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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Value of the SAGES Learning Center in introducing new technology

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Abstract
Background: The Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) Learning Center is a group of educational "classrooms" designed to tutor meeting attendees on specific technology-intensive content areas. The objectives of the Robotics Station were to familiarize participants with basic laparoscopic skills as implemented with surgical robotic assistance and to help them explore the benefits and drawbacks of using robotics in their institutions.
Methods: Sixty-six volunteer surgeon attendees of the 2003 SAGES meeting representing a diverse group of backgrounds and possessing varying levels of surgical experience were directed through a series of drills on two different surgical robots. Each participant was directed through a series of three drills that practiced surgically relevant skills. Participants were given feedback on their performance. They then completed a 12-question computer-based questionnaire that surveyed their personal demographic backgrounds, their impressions of robotic surgery, and their opinions regarding the learning center's utility in educating them about new technology.
Results: Sixty-eight percent of participants had never used a surgical robot, and 89% had never used a robot clinically. Eighty-eight percent of respondents found one or both robots easier to use than they had expected, and 91% found that one or both robots made simple surgical tasks easier compared to standard laparoscopy. Sixty-four percent of participants stated that they were more likely to pursue purchase of a robotic system for use in their practice as a result of their exposure to robotics in the Learning Center. After completing the Robotics Station, 80% of surgeons believed that current surgical robots are of clinical benefit. However, 71% of participants stated that surgical robotic systems priced above $500,000 would not be financially viable in their practices.
Conclusion: The structured learning environment used in the SAGES Learning Center fostered among participants a positive attitude toward surgical robotics. The format of their exposure to this technology at the Robotics Station also enabled participants to gauge the potential financial value of surgical robots in clinical practice. The SAGES Learning Center Robotics Station succeeded in exposing surgeons to surgical robotics in a way that helped them assess the value of this technology for their individual practices and institutions.

Key words: Continuing medical education — Robotics — Surgery — Technology — Learning center — SAGES

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Carl Sagan once said, "We live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science and technology." Western society's ongoing struggle to keep pace with the ever-changing face of technology is no truer than in the field of medicine. Within medicine, the procedure-based disciplines, of which surgery is the archetypal example, face unique challenges regarding technology because the "tools of the trade" are constantly changing. The physician's need for continuing medical education (CME) is not new, but the way in which CME must be delivered to be effective has changed radically [3], especially for surgeons. It is obvious that surgeons cannot learn to perform laparoscopic common bile duct exploration, interventional endoscopy, or intraoperative ultrasound, for example, simply by reading a journal article or attending a lecture [2]. Traditional didactic-based CME is simply not enough for the surgeon of the new millennium [5].

The Learning Center of the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) is a group of educational "classrooms" designed to tutor

meeting attendees on specific technology-intensive content areas. The SAGES Learning Center was born out of the minimally invasive surgical revolution: As laparoscopic and endoscopic approaches to therapy rapidly became ''standard of care'' for many different procedures, surgeons and surgeons-in-training suddenly found themselves in great need of procedure CME [4]. The first Learning Center took place during the 1991 annual meeting of SAGES in Monterey, California. Commensurate with SAGES's ongoing commitment to both endoscopy and laparoscopy [6], the focus of the first Learning Center curriculum was twofold. The endoscopy initiative consisted of six stations focusing on upper gastrointestinal endoscopy, colonoscopy, and anorectoal pathology. Laparoscopy learning focused two stations on diagnostic laparoscopy and a separate ''course'' on laparosopic suturing taught on an ad hoc basis to 450 surgeons at 60 stations over 3 h. (S. Matthews, Executive Director, SAGES, personal communication). Over the past 12 years, the Learning Center has kept pace with the rapid evolution of technology and now has stations introducing participants to virtual-reality simulators, personal digital assistants, ultrasound, and, in 2003, surgical robotics.

The objectives of the SAGES Learning Center Robotics Station were to familiarize participants with basic laparoscopic skills as implemented with surgical robotic assistance and to encourage them to explore the benefits and limitations of using robotics in their institutions. In this study, participants were surveyed for the purpose of determining whether or not these goals were met and to obtain participant opinion regarding the benefits, limitations, and overall value of surgical robotics.

