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Perceptions of Surgical Robotics - Analysis and Study Design

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Perceptions of Surgical Robotics:

Analysis and Study Design

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Submitted to:

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By:

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Abstract

This research is intended to discern the perception of surgical robotics, and determine how this information can be used to further the field. This IQP presents a data analysis of the results of a study to evaluate the perception of surgical robotics, with the aim of helping those in the medical field properly communicate and interact with prospective patients. The preliminary study was distributed by a prior IQP team. Study populations include post-operative patients, practitioners, and the general population. The data identifies demographic trends which may help to tailor outreach. It is found that recovery time and success rate are among the most important factors which impact a patient's decision to undergo robotic surgery. There is inconsistency in the understanding of the advantages and nature of robotic surgery, and a need for better education in these areas. In addition, this IQP presents revised forms of the three surveys, as well as a journal paper drafted with the results.

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Introduction

Robotic Assisted Surgery (RAS) is the next step in the development of surgical techniques. Laparoscopic surgery has been in common use for decades, but surgeons could not achieve the same kind of maneuverability and visibility that were the advantages of open surgery. RAS hopes to solve this problem, providing the convenience of open surgery coupled with the reduced invasiveness of laparoscopic surgery. In 2000, the da Vinci Surgical System was granted FDA approval for general laparoscopic procedures. Since then, over 1,600 systems have been sold (Surgical 2010), and da Vinci now dominates the market for robotic-assisted surgery. This study focuses on the perceptions of and experiences with the Da Vinci system, as well as perceptions of robotics in surgery in general.

The successful implementation of this promising new technology rests largely on the willingness of the public and of the medical establishment to accept and support it, as well as having a thorough understanding of its capabilities and shortcomings. To this end, it is necessary to identify the current perceptions of RAS and identify any misconceptions or worries which may be hindering its progress. A previous IQP team developed and distributed surveys to determine these perceptions. This project will present an analysis of this data and present revised surveys which will help obtain more useful responses, with the goal of assisting proponents of this technology in addressing the needs and concerns of patients and practitioners alike.

Objectives

The overall research aims at understanding the perceptions of RAS from the perspectives of three subject groups: *practitioners* of robotic surgical systems, *patients* who have undergone robotic-assisted surgery, and members of the *general population*. Each subject group was evaluated separately, and differences among the populations were also studied. The study objectives are as follows:

- Determine the overall perception of robots in surgery from each perspective
- Discover common misconceptions and areas of concern which need to be addressed
- Identify demographic trends in order to better understand how to communicate effectively to different groups of people

This paper presents the improvements to the survey methods based on preliminary data to further these objectives. This additional work is aims to further refine our understanding of these issues, and how they affect work being done in the field of robotic-assisted. Specific objectives for this work are as follows:

- Perform a more thorough analysis of the data, taking into account responses which have been obtained since the last analysis was performed
- Identify weaknesses and possible ambiguities in the survey design, based on preliminary responses and close analysis
- Expand the surveys to be more precise in areas where responses are very similar
- Increase the focus on areas which have shown to be of particular interest to practitioners, or which conflict with existing data

- Resubmit the revised surveys for IRB approval for distribution at hospitals
- Prepare the data for publishing in a scholarly journal

In the following sections, the work to accomplish these objectives will be presented and discussed, while looking forward to future work.

Literature Review

Robotic-Assisted Surgery is an advanced form of laparoscopic surgery, in which the surgeon operates through small incisions in the abdomen or pelvic area instead of through large “open” incisions. This method is also known as Minimally Invasive Surgery (MIS) and is used to reduce blood loss and recovery times. However, this method sacrifices visibility, and reduces the dexterity of the surgeon. RAS is designed to provide the benefits of laparoscopic surgery while compensating for these drawbacks. A surgeon using the da Vinci system sits in an immersive console which displays a 3-dimensional view of the operating region. Intuitive tools control the arms and wrists of the robot, which are capable of greater freedom of movement than laparoscopic tools.

The da Vinci system is by far the most successful RAS system, but there are several other systems in the field. PROBOT, developed in the late 1980’s, is a compact robot used the assist in transurethral prostatectomies. ROBODOC, by Integrated Surgical Systems, remains the only robot which is FDA-approved for orthopedic surgery. The company Computer Motion marketed two surgical systems, AESOP and ZEUS. Intuitive Surgical later bought out CM and phased out the use of ZEUS in favor of da Vinci (Kalan, et al. 2010).

Robotic-Assisted Surgery has been widely used to perform laparoscopic radical prostatectomies, and as a consequence, much of the data is in this context. The use of the da Vinci system has been shown to reduce the learning curve of experienced open surgeons transitioning to a laparoscopic environment (Ahlering, Skarechy, et al. 2003), and also to be accessible to most laparoscopic surgeons (Lenihan, Kovanda and Seshadri-Kreaden 2008). The system is also noted for its relative safety, with reduced blood loss and complication rates (Abodeely, et al. 2010, Buchs, et al. 2010, Ahlering, Robotic prostatectomy: Is it the future? 2006). RAS has also been shown to be safe and provide advantages for elderly patients (Scales, et al. 2005). As these procedures become more mainstream, it is important to know how such a new technology is received. In this paper, we will discuss existing work done in this area and present new findings. RAS has been under a great deal of criticism for its cost, but reduced recovery times and complications support the economic feasibility of the system (Scales, et al. 2005). While much of the literature is very positive, there remain worries about the limitations and complications which can arise from transitioning to RAS (Murphy, et al. 2009).

Related Work

Existing literature on the satisfaction of patients and doctors has shown a good deal of satisfaction with complication rates and recovery times for RAS. Bultitude et al. describe increasing interest in robotic procedures, as well as good reception from patients, albeit after initial skepticism (Bultitude, et al. 2009). However, many people, especially the elderly, are hesitant to accept robots in medical settings. (Broadbent, Stafford and MacDonald 2009). Studies have also been done which identify differences in how men and women perceive robots in a medical setting. Kuo et al. found that men were significantly more optimistic and accepting of robots for medical uses than women (Kuo, et al. 2009). Overall, research in this area is thin, and it is important that we collect more data in order to form a clear view of the landscape for RAS. Most of the data concerns patient data, and we propose to analyze that population alongside practitioners as well as the general population.

