided	NA	5 (17)	
My institution doesn't require proctoring	0	1 (3)	
I don't know	42 (34)	9 (31)	
Missing	6	0	
I have to maintain certain amount of robotic cases per month/year to keep credentialed			
True	33 (27)	19 (90)	< 0.01
False	24 (20)	2 (10)	
I don't know	64 (53)	8 (28)	
Missing	7	0	
What is the minimum number of cases that your institution requires yearly to maintain credentialed?			
1 – 5 cases	–	1 (3)	
6 – 9 cases	–	3 (10)	
10 – 20 cases	–	13 (45)	
21 – 50 cases	–	0	
> 50 cases	–	0	
My institution does not require a minimum number of cases	–	0	
Missing	–	12	

Table 4.
Opinions on Learning Curve of Using Robotic Platform

	Residents/Fellows			Attendings		
	2013 Survey n = 137 (%)	2021 Survey n = 73 (%)	*P*-value	2013 Survey n = 128 (%)	2021 Survey n = 29 (%)	*P*-value
How many cases do you think one generally needs to perform to become independent?						
1 – 5 cases	0	0	< 0.01	13 (12)	1 (4)	< 0.01
6 – 10 cases	7 (6)	0		22 (21)	2 (7)	
11 – 20 cases	36 (30)	4 (6)		41 (39)	5 (19)	
21 – 50 cases	54 (45)	36 (55)		23 (22)	13 (48)	
> 50 cases	15 (13)	25 (38)		7 (7)	6 (22)	
Missing	18	7		22	3	

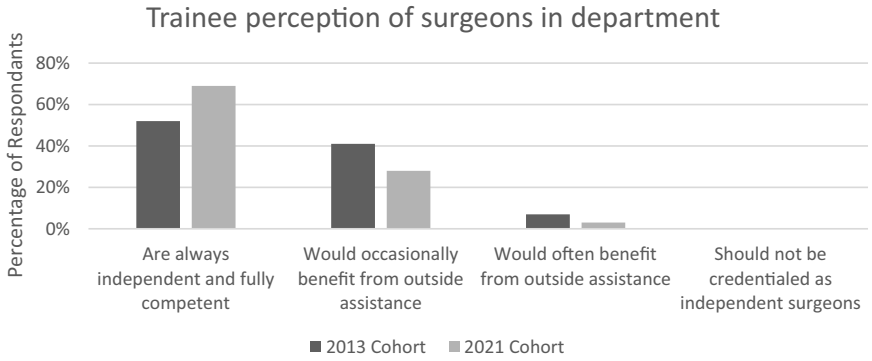

Figure 2. Trainee perception of attending surgeon independence and safety from 2013 to 2021.

This may be partially mitigated by the increase in percentage of surgeons who have bedside-assisted prior to sitting at the console; however, almost one-quarter of surgeons reported never having bedside-assisted prior to console work, and over half had assisted in ≤ 10 cases. This practice is contrary to the recommended AAGL privileging guidelines[17] and prior reports suggesting that bedside assisting in > 10 cases is instrumental in order to understand the platform's uses and limitations to operate it safely at a distance from the bedside.[23,24] The console surgeon, remote from the patient and the operating instruments, is required to diagnose and resolve technical problems encountered at distant areas of the operating room. Proficiency in this practice is only gained through repeated exposure to the potential issues, which is ideally first encountered at the bedside with an experienced robotic proctor who can guide through this trouble-shooting process.