Material and methods

Participants

Attendees of the 2003 SAGES meeting who went through the Learning Center Robotics Station (Fig. 1) and agreed to participate in this standardized hands-on educational curriculum and posteducation survey were eligible for this study. No attendee was excluded and thus it was assumed that the participant pool would be composed of a diverse group of surgeons and surgeons-in-training possessing varying levels of surgical experience. The Learning Center Robotics Station was developed, organized, and run by academic surgeons and residents. Involvement of surgical robotic company representatives was limited to the degree necessary to manage and maintain the robots. No company sales representatives were involved in the educational process, and participants interested in purchase of robotic systems were directed to the commercial exhibits.

Robotics station curriculum

Over a period of 30 min per person, participants were directed through a series of three drills—''paper cut,'' ''ring swap,'' and ''thread the needle''—on two different surgical robots: Intuitive Surgical's *daVinci Surgical System* and EndoVia's *Laprotek System*. The paper cut drill timed each participant grasping a piece of paper in one ''hand'' and then cutting along four standardized lines using robotic scissors in the other ''hand.'' In the ring swap drill, participants grasped and removed two small rubber rings (one in each ''hand'') from irregularly shaped rubber cones and then replaced the rings on opposite cones. This task

Fig. 1. Set-up for the SAGES Learning Center Robotics Station. All 66 surgeon attendees of the '2003 SAGES meeting who went through the Learning Center Robotics Station practiced surgical drills on each of two surgical robots: Intuitive Surgical's *daVinci Surgical System* and EndoVia's *Laprotek System*.

was repeated three consecutive times and a total time was reported to the participant. In the final task, thread the needle, participants were asked to thread a 22-mm half-circle taper-point needle (V-20) connected to a 3–0 braided absorbable suture through as many fish hook needle eyes as possible in 2 min. Embedded in these drills was an implicit need to practice the general laparoscopic surgical skills of bimanual object grasping and manipulation, instrument moving, and camera operation. Participants were given feedback on their performance in the form of both drill ''scores'' and subjective expert opinion from the instructors.

Posteducation survey

After completing the standardized Robotics Station educational curriculum, all participants were asked to complete a 12-question computer-based, multiple-choice and free text questionnaire (Table 1) that surveyed their personal demographic backgrounds, their initial reactions to robotic surgery, and their opinions about the current state of robotic technology. The survey also sought to assess the Learning Center Robotics Station's utility in educating them about new technology.

Data analysis/description of statistical methods

The computer-based questionnaire used in this study automatically entered respondent data into an Access database (Microsoft Corporation, Redmond, WA, USA). The data were queried and analyzed using Excel (Microsoft). Descriptive statistics and graphical representation of data were used to analyze the survey data. All charts were created in Excel. Chi-square analysis using McNemar's test was performed to compare ease of system use and ease of simple task performance between robots. Differences were considered significant when $p < 0.05$.

Results

Participant demographics

All 66 surgeon and surgeon-in-training attendees of the SAGES Learning Center Robotics Station agreed to participate in the standardized Robotics Station curriculum and complete the postinstruction survey (100% response rate). Descriptive demographic data about the

Table 1. SAGES Learning Center Robotics Station posteducation participant survey

Participant demographic data
What is your level of surgical experience?
How would you categorize the current scope of your surgical practice?
In which of the following surgical specialties are you board eligible/board certified or in training?
Prior to today, how would you categorize your level of experience with surgical robotic technology?
Do surgical residents/fellows participate in the care of your patients?
First impressions of robotic surgery
Did you find the systems easier to use, harder to use, or about what you expected?
Did you find that robotic technology made simple tasks (e.g., moving objects, suturing, etc.) easier,harder, or about the same compared to standard laparoscopy?
Opinions regarding the state of current surgical robotic technology
What do you think are the most significant benefits of current surgical robotics systems?
What do you think are the most significant limitations of surgical robotics currently preventing their widespread clinical use?
Value of the Learning Center Robotics Station
What do you think is currently the appropriate role for surgical robotic systems?
What is the highest price at which you think a surgical robotic system would remain a viable option for you and/or your institution?
After your experience today at the Learning Center's Robotics Station, are you more or less likely to pursue purchase of a robotic system for use in your practice?