Methods

Information about the perceptions of surgical robots was gathered through a series of surveys, distributed to three populations: *post-operative patients*, *robotic surgery practitioners*, and the *general population*. These surveys were designed to gather useful information which could be used to help hospitals and practitioners. Area of interests included:

- Demographic information, including age, income level, comfort with technology, religion, and education level. This would help determine how different groups of people perceive RAS.
- Perceptions of the relative strengths of RAS in the areas of cost, recovery time, procedure time, success rate, and cosmetics.
- Perceptions of the learning curve and skill level required to be highly skilled at RAS. This will help surgeons understand what expectations patients have about their experience.
- Perceptions of the role and level of control of the robot in RAS. This will help identify misconceptions about the system.

Meetings with practitioners were used to help craft the surveys, in order to identify the most relevant topics to investigate. The surveys were also edited in response to submission to the Internal Review Boards of WPI and hospitals which were to supply patients to take the survey.

Once preliminary data was received, further interviews were conducted with practitioners. Dr. Heip Nguyen of Children's Hospital Boston, and Dr. Balchandra Parulkar of St. Vincent's hospital helped by responding the preliminary data and steering future work.

Study Populations

Patient data was gathered from post-operative surveys at St. Vincent's hospital in Worcester, MA. Surveys were mailed to patients of at least 18 years of age who had undergone RAS, found from a database of existing patients. Each potential participant was mailed a hard copy of the survey with a return envelope. A total of 111 valid responses have been received.

The practitioner survey was distributed randomly to surgeons through contact information on Intuitive Surgical's website. These surgeons are those who have completed a product education course with Intuitive, and chose to be listed. 15 surgeons from each state were contacted, and directed to an online form to answer the survey. A total of 35 responses were received, of which 30 were valid, a total valid response rate of 4%.

General population data was collected through the use of random mailings. A pilot mailing of 50 surveys resulted in a 10% return rate. 1000 surveys were distributed in order to achieve the goal of at least 80 completed surveys. Survey recipients were obtained through an online lead-supplying service, www.leadsplease.com. Of the 1000, 63 were returned resulting in a 6.5% total return rate (including the pilot).

In order to achieve the goal, additional surveys were distributed through online survey postings on websites and forums. Participants were directed to an online form similar to the practitioner form. This resulted in an additional 32 responses. In total, 93 valid responses were received (5 from pilot + 63 from full mailing + 32 from online - 7 invalid responses).

Table 1 describes demographic data from the three populations. At St. Vincent's, the Da Vinci is used primarily for radical prostatectomies, so patient demographic data is largely middle-aged and male.

	Patients	Practitioners	General Population
Number	111	30	93
Gender	92.5% Male	87% Male	61% Male
Age	60 Yrs. (30-78)	47 Yrs. (33-64)	45 Yrs. (16-80)

Table 1: Population demographics

Data Analysis

The collected data was analyzed using the statistical software SPSS. Several features of the software were used to produce the results you will see in the next section. SPSS scripts for the generated tables and graphs are provided in Appendix F. Previously collected data had to be reformatted and encoded to facilitate proper analysis, and new patient data was added. Existing analysis was updated with the new data.

In order to make statements about demographic trends, correlations were determined. Correlations were identified using a bivariate correlation test. Relevant correlations with statistical significance of at least 95% are reported. These tests related scaled answers with other information such as education level or income level. Correlation tests were useful in a few situations, but were not adequate to describe the data from non-scaling data, which was the form of the majority of the survey data.

Frequency tables are generated from Descriptive Statistics tools. Frequencies and Crosstabs are used. This data shows the most popular responses to non-scaling questions, and shows how these responses correlate with other factors, such as willingness to undergo robotic surgery. This analysis was used to display general levels of response to various questions, but could not establish confident levels of significance.

Results

In this section, some results which are of potential use to those who work with surgical robotics are presented and summarized. Survey improvements designed to achieve more significant results are summarized in the Discussion section.

Factors affecting patient decisions

Figure 1 shows the average ratings for six factors which contributed to patients' decisions to undergo robotic surgery. "Recovery Time" (mean = 4.67) and "Success Rate" (4.57) scored the highest. The "State-of-the-Art" aspect (4.27) was next, followed by "Procedural Time" (3.84) and "Scarring/Cosmetics" (3.79). "Cost" (3.51) was rated as the least important factor.

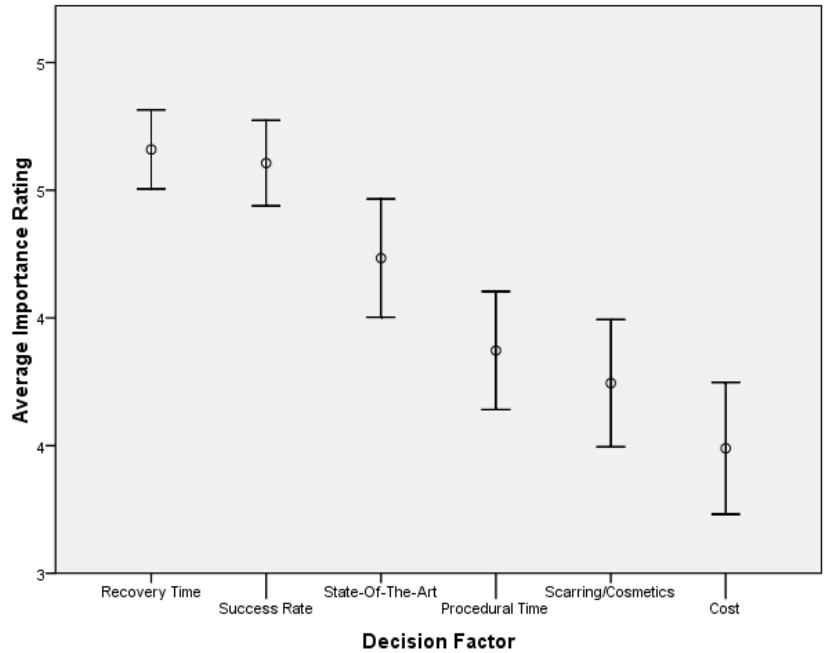

Figure 1: Participants were asked to rate each of six factors regarding their importance in the choice to undergo RAS. This graph shows the mean response for each factor, with error bars representing 95% confidence.