In our study, there was a significant increase in the number of attendings who reported institutional requirements for a minimum case volume per month or year to remain credentialed (27% to 90%). Across most medical certifications, regardless of specialty, re-examination of skill and knowledge is required for continued medical practice. Case specific gynecologic surgical volume has recently come to the forefront of gynecologic surgery, with better postoperative surgical outcomes reported in high volume surgeons compared to low volume surgeons.[25,26] This further supports the practice of requiring minimum case volume in order to maintain credentialing in a procedure to best optimize patient safety and outcomes. It is encouraging there was an increase in institutional requirements for case minimums; however, concerning that there are still some academic institutions without these guidelines in place. From an institutional standpoint, one must consider that robotic time is often limited and in high demand. An

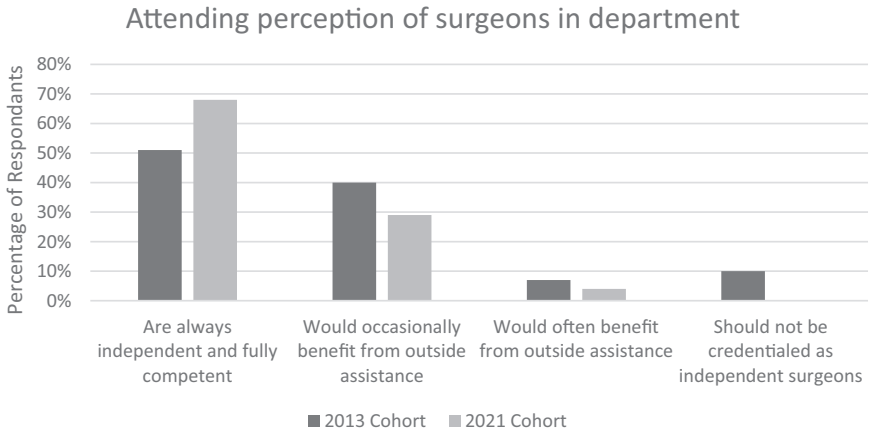

Figure 3. Attending surgeon perception of colleagues' independence and safety from 2013 to 2021.

unintended consequence of minimum case volumes may be to encourage surgeons to perform cases robotically that otherwise would have been performed laparoscopically, unnecessarily utilizing this limited resource and potentially adding unnecessary time or cost to their cases.

Standardized training for residents and fellows has also become a priority with the expansion of robotic surgery in clinical practice. While many programs have a curriculum, the current edition of the Council on Resident Education in Obstetrics and Gynecology Core Curriculum does not have specific criteria for training in robotic surgery.[5] Studies have shown diverse training curricula, including virtual reality simulators, didactics, and wet labs. However, there are not yet strong data on the most effective training for surgical trainees.[18] In the 2021 cohort, only 54% of trainees reported an institutional curriculum to become robotically trained. This is not significantly different than a 2011 survey of the ACGME obstetrics and gynecology residency programs, showed 58% of residency programs included a robotic curriculum in their residency training.[27] This is surprising given the increase in robotic hysterectomies over the last ten years and development of national programs such as the Robotic Training Network, and the Fundamentals of Robotic Surgery. Interestingly, while there was a significant increase in robotic case volume for attendings from 2013 to 2021, the case volumes for trainees were not significantly different at the two time points. This may be due to impact from the COVID-19 pandemic; while attendings considered their pre-pandemic numbers, trainees may not have been performing any robotic cases prior to 2020. Another residency consideration regarding the increased adoption of robotic surgery is the potential for robotics to impinge on training in other minimally invasive techniques. As more cases are performed robotically, fewer may be performed via traditional laparoscopy or vaginal surgery, raising concerns about sufficient experience and skill to confidently perform these other modalities of hysterectomy upon graduation.

Concerns around robotic credentialing and training extend across specialties. The American Urologic Association created guidelines on robotic privileging that include recommendations on residency numbers (20 cases) or alternative pathways post-residency including online courses, industry sponsored training, a skills checklist, and the approval of a proctor.[28] The Institute for Surgical Excellence recently convened a multidisciplinary group of experts to develop robotic credentialing guidelines after identifying technical proficiency and patient safety concerns due to the heterogeneity in credentialing between hospitals and specialties. They concluded credentialling should focus on performance evaluation rather than just case numbers. This would include knowledge evaluations, simulation, bedside assisting, proctoring, and a video case review as well as multifaceted requirements for privileging maintenance.[29]

Overall, the expansion of credentialing and training in robotic gynecology is encouraging; however, this may still be insufficient, as both trainees and attendings continue to report concerns regarding the safety of the robotic practices at their institutions.