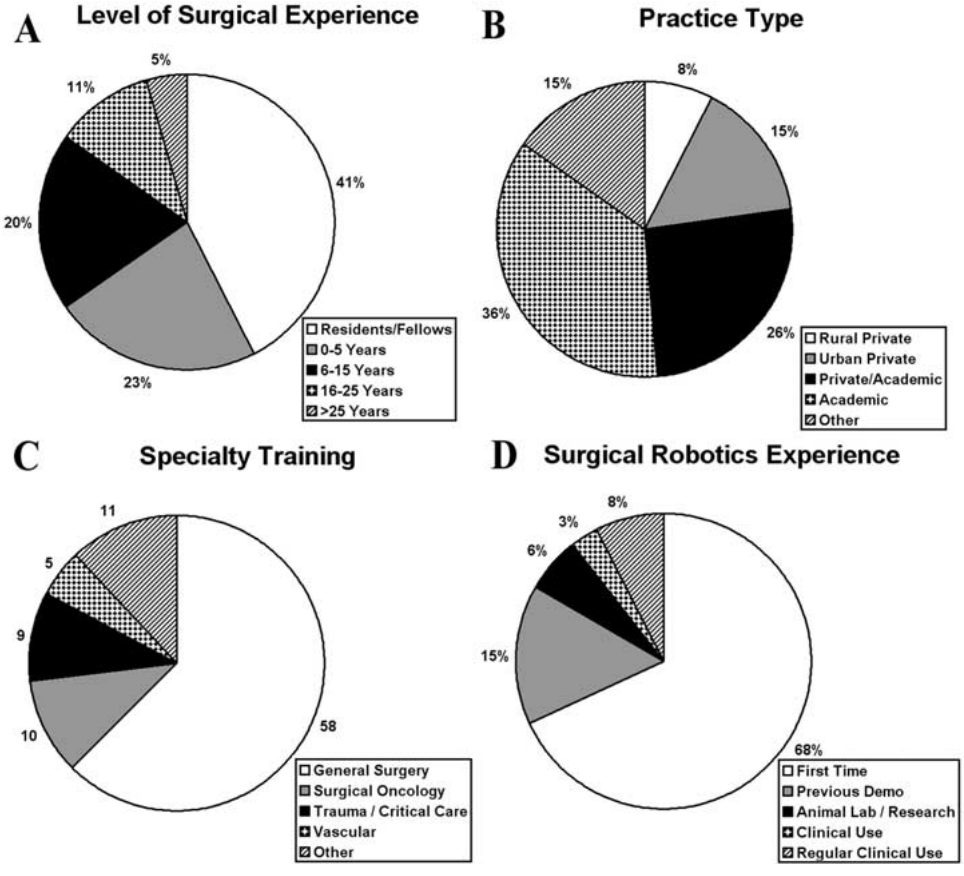

Fig. 2. Demographics for participants at the 2003 SAGES Learning Center Robotics Station. **A** Level of surgical experience. **B** Scope of surgical practice. **C** Training background. **D** Previous experience with surgical robotics. Data are expressed as a percentage of the total number of answers (66) except for training background (**C**) in which the raw number is expressed to allow for multiple answers among respondents.

participants are presented graphically in Fig. 2. Fifty-nine percent of participants were board-certified/board-eligible attending surgeons, whereas the remaining 41% of participants were current surgical residents/fellows. Sixty-two percent of participants identified themselves as practicing solely or partially in academic practice, and 79% of respondents indicated that residents and/or fellows participated in the care of their patients. Fifty-eight of the 66 participants (88%) identified themselves as having been trained in general surgery or as current general surgery residents. Twenty-seven (47%) of these general surgeons also identified themselves as board certified/board eligible or currently in training for a surgical subspecialty. Sixty-eight percent of participants had never used a surgical robot, and 89% of participants had never used a robot clinically.

First impressions of robotic surgery

After participating in the SAGES Learning Center Robotics Station and completing a standardized