Patient post-op correlations

Table 2 shows relevant correlations found in the patient post-op data. The “state-of-the-art” aspect is valued more highly by those who have completed higher levels of education (p = 0.049). Those with a higher income care less about the cost of the operation (p = 0.006), and hold higher expectations for the experience of RAS practitioners (p = 0.031).

Correlation	Significance Level
Higher education level and valuing “state-of-the-art” aspect higher.	0.05
Higher income and valuing cost less	0.01
Higher income, and higher standard for surgeon experience	0.05

Table 2: Patient post-op correlations

General population correlations

Table 3 shows relevant correlations found in the general population survey data. Younger respondents are more likely to choose RAS ($p = 0.039$), and think the robot has a higher level of control ($p = 0.014$). Those who think the robot has greater levels of control also expect higher costs ($p = 0.012$). Women are less likely than men to choose RAS over traditional surgery ($p = 0.028$).

Correlation	Significance Level
Younger respondents think the robot has more control	0.05
Those who think the robot has greater control think that the operation costs more	0.05
Younger respondents are more likely to prefer RAS	0.05
Women are less likely to prefer RAS	0.05

Table 3: General population correlations

Perceptions of learning curve

Figure 2 shows the perception of learning curve for robotic-assisted surgery. Perceived learning curve was measured by asking participants to select the number of procedures they believed were necessary for a surgeon to perform before being considered “highly skilled”. Patients overwhelmingly believe that surgeons require 50 or more procedures to become highly skilled at RAS. Practitioners and the general population are more mixed. Most practitioners answered either “10-20” or “50+” showing the possibility of two distinct groups among practitioners.

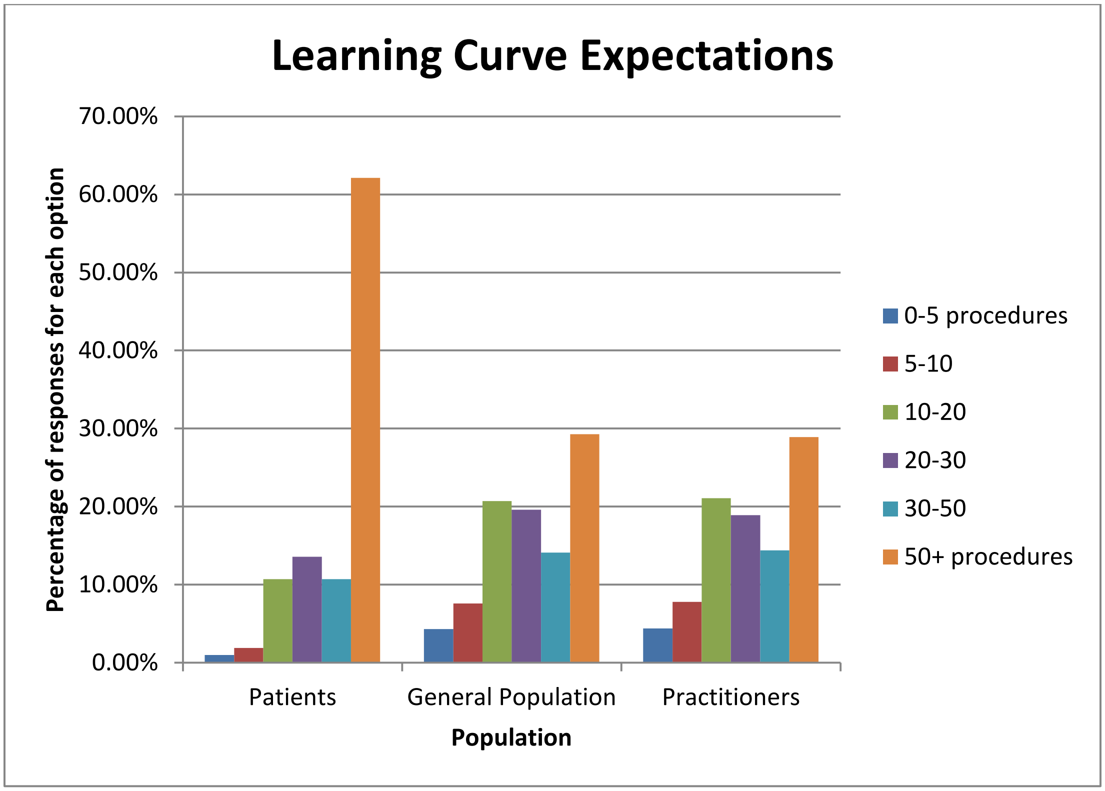

Figure 2: Participants from each population were asked to estimate the number of procedures required for a surgeon to become "highly skilled" at RAS.

Perceptions of the robot and its impact

Table 4 shows that an overwhelming majority of respondents (96.2% of patients, and 84.6% of the general population) correctly identified the robot as an “Enhanced Surgical Instrument”. However, responses to the question of control are much more variable, even in the practitioner population. Opinions on the cost of the procedure are also mixed, with 43.9% of patients and 43.8% of the general population thinking that it costs more. In all three populations, a plurality of respondents think that RAS reduces recovery time, with the patient population being the most confident (67.1%). In all three populations, a majority think that RAS reduces operation times.