Perception of Safety

Compared to the 2013 cohort, in 2021 more attendings and residents agreed that gynecology attendings in their departments are always fully independent and competent

Table 5.
Opinions on Safety of Robotic Platform in Gynecologic Surgery

	Residents/Fellows			Attendings		
	2013 Survey n = 137 (%)	2021 Survey n = 73 (%)	*P*-value	2013 Survey n = 128 (%)	2021 Survey n = 29 (%)	*P*-value
On average GYN attendings in my department						
Are always independent and fully competent	61 (52)	45 (69)	0.07	56 (51)	19 (68)	0.44
Would occasionally benefit from outside assistance	48 (41)	18 (28)		44 (40)	8 (29)	
Would often benefit from outside assistance	8 (7)	2 (3)		8 (7)	1 (4)	
Should not be credentialed as independent surgeons	0	0		1 (1)	0	
Missing	20	8		19	1	
I feel that there are attendings/people doing robotic cases independently who lack the skills to do so safely on a consistent basis						
True	30 (25)	4 (6)	< 0.01	34 (30)	6 (21)	0.32
False	90 (75)	61 (94)		79 (70)	23 (79)	
Missing	17	8		15	0	
I wish there were someone more expert in the room						
Never	38 (32)	34 (52)	0.06	46 (54)	8 (33)	0.11
Rarely	55 (47)	23 (35)		25 (29)	14 (58)	
Sometimes	19 (16)	7 (11)		8 (9)	1 (4)	
Frequently	5 (4)	1 (2)		3 (4)	1 (4)	
Always	0	0		3 (4)	0	
Missing	20	8		43	5	
I feel that cases are booked beyond my/the attending's skill level						
Never	36 (31)	29 (45)	< 0.01	67 (69)	12 (50)	0.16
Rarely	60 (51)	32 (49)		29 (30)	11 (46)	
Sometimes	20 (17)	1 (2)		1 (1)	1 (4)	
Frequently	1 (1)	1 (2)		0	0	
Always	0	2 (3)		0	0	
Missing	20	8		31	6	

when performing robotic surgery (52% to 69% for trainees, 51% to 68% for attendings), but this change was not significant for either group. This means about one-third of both groups felt the attending surgeons in their department were *not* fully independent. Additionally, in 2021 almost a quarter of attending physicians felt their colleagues were consistently performing unsafe surgeries, which was similar to the 2013 numbers. Greater than 50% of trainees and attendings reported that cases were booked above the attending's skill level, although this largely seen as a rare event. This is a significant safety concern, even if only happening occasionally.

It is possible that the robotic platform allows for a false sense of security, encouraging surgeons to book cases above their skill level. Given the varying degrees of experience, skill, and surgical volume among attendings in any given gynecology department, it is also possible there would be similar percentages reported if asking about other procedures, such as abdominal or laparoscopic hysterectomy. These data may be an indictment of our credentialing programs as a whole and is highlighted in robotics only due to the new paradigms required to teach and integrate new users in robotics. The complexity of the robotic platform and necessarily deliberate approach to teaching it leads to greater scrutiny of the process, which is necessary to ensure patient safety.