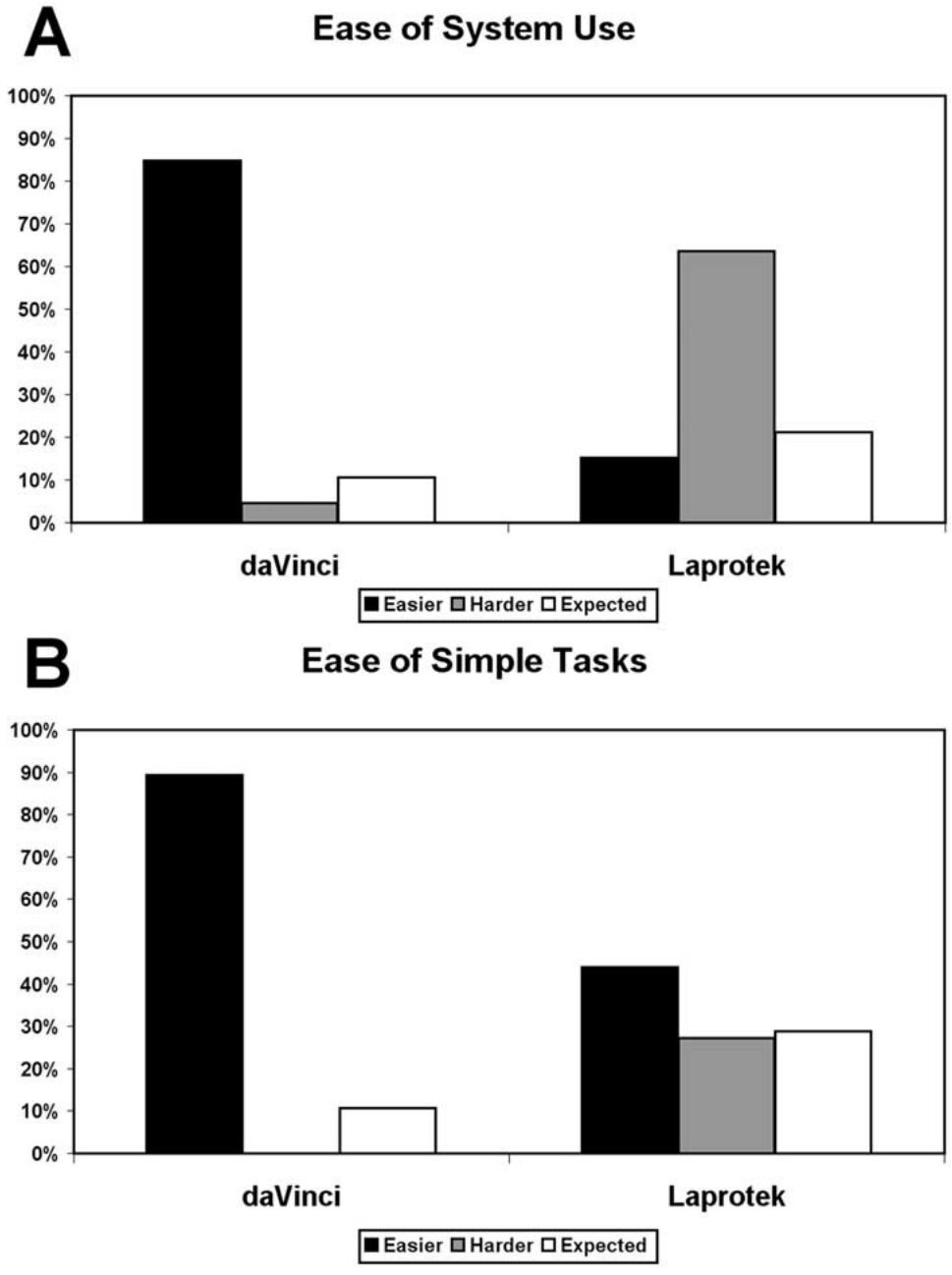

Fig. 3. First impressions following robot use at the SAGES Learning Center Robotics Station. **A** Participants indicated whether they found each of the robotic systems easier to use, harder to use, or about what they expected. **B** Respondents specified whether the robotic technology made simple tasks (e.g., moving objects and suturing) easier, harder, or about the same compared to standard laparoscopy. $p < 0.001$ for both ease of system use (**A**) and ease of simple tasks (**B**) between daVinci and Laprotek robots.

familiarization and procedural drill curriculum on two surgical robots, participants were asked questions about their impressions of surgical robotics. Eighty-eight percent of participants found at least one of the robots easier to use than they had expected, and 91% believed that at least one robot made simple surgical tasks easier compared to standard laparoscopy. Figure 3A shows that when comparing ease of robotic system use between robots, respondents found daVinci significantly easier than Laprotek ($p < 0.001$). Furthermore, participants were significantly more likely ($p < 0.001$) to describe daVinci, rather than Laprotek, as making simple tasks easier compared to standard laparoscopy (Fig. 3B).