	Patients	General Population	Practitioners
Role of the robot in RAS			
I'm not sure	01.3%	07.7%	N/A
Enhanced surgical instrument	96.2%	84.6%	
Independently-thinking surgeon	01.3%	01.1%	
Diagnostic tool	01.3%	05.5%	
Robot's involvement in control			
I'm not sure	06.3%	15.4%	10.3%
No involvement	19.0%	04.4%	44.8%
Minimal involvement	29.1%	36.6%	17.2%
Major involvement	38.0%	36.6%	27.6%
Complete involvement	07.6%	05.5%	00.0%
Relative cost			
More	43.9%	43.8%	N/A
Less	37.8%	25.8%	
Same	18.2%	28.1%	
Relative recovery time			
More	26.3%	22.0%	22.0%
Less	67.1%	42.9%	41.8%
Same	06.6%	34.1%	34.1%
Relative procedural time			
More	23.6%	10.0%	55.1%
Less	55.5%	68.9%	67.8%
Same	20.8%	18.9%	18.9%

Table 4: In "Role", patient post-op and general population participants were asked to indicate the role of the robot in RAS, from the listed possibilities. In "Control", patient post-op and general population participants were asked to indicate the level of control the robot has, from the listed possibilities. In "Factor", participants in the patient post-op and general population groups were asked to indicate the relative cost, recovery time, and procedure length of RAS compared to other forms of surgery. The frequency of each response for the two populations is presented here.

Relating perceptions to acceptance

Table 5 shows how the responses to two questions are related to the preference of general population respondents for RAS over traditional forms of surgery. The data indicate that those who see the robot as having more control are more likely to choose it over traditional surgery. Learning curve data is inconclusive, but shows a slight increase among those with high expectations, when only the most significant answers are taken into account.

Perceived Robot Control	**Preference for RAS**
No Response	50.0% (n = 2)
I'm not sure	50.0% (n = 14)
No involvement	75.0% (n = 4)
Minimal involvement	53.3% (n = 30)
Major involvement	72.7% (n = 34)
Complete involvement	80.0% (n = 5)
Learning Curve Expectation	
No Response	50.0% (n = 4)
0-5	33.3% (n = 3)
5-10	85.7% (n = 7)
10-20	52.6% (n = 19)
20-30	58.8% (n = 18)
30-50	76.9% (n = 13)
50+	62.5% (n = 24)

Table 5: Among the general population, the rate at which participants would choose RAS over traditional forms of surgery, based on their responses to the following questions "What do you think the robot's involvement is in the control of robotic assisted surgery?", and "How many procedures do you think a surgeon needs to perform before they become highly skilled at robotic surgery?"

Discussion and Survey Improvements

Quantitative and qualitative analysis of the response data presented many expected and several counter-intuitive results. In this section, the results of the data analysis will be discussed, along with the specific modifications made to the three surveys to improve future results.

Results Discussion

Preliminary survey data show promising reactions to RAS technology, and optimistic estimations of its benefits. This is reassuring, as in many cases the introduction of robotic systems into sensitive areas of life (such as medicine) has met some resistance.

Factors taken into account when patients are choosing RAS provide much useful information. The results show that the advantages of RAS in terms of recovery time and success rate are resonating well with patients. There also appears to be a strong attraction to RAS from the “state-of-the-art” aspect. It reflects a growing willingness to take advantage of new technology. Our data also shows that women and older persons are more hesitant to choose RAS over traditional surgery. This is consistent with existing studies (Kuo, et al. 2009).

Perceptions of the number of procedures needed for a surgeon to become highly skilled at RAS were very mixed. It is useful to compare these results with existing data. Ahlering et al. studied a surgeon transitioning from open to robotic-assisted surgery with a learning curve of 12 operations (Ahlering, Skarechy, et al. 2003). Lenihan et al. studied the learning curve of gynecological surgery and arrived at a total of 50 procedures needed before stabilization of operation times (Lenihan, Kovanda and Seshadri-Kreaden 2008). Menon et al. compared the results of laparoscopic surgeries and RAS in radical prostatectomies, and found that after 18 surgeries, RAS results reached that of surgeries by experienced laparoscopic surgeons (Menon, et al. 2002). Giulianotti et al. suggest that 20 operations are sufficient (Giulianotti, et al. 2003). Conclusions regarding learning curve, however, are mixed and largely anecdotal. Kaul et al. discuss the difficulties in establishing consistent measures of learning curve for RAS (Kaul, Shah and Menon 2006). The survey data show that the general population and the practitioner population have very similar responses, but the patient population is much more skewed. In general, patients have a much higher expectation of surgeon experience than has been described in the literature.

There is conflicting data regarding the level of understanding of the role of the robot. While most respondents in each population correctly identified the robot as an “enhanced surgical device” a large portion of them also indicated that the robot had a good deal of control in the operation. The da Vinci actually exercises little to no real control over the operation, acting mainly as a teleoperation device.

There is also a lot of variation in the opinions of all populations regarding the cost, recovery time, and procedural time of RAS. There is much education needed about the nature and advantages of RAS. Responses about these topics were wide-ranging, and there does not seem to be a firm “common-knowledge” about RAS. In particular, people are not well-informed as to the nature of the system's control during surgery, and of the surgeon’s learning curve. Labeling the procedure “robotic” gives an impression of automation, which is not appropriate in this case. This knowledge would be useful for practitioners who are introducing the system to a patient, as the misconception is common.

Survey Improvements

A main focus of this project was to use the existing preliminary data to develop more effective surveys for future distribution. When discussing results with Dr. Nguyen, and based on further research, it became apparent that asking comparative questions (e.g. "How does RAS impact recovery times?") does not make sense unless stating whether the comparison is being made to endoscopic or open surgery. In order to remedy this, such questions were broken up into two parts.

There appeared to be some inconsistent results found due to inconsistencies of scale among the survey questions, specifically the recovery time, cost, and procedure length questions. Contrary to the rest of the survey, the "positive" responses to these questions were the low answers, but the generic terms "more" and "less" were being used. There were several cases where patients clearly indicated satisfaction with one or more of these factors but seemed to say they thought that RAS "dramatically increases" recovery time, for example. In the updated surveys, the nature of the comparisons is much clearer.