In general, attendings seem to become *less* confident over time in their own skills and those in their department,

Table 6.
Opinions on Institutional Use of Robotic Platform

	Residents/Fellows			Attendings		
	2013 Survey n = 137 (%)	2021 Survey n = 73 (%)	*P*-value	2013 Survey n = 128 (%)	2021 Survey n = 29 (%)	*P*-value
I believe that in my institution/department the robot is being utilized in a way that consistently improves quality of patient care/outcomes						
Strongly Agree	27 (23)	27 (42)	< 0.01	29 (25)	9 (33)	0.46
Somewhat Agree	51 (43)	31 (48)		35 (30)	9 (33)	
Neutral	25 (21)	6 (9)		14 (12)	4 (15)	
Somewhat Disagree	14 (12)	1 (2)		30 (25)	5 (19)	
Strongly Disagree	2 (2)	0		10 (8)	0	
Missing	18	8		10	3	
I believe that in my institution the robot is being chosen for appropriate cases on a consistent basis						
True	80 (67)	65 (100)	< 0.01	68 (59)	23 (96)	< 0.01
False	39 (33)	0		47 (41)	1 (4)	
Missing	18	8		13	5	
I believe that my institution wants more of our gynecologists to become robot trained						
True	70 (59)	38 (58)	0.82	56 (46)	6 (21)	0.02
False	48 (41)	28 (42)		65 (54)	22 (79)	
Missing	19	7		7	1	
I believe the robotic platform makes minimally invasive surgery more accessible to those lacking traditional (i.e., straight stick) laparoscopic skills						
True	83 (69)	35 (53)	0.03	68 (59)	22 (79)	0.05
False	37 (31)	31 (47)		48 (41)	6 (21)	
Missing	17	7		12	2	

although our smaller sample size of 2021 attendings did not show any of these changes to be significant. Trainees, on the other hand, became more confident in the skills and safety of those they trained under.

Institutional Application of Robotic Surgery

Both trainee and attending respondents generally felt more positively about how the robotic platform was being used at their institutions. There was an increase in those that agreed the robotic platform was being utilized in a way that improved patient care and that appropriate cases were selected. As the robotic platform becomes increasingly available, it is not surprising there is a wider acceptance of it. Attending surgeons reported a decrease in institutional desire for more gynecologists to be trained in robotics (46% to 21%). This may be because a larger proportion of surgeons were already trained in robotic surgery either in residency or early in their career. At both time points, most trainee and attending respondents believed that the robotic platform makes minimally invasive surgery more accessible to those lacking traditional laparoscopic skills. This highlights a potentially significant benefit of the robotic platform: allowing more surgeons to offer a minimally invasive alternative to open surgery.

Limitations

We acknowledge the limitations of our study. The survey study design limits generalizability to all practitioners of robotic surgery as participants are self-selecting and we are unable to comment on response rate given we do not know how many gynecologists received the survey. Additionally, this study was conducted only at academic institutions, which may have very different practice patterns and perceptions than community hospitals. The two

time points did not survey the same participants, used a different survey platform, and there were demographic differences between cohorts, such as training level and geography, making comparisons between them less reliable. Additionally, the robotic surgery platforms have been improved over time, so the technology utilized was likely not the same between groups. There are no validated survey tools in this area of study, so these survey questions were not validated. Our sample was a convenience sample, without equal representation of institutions across geographic area. The sample size was relatively small, which may have limited the ability to identify significant findings.

CONCLUSION

Use of robotic surgery in gynecology has increased overtime, which has been accompanied by an expansion of credentialing and privilege maintenance protocols. Perceptions of safety and competency have also improved over time, specifically by trainees who are more likely to witness the skills of multiple faculty in their department. However, questions remain on whether the current credentialing and privilege maintenance protocols are sufficient. The specific goals of the credentialing process must be clearly outlined at the institutional level to ensure patient safety. Standards for credentialing should be set by surgical and specialty societies such as ACOG and the AAGL in order to achieve uniformity of expectations and expertise amongst those practicing robotic gynecologic surgery. These should go beyond the previously recommended minimum of two proctored cases as there is evidence that current standards may not be sufficient to ensure patient safety and surgeon competency. Requiring at least 20 cases with clear demonstration of proficiency through standardized skill assessment prior to full independent privileges is better aligned with data on the robotic platform learning curve and surgeon perspectives.

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