Opinions about the technology

Participant opinion regarding the benefits and limitations of current surgical robotic systems was also determined (Fig. 4). The three most commonly cited benefits of surgical robotics were enhanced mechanical/manipulative ability (47%), optics/visual capability (30%), and motion scaling/elimination of tremor (19%). Other benefits of surgical robotics included the potential to use robots as public marketing tools for hospitals and the surgical robotic application of telesurgery. The most significant limitation of surgical robotics was believed to be the high cost of current systems (55%): \$1.25 million for a four-arm daVinci (\$1 million for the three-arm version) [1] and \$250,000, projected for Laprotek. Other

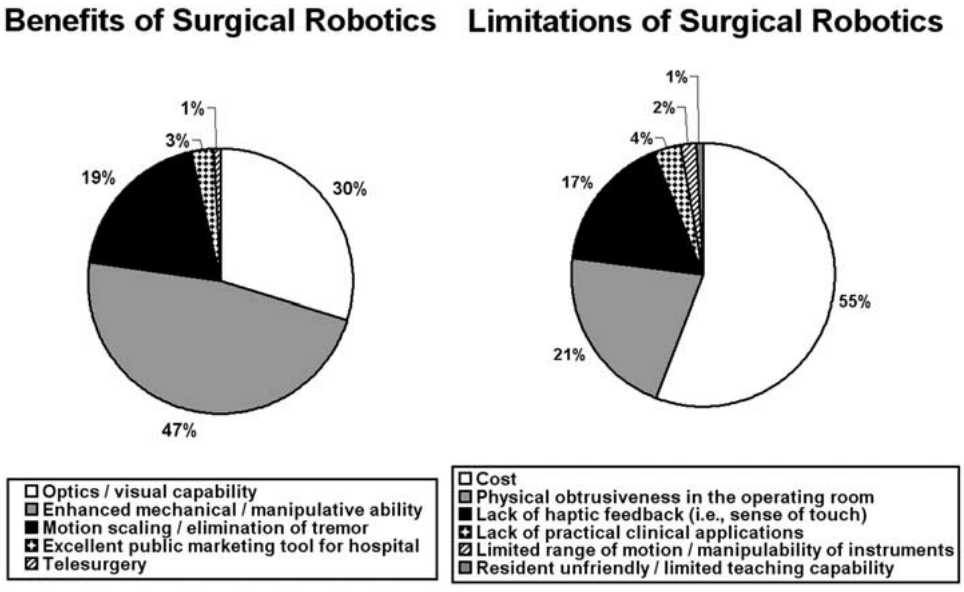

Fig. 4. Participant opinion regarding the most significant benefits and limitations of current surgical robotic systems.

limitations of current surgical robots cited by respondents were physical obtrusiveness, lack of haptic feedback, lack of clinical applications, limited range of motion, and limited teaching capability.

Value of the learning center

Three questions in the postsurgical robotics instruction survey assessed the Robotics Station's effectiveness in enabling surgeons and surgeons-in-training to determine the value of new surgical technology. Eighty percent of participants believed that current surgical robots are of clinical benefit, but slightly more than half of these individuals believed that the appropriate role for this technology is limited to large referral centers (42% compared to 38% advocating broad clinical use) (Fig. 5A). Figure 5B shows the relationship between theoretical costs of surgical robots and the perceived affordability of such costs by the respondents. Fewer than 15% of participants indicated that a robot costing $1 million or more would be affordable, and 71% of participants stated that surgical robotic systems priced above $500,000 would not be financially viable in their practices. Removing surgeons-in-training from the analysis had no significant effect on this relationship. Finally, 64% of participants stated that they were more likely to pursue purchase of a robotic system for use in their practice as a result of their exposure to robotics in the Learning Center (Fig. 5C).

Discussion

In the current study, attendees of the 2003 annual meeting of SAGES who participated in the Learning Center Robotics Station were surveyed regarding their initial impressions of surgical robotics, their opinions about the current state of surgical robotic technology, and their opinions about the Learning Center's ability to introduce them to new technology in a way that enabled them to assess the value of that technology for their surgical practice and their institution. The Learning Center Robotics Station sought to accomplish these tasks by teaching participants about surgical robotics using a "hands-on" approach in which every student received feedback from the instructors while practicing specific surgical tasks embedded in three standardized drills on each of two robots: Intuitive Surgical's *daVinci Surgical System* and EndoVia's *Laprotek System*.