One potentially interesting piece of data is the perceptions of the learning curve for RAS. In the original survey, respondents were asked to indicate the number of procedures required for a surgeon to become "highly skilled" at both RAS and at traditional laparoscopic surgery. Many people expressed an inability to answer to specific numbers on the survey, so the question was changed to instead ask directly whether they thought it takes more or less time to become skilled at RAS compared to laparoscopic.

Looking forward to data from Children's Hospital, new fields were added to accommodate young patients who need a parent to fill out the survey. A new field to indicate the procedure being performed was also added. When asking patients about factors which were important when choosing RAS, four additional factors were added: "complication rate", "safety", "complexity", and "availability". The factor questions were also rescaled to allow for negative factors, which was not available in the preliminary survey.

There was a possibility of confusion regarding the question of robotic control, as many people are not familiar with what was meant by the word "control". To clear this up, the question was changed to "To the best of your ability, please indicate the robotic system's control ***in decision-making*** during your operative procedure." (Emphasis is on inserted words) This emphasis on decision-making will help to clarify if there is confusion regarding the robot's role in the process. Many questions were interpreted in unexpected ways, and this was used to improve the surveys for future data collection.

Journal Paper

A deliverable of this project is a journal paper describing the work for submission to the Journal of Robotic Surgery. A draft of the paper can be found in Appendix G. Many of the works cited were used as models for the paper, several from the Journal of Robotic Surgery itself. This exercise helped to apply more rigorous standards to the data presentation, and to learn the tools for producing modern journal papers, namely LaTeX for document preparation and JabRef for source management. The goal of the journal paper was to provide the most useful information for practitioners and hospitals that have to interact with and educate patients regarding RAS. Knowledge of existing misconceptions and the factors which affect the decision to undergo RAS will help improve this communication.

Future Work

Preliminary data analysis enabled the development of improved survey designs which are expected to return more useful results in the future. IRB approval for the new surveys is underway at Children's Hospital. When additional data is recovered, it will be necessary to determine to what extent the new data can be compared to or combined with existing data and a new analysis will need to be performed.

In general, further research will be needed when new robotic systems come into use in the medical field. This will make it more difficult to generalize to robotic-assisted surgery as a whole, as the new systems might be very different in capabilities and implications. It is also possible that the perceptions of the da Vinci system will affect the perceptions of future systems, which would make it more difficult to properly communicate the capabilities of new systems. Making a clear distinction is likely to be a vital task in the future.

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Appendices

Appendix A Post-Operative Survey (Revised)

Patient Post-Operative Survey

The following answers are being provided by:

[the patient]   [a parent/guardian]

Age: _____

Age of patient: _____

Procedure performed: ______________________________________

Please indicate your job title: ________________

Country of origin: ________________

Please indicate highest degree you have acquired:

[High School or less]   [Master's Degree]   [J.D./Law]

[Associate's Degree]   [Ph.D/Doctoral Degree]   [M.B.A/Business]

[Bachelor's Degree]   [Post-Doctoral Degree]   [M.D./Medical]

On average, how many hours a week do you use computer technology (e.g. computers, iPods, cell phones)?

[0 to 5]   [6 to 11]   [12 to 17]   [18 to 23]   [24 or more]

How would you categorize your comfort with current technology (e.g. computers, iPods, cell phones)?

[uncomfortable] [somewhat comfortable] [comfortable] [very comfortable]

To the best of your ability, categorize your familiarity with the robotic surgical system prior to meeting with your physician.

[unfamiliar] [vaguely familiar] [familiar] [very familiar]

To the best of your ability, categorize your familiarity with the robotic surgical system just prior to your operative procedure.

[unfamiliar] [vaguely familiar] [familiar] [very familiar]

To the best of your ability, please categorize the role of the robotic system in the operating room.

[I'm not sure] [surgical hand utensil] [independently thinking surgeon] [pre-operative planning device]

[other: _____________]

To the best of your ability, please indicate the robotic system's control in decision-making during your operative procedure.

[I'm not sure] [no control] [minimal control] [major control] [complete control]

To the best of your ability, please indicate the surgeon's control in decision-making during your operative procedure.

[I'm not sure] [no control] [minimal control] [major control] [complete control]

Please indicate who first suggested robotic assisted surgery as treatment option.

[I did] [family] [friends] [physicians] [advertisement] [other]

Did you research the robotic surgical system online?

[yes] [no]

How willing were you to undergo robotic assisted surgery prior to your operation?

[unwilling] [hesitant] [neutral] [willing] [eager]

To the best of your knowledge, how does the overall cost of robotic surgery compare to the following options?

Compared to Open Surgery:

[dramatically less] [less] [no difference] [more] [dramatically more]

Compared to Endoscopic Surgery:

[dramatically less] [less] [no difference] [more] [dramatically more]

To the best of your knowledge, how does robotic surgery influence patient recovery time, compared to the following options?

Compared to Open Surgery:

[dramatically decreases] [decreases] [no difference] [increases] [dramatically increases]

Compared to Endoscopic Surgery:

[dramatically decreases] [decreases] [no difference] [increases] [dramatically increases]

To the best of your knowledge, how does robotic surgery influence the length of a typical operation, compared to the following options?

Compared to Open Surgery:

[dramatically decreases] [decreases] [no difference] [increases] [dramatically increases]

Compared to Endoscopic Surgery:

[dramatically decreases] [decreases] [no difference] [increases] [dramatically increases]

Do you think it takes a surgeon more time or less time to become highly skilled at robotic surgery compared to traditional laparoscopic (minimally-invasive) surgery?

[much less time] [less time] [same time] [more time] [much more time]

Please rate the following factors' importance in choosing robotic assisted surgery as a treatment method.