The demographic data collected in the survey reveal that almost two-thirds of Robotics Station participants were either current surgical residents/fellows or had been in surgical practice for 5 or fewer years. This overweighting of less experienced surgeons in our survey suggests that our study is not necessarily representative of the surgeon population at large. Given the high-tech futuristic nature of surgical robotics, it is not surprising that such a self-selection bias occurred. Other than a more general acceptance of new technology by younger surgeons, other explanations for this bias include the possibility that more experienced surgeons may have been more heavily committed to presentation, administration, or other functions at the SAGES meeting that precluded their participation in the Learning Center. It is also possible that more experienced surgeons were less willing to wait in line for the Robotics Station (a wait that was often as long as 1 h). The demographic data also reveal that only one-fourth of Robotics Station participants were in traditional private practice settings. Although this is perhaps also not surprising given the academic bent of a large proportion of SAGES attendees, it is possible that a survey of primarily private practice surgeons would reveal less enthusiasm for surgical robotics than that of our respondents. Only half of the individuals in our study were trained solely in general surgery, indicating a subspecialist-intensive selection bias. Finally, it is clear that the individuals in our study could be characterized as generally naive regarding surgical robotics: 68% had no experience at all with

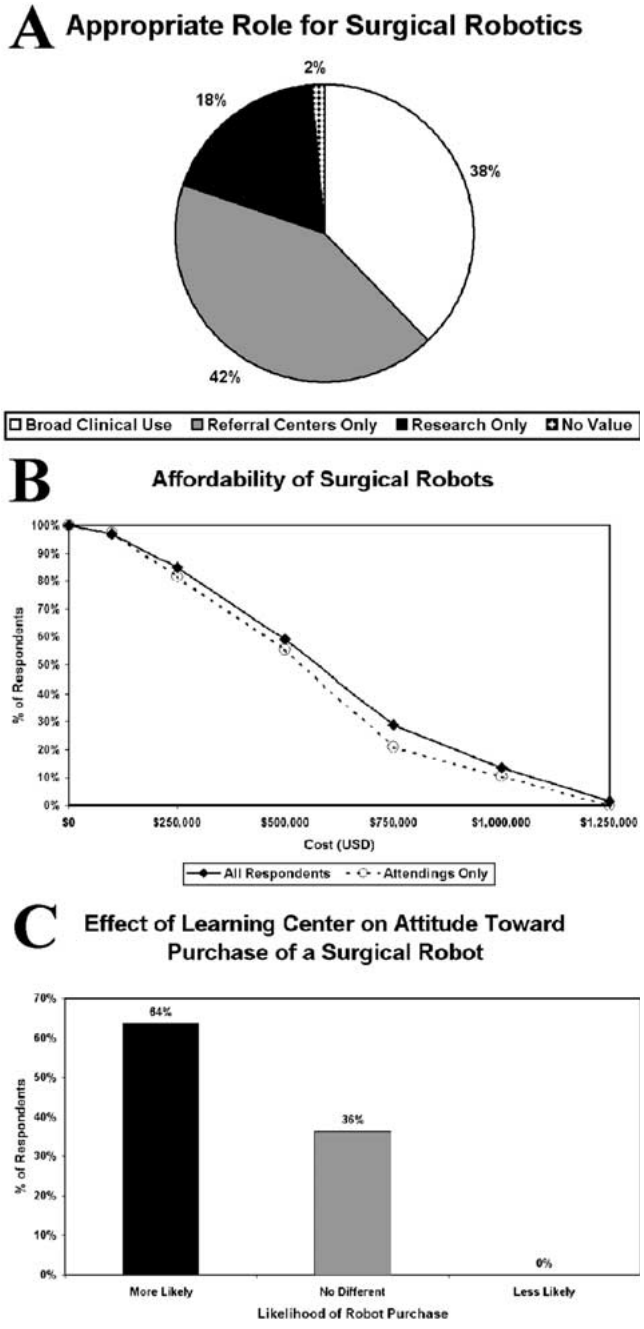

Fig. 5. Value of the SAGES Learning Center in introducing surgical robotics technology. **A** Respondents indicated how the Learning Center affected their view about the most appropriate role for robotic systems in current surgical practice. **B** Surgeons and surgeons-in-training were asked what the highest price was at which a surgical robot would remain a viable option for them and their institution. **C** Participants were asked how their participation in the Learning Center Robotics Station affected their enthusiasm for pursuing purchase of a surgical robot.

surgical robots and an additional 15% had only ''demoed'' a robot in the past. Thus, it seems fair to say that our study does reveal surgeonsonitial impressions of surgical robotics.