(1 = Strong Negative Factor, 3 = No Effect, 5 = Strong Positive Factor)

[recovery time]	[1]	[2]	[3]	[4]	[5]
[success rate]	[1]	[2]	[3]	[4]	[5]
[state of the art]	[1]	[2]	[3]	[4]	[5]
[procedural time]	[1]	[2]	[3]	[4]	[5]
[scarring/cosmetics]	[1]	[2]	[3]	[4]	[5]
[cost]	[1]	[2]	[3]	[4]	[5]
[complication rate]	[1]	[2]	[3]	[4]	[5]
[safety]	[1]	[2]	[3]	[4]	[5]
[complexity]	[1]	[2]	[3]	[4]	[5]
[availability]	[1]	[2]	[3]	[4]	[5]

Appendix B Practitioner Survey (Revised)

Robotic Surgery Practitioner Survey

Age: _____

Specialization: ________________

Primary responsibility in OR: ________________

Country of origin: ________________

On average, how many hours a week do you use computer technology (e.g. computers, iPods, cell phones)?

[0 to 5] [6 to 11] [12 to 17] [18 to 23] [24 or more]

How would you categorize your comfort with current technology (e.g. computers, iPods, cell phones)?

[uncomfortable] [vaguely comfortable] [comfortable] [very comfortable]

Regarding computers and technology, which of these categorizations best describes you?

[cannot use a computer] [start and access email/basic features] [use computers for leisure] [troubleshoot and resolve problems] [write computer programs]

To the best of your ability, categorize the time and effort you invest in discussing robotic assisted surgery (RAS) as a treatment option with each patient relative to laparoscopic surgery.

[much less] [less] [the same] [more] [much more]

To the best of your ability, categorize the time and effort you invest in discussing robotic assisted surgery (RAS) as a treatment option with each patient relative to open surgery.

[much less] [less] [the same] [more] [much more]

In your experience, how often is robotic assisted surgery (RAS) used to replace laparoscopic surgery, when both are viable treatment options?

[never] [infrequently] [frequently] [very frequently] [every time]

In your experience, how often is robotic assisted surgery (RAS) used to replace open surgery, when both are viable treatment options?

[never] [infrequently] [frequently] [very frequently] [every time]

To the best of your knowledge, how does the overall cost of robotic surgery compare to the following options?

RAS costs ________ compared to Open Surgery:

[dramatically less] [less] [no difference] [more] [dramatically more]

RAS costs ________ compared to Endoscopic Surgery:

[dramatically less] [less] [no difference] [more] [dramatically more]

To the best of your knowledge, how does robotic surgery influence patient recovery time, compared to the following options?

Robotic surgery recovery times are _________ compared to Open Surgery:

[much shorter] [shorter] [the same] [longer] [much longer]

Robotic Surgery recovery times are _________ compared to Endoscopic Surgery:

[much shorter] [shorter] [the same] [longer] [much longer]

To the best of your knowledge, how does robotic surgery influence the length of a typical operation, compared to the following options?

Robotic surgery procedural times are _________ compared to Open Surgery:

[much shorter] [shorter] [the same] [longer] [much longer]

Robotic surgery procedural times are _________ compared to Endoscopic Surgery:

[much shorter] [shorter] [the same] [longer] [much longer]

To the best of your knowledge and experience, how does robotic surgery influence the overall length of a typical operation?

[dramatically decreases] [decreases] [remains the same] [increases] [dramatically increases]

To the best of your knowledge and experience, how does robotic surgery influence the setup time of a typical operation?

[dramatically decreases] [decreases] [remains the same] [increases] [dramatically increases]

Do you think it takes a surgeon more time or less time to become highly skilled at robotic surgery compared to traditional laparoscopic (minimally-invasive) surgery?

[much less time] [less time] [same time] [more time] [much more time]

Please rate the following factor's importance in choosing RAS as a treatment option?

(1 = Strong Negative Factor, 3 = No Effect, 5 = Strong Positive Factor)

[ergonomics]	[1]	[2]	[3]	[4]	[5]
[patient recovery]	[1]	[2]	[3]	[4]	[5]
[patient demand]	[1]	[2]	[3]	[4]	[5]
[procedural time]	[1]	[2]	[3]	[4]	[5]
[hospital costs]	[1]	[2]	[3]	[4]	[5]
[reputation]	[1]	[2]	[3]	[4]	[5]

[state of the art] [1] [2] [3] [4] [5]

In your experience, if RAS is chosen as a treatment method, of the following options what is the strongest motivating factor behind the decision?

[ergonomics] [patient recovery] [patient demand] [hospital costs] [reputation] [state of the art]

To the best of your ability, please indicate the robotic system's control in decision-making during your operative procedure.

[no control] [minimal control] [major control] [complete control]

To the best of your ability, please indicate the surgeon's control in decision-making during your operative procedure.

[no control] [minimal control] [major control] [complete control]

Appendix C General Population Survey (Revised)

General Population Survey

Age: _____

Please indicate your job title: ________________

Country of origin: ________________

Please indicate highest degree you have acquired:

[High School diploma]	[Master's Degree]	[J.D./Law]
[Associate's Degree]	[Ph.D/Doctoral Degree]	[M.B.A/Business]
[Bachelor's Degree]	[Post-Doctoral Degree]	[M.D./Medical]

On average, how many hours a week do you use computer technology (e.g. computers, iPods, cell phones)?

[0 to 5] [6 to 11] [12 to 17] [18 to 23] [24 or more]

How would you categorize your comfort with current technology (e.g. computers, iPods, cell phones)?

[uncomfortable] [vaguely comfortable] [comfortable] [very comfortable]

Regarding computers and technology, which of these categorizations best describes you?

[cannot use a computer] [start and access email/basic features] [use computers for leisure] [troubleshoot and resolve problems] [write computer programs]

Which of the following most closely matches how often you play electronic video games?

[not at all] [rarely] [several times a month] [several times a week]

To the best of your ability, categorize your familiarity with robotic surgical systems.

[unfamiliar] [vaguely familiar] [familiar] [very familiar]

To the best of your ability, please categorize the role of a robotic system in robotic surgery.

[I'm not sure] [surgical hand utensil] [independently thinking surgeon] [pre-operative planning device]

To the best of your ability, please indicate the robotic system's control in decision-making during a robotic surgery procedure.

[I'm not sure] [no control] [minimal control] [major control] [complete control]

To the best of your ability, please indicate the surgeon's control in decision-making during a robotic surgery procedure.

[I'm not sure] [no control] [minimal control] [major control] [complete control]

To the best of your knowledge, how does the overall cost of robotic surgery compare to the following options?

RAS costs ________ compared to Open Surgery:

[dramatically less] [less] [no difference] [more] [dramatically more]

RAS costs ________ compared to Endoscopic Surgery:

[dramatically less] [less] [no difference] [more] [dramatically more]

To the best of your knowledge, how does robotic surgery influence patient recovery time, compared to the following options?

Robotic surgery recovery times are _________ compared to Open Surgery:

[much shorter] [shorter] [the same] [longer] [much longer]

Robotic Surgery recovery times are _________ compared to Endoscopic Surgery:

[much shorter] [shorter] [the same] [longer] [much longer]

To the best of your knowledge, how does robotic surgery influence the length of a typical operation, compared to the following options?

Robotic surgery procedural times are _________ compared to Open Surgery:

[much shorter] [shorter] [the same] [longer] [much longer]

Robotic surgery procedural times are _________ compared to Endoscopic Surgery:

[much shorter] [shorter] [the same] [longer] [much longer]

Do you think it takes a surgeon more time or less time to become highly skilled at robotic surgery compared to traditional laparoscopic (minimally-invasive) surgery?

[much less time] [less time] [same time] [more time] [much more time]

How often do you think robotic surgery is used to replace traditional laparoscopic (minimally-invasive) surgery, when both are viable treatment options?

[never] [infrequently] [frequently] [very frequently] [every time]

Would you choose to undergo robotic surgery if traditional operating methods were also suitable?

[yes] [no]

Appendix D Children's Hospital IRB Application, Part B

Part B: Experimental Design and Protocol – ALL APPLICANTS MUST COMPLETE THIS FORM

All investigators must submit a completed Part B with their New Protocol or 3 Year Rewrite application. If a protocol from a corporate sponsor or cooperative group is available, this must also be submitted.

Each question in Part B should be answered thoroughly with answers that are specific to how the research will be conducted at Children's Hospital, Boston.

Do not cut and paste from the protocol or from a grant application to complete Part B. Instead, complete each question in Part B by referencing the applicable page and section number of the protocol which answers the questions in Part B. For some questions in Part B, such as those regarding recruitment methods, confidentiality provisions, and adverse event reporting, you will need to provide complete answers rather than references to the protocol, since the protocol will not address these items as they apply specifically to how the research will be conducted at CHB.

Further information may be obtained by referring to **the polices and procedures on the CCI website**

Please provide a brief summary or abstract of this research protocol

1. Specific Aims /Objectives

This research aims to identify issues in the current social perceptions of robotic assisted surgery among patients who have undergone a robotic procedure. Results will be used to help educate hospitals and practitioners about communicating with patients. Understanding social issues surrounding the use of robotics in medical spaces is important as such use is becoming more common, in surgery and in other forms of patient care.

2. Background and Significance

Three main surgical techniques exist in the medical field: open surgery, laparoscopic surgery, and robot-assisted (RAS). RAS is one of the most recent advances in minimally invasive medical technology. Previous studies show that RAS yields a short learning curve and possesses an assortment of advantageous improvements over both laparoscopic surgery and traditional open surgery. No innovative development in the medical field can reach its full potential, however, until it is thoroughly understood and accepted by the public. As society's perception of RAS is better understood, subsequent action can be taken to promote a more uniform understanding of RAS.

3. Preliminary Studies/Progress Report

A similar survey has been successfully run with St. Vincent's Hospital in Worcester, MA. We were able to achieve significant results which have helped craft the version of the survey we present here. This second round of surveys will help to refine our conclusions with more targeted questions in key areas.

4. Design and Methods

a. Study Design

This study will consist of a brief anonymous survey. Study design draws from interviews with practitioners of RAS as well as preliminary studies which have been conducted as part of this research project. Feedback from initial surveys has helped us to adjust questions in several areas and identify the most promising potential results. Questions have also been designed to compare well with surveys being carried out among other populations as a part of a larger project.

b. Patient Selection and Inclusion/Exclusion Criteria

Eligibility requirements are as follows: must have undergone RAS. Parents or guardians will complete the survey for patient subjects under the age of 14.

c. Recruitment Methods

i. HOW, WHERE and WHEN will potential subjects be recruited?

Eligible patients/parents will be informed about the study during their postoperative clinic visit in the Department of Urology at CHB by their physician.

ii. WHAT recruitment methods and materials (e.g. posters, fliers) will be used? ***- attach all materials***

Subjects for the post-operative patient survey will be recruited from Children's Hospital Boston and retrospectively mailed a hardcopy of the survey. Subjects for the practitioner survey will be randomly recruited by contacting surgeons (an equal number from each state) listed on Intuitive's website who will then be invited to forward the survey to anyone else directly involved in their RAS OR. Using Intuitive's "surgeon-finder" portion of their website, surgeons will be selected by state. A quota of 15 per state was filled by selecting the first 15 surgeons listed per state (there is no specific order to how surgeons are listed on the surgeon-finder website. Subjects for the general population survey will be recruited through a mailing list randomly generated by a directory website. Additionally, the general public survey will be posted in several online locations.

iii. WHO will be responsible for subject recruitment?
Dr. Nguyen

d. Description of Study Treatments or Exposures/Predictors

None

e. Definition of Primary and Secondary Outcomes/Endpoints

To better understand the social perception of robot-assisted surgery from the perspective of patients, which will also be compared with data from other populations as part of this research project.

f. Data Collection Methods, Assessments and Schedule (what assessments performed, how often)

Responses will be analyzed for statistical significance using SPSS. Analysis will begin as soon as data is received, with confidence improving as more surveys are returned. Based on our previous results, we should expect the bulk of all responses within one month.

g. Study Timeline (as applicable)

Study subjects will have a 1 month period to complete the survey. Data from surveys received after one month will be specifically distinguished from any received within the one month time frame.

h. Adverse Event Criteria and Reporting Procedures.