Respondents of our survey indicated whether they found use of the robots ''easier,'' ''harder,'' or ''about what [they] expected.'' Those surveyed were also asked to compare to standard laparoscopy the robots' ability to allow them to perform simple surgical tasks. As the systems were configured in the 2003 SAGES Learning Center, it is clear that participants found daVinci superior to Laprotek. However, this comparison is not altogether fair. The Laprotek robot is not yet FDA approved, so the robot being used at the Robotics Station was a prototype of sorts (in contrast to the four-arm production model daVinci robot that was used). Furthermore, Laprotek is designed to be used with many different third-party scope/camera configurations (including high-fidelity three-dimensional systems). However, the visualization system being used with the Laprotek robot in the 2003 Learning Center was a relatively low-resolution, two-dimensional system. Given that nearly one-third of respondents reported ''enhanced optics/visual capability'' as one of the most significant benefits of current surgical robotic systems, it is very possible that our results would have been different had a higher quality camera setup been used with Laprotek. Finally, surgeons should filter these results through a cost-benefit-analysis lens. The cost of the daVinci system as configured at the Robotics Station was $1,250,000 compared to a projected cost of $250,000 for Laprotek.

If the SAGES Learning Center only *introduces* surgeons to new technology, then little is gained over what already occurs with wine and cheese on the vendor exhibit floor. The goal of the Learning Center is to go beyond introductions and attempt to create an environment in which participants can formulate personal convictions about the actual value of new technology to their surgical practice. At the Robotics Station, we tried to foster such an environment in a number of ways. First, by having users of surgical robots from academic hospitals direct participants through the curriculum rather than inherently biased company sales personnel, we encouraged surgeons to think critically about the actual benefits and limitations of these very expensive tools. By asking each participant to complete a postinstruction survey, we sought to continue thoughtful consideration of the real value of surgical robotics among the respondents. The responses to these questions reveal a great deal about the effectiveness of the Robotics Station. Given that at the time of our survey fewer than 300 surgical robotic systems were in clinical use worldwide, and that only 8% of those surveyed indicated that they use a robot clinically on a regular basis, it is noteworthy that following their participation in the Learning Center, 38% of respondents agreed that surgical robots are ''of value to all surgeons in all practice settings,'' and an additional 42% believed that surgical robots should ''be used in select cases at large referral centers.'' After participating in the Robotics Station, only one surgeons indicated that surgical robotic systems were of ''no value'' in the practice of surgery.

We also attempted to stimulate cognition regarding the financial ''worth'' of surgical robots among participants. Although it is ambitious to ask surgeons to put an exact dollar amount on the value of a surgical tool, we asked participants to consider what the highest price would be for a surgical robot that would still allow purchase of such an instrument to be a viable option for

their practice or institution. Only 9 of the 66 respondents indicated that a robot costing $1,000,000 or $1,250,000 would be affordable to them and/or their institution. This is particularly interesting given that the only surgical robotic systems available for purchase at the time of the survey (daVinci and Computer Motion's Zeus) are in this price range (the less expensive Laprotek is still not commercially available for clinical use). Because surgical residents typically have relatively less depth of understanding regarding the importance of the financial costs associated with the practice of surgery, we had hypothesized that removing surgeons-in-training from the analysis would skew this curve to the left. However, the curves for "attendings only" and "all respondents" were virtually identical. Finally, to assess the utility of the Learning Center Robotics Station in affecting the stance of surgeons toward surgical robotics, we asked participants what effect the Learning Center had on the likelihood that they would pursue purchase of a robot for use in their practice. Only one-third of respondents indicated that they were neither more nor less likely to purchase a robot after receiving the Robotics Station curriculum. Interestingly, of the remaining two-thirds of participants for whom the Learning Center did have a significant effect from a robot purchasing likelihood standpoint, all stated that they were more likely (rather than less likely) to buy a robot as a result of their exposure to robotics in the Learning Center.

In conclusion, the structured learning environment used in the SAGES Learning Center fostered among participants a positive attitude toward surgical robotics. The format of their exposure to this technology at the Robotics Station also enabled participants to gauge the potential financial value of surgical robots in clinical practice. The Robotics Station succeeded in exposing surgeons to surgical robotics in a way that effectively helped them assess the value of this technology for their individual practices and institutions. The SAGES Learning Center serves as a model for organizations desiring to introduce new technology to physicians in a meaningful CME context.

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