No interventions are planned. Patients will be advised that if they have concerns regarding the study or the results of their surgery to contact the PI who will direct the patient to the appropriate resource.

5. **Data Management and Statistical Analysis**

a. **Data Management Methods**

All answers on the survey will be numerically coded. SPSS will be used to perform statistical analysis of responses within and among each of the three study groups.

b. **Quality Control Method**

c. **Data Analysis Plan**

All answers will be numerically coded in excel and SPSS. Numerical codes and their frequencies will undergo statistical analysis.

d. **Statistical Power and Sample Considerations**

From our preliminary work, we found significant results in several areas with only the first 30 responses. From earlier estimates, and experience from St. Vincent's, we expect at least a 40% response rate from patients. Dr. Nguyen is confident there are more than enough patients which fit our criteria for a successful survey.

e. **Study Organization**

f. Data and Safety Monitoring Plan

All data will be stored in a password protected file. Completed paper surveys will be kept in a locked cabinet in the urology department.

6. Risks and Discomforts

None.

7. Potential Benefits

RAS is a fairly new surgical technology in the medical field. This study will pioneer an investigation on perception of RAS from three main, varying perspectives including that of practitioners, the general public, and post-operative patients. Conclusions drawn after data analysis could narrow the scope of focus for potential future research.

8. Privacy Provisions

There will be no personal data collected on parents or patients in this study. We will use implied consent in this study meaning that the cover letter given to the parent/guardian/patient along with the survey will explain the study and include a statement stating that completing and returning a survey constitutes implied consent. In this way we ensure privacy by not identifying surveys with a signature or name. The survey number key will be used to verify needed aspects of the data collection that are specifically detailed in the cover letter. Survey responses will be assessable to only study personnel.

9. Confidentiality Provisions

All information will be accessible to only study personnel.

10. References

Very little research has been done in this area. Study questions are based on our preliminary study, which have yielded significant results.

11. Appendix Materials – please check off as appropriate if included with submission.

- ☐ Sponsor's Protocol
- ☐ Federal grant application (3 copies)
- ☐ Investigator brochure (3 copies)
- ☐ X Survey, questionnaires, assessments
- ☐ Flow charts, schemas
- ☐ X Recruitment letters, postings, flyers
- ☒ Other

Appendix E Correlation Tables

PATIENT POST-OP Corr. Sig. N	What is your age?	What is your total annual household income?	Education Level (Scaled)	Recovery Time	Success Rate	State-Of-The-Art	Procedural Time	Scarring / Cosmetics	How many procedures before becoming highly skilled at robotic assisted surgery?
What is your age?	1	-.036	.037	.056	.101	.115	.062	-.043	.114
		.727	.704	.562	.298	.233	.532	.658	.250
	111	99	110	110	107	109	105	108	103
What is your total annual household income?	-.036	1	.397**	.085	.049	-.172	-.197	-.180	.232*
	.727		.000	.403	.637	.092	.059	.079	.026
	99	99	98	98	95	97	93	96	92
Education Level (Scaled)	.037	.397**	1	-.035	.054	-.235*	-.216*	-.234*	-.016
	.704	.000		.721	.579	.014	.028	.015	.876
	110	98	110	109	106	108	104	107	102
Recovery Time	.056	.085	-.035	1	.632**	.443**	.377**	.446**	.269**
	.562	.403	.721		.000	.000	.000	.000	.006
	110	98	109	110	107	109	105	108	103
Success Rate	.101	.049	.054	.632**	1	.366**	.519**	.283**	.170
	.298	.637	.579	.000		.000	.000	.003	.087
	107	95	106	107	107	107	103	106	102
State-Of-The-Art	.115	-.172	-.235*	.443**	.366**	1	.441**	.442**	.175
	.233	.092	.014	.000	.000		.000	.000	.078
	109	97	108	109	107	109	105	108	102
Procedural Time	.062	-.197	-.216*	.377**	.519**	.441**	1	.607**	-.049
	.532	.059	.028	.000	.000	.000		.000	.632
	105	93	104	105	103	105	105	104	98
Scarring/Cosmetics	-.043	-.180	-.234*	.446**	.283**	.442**	.607**	1	.123
	.658	.079	.015	.000	.003	.000	.000		.218
	108	96	107	108	106	108	104	108	102
How many procedures before becoming highly skilled at robotic assisted surgery?	.114	.232*	-.016	.269**	.170	.175	-.049	.123	1
	.250	.026	.876	.006	.087	.078	.632	.218	
	103	92	102	103	102	102	98	102	103

GENERAL POPULATION Corr. Sig. N	What is your age?	What is your annual household income?	On average, how many hours a week do you use computer technology (i.e. computers, i-pods, cell phones)?	What do you think the robot's involvement is in the control of robotic assisted surgery?	How do you think the overall cost of robotic surgery compares to traditional treatment options for a hospital?	How do you think robotic surgery influences patient recovery time?	How do you think robotic surgery influences the length of a typical operation?	How many procedures do you think a surgeon needs to perform before they become highly skilled at robotic assisted surgery?
What is your age?	1	.047	-.248*	-.258*	-.171	.009	.140	-.091
		.664	.017	.014	.110	.932	.189	.394
	92	87	92	90	88	90	89	89
What is your annual household income?	.047	1	.284**	.072	-.108	-.060	-.070	-.060
	.664		.007	.502	.322	.581	.519	.579
	87	90	90	88	86	88	88	88
On average, how many hours a week do you use computer technology (i.e. computers, i-pods, cell phones)?	-.248*	.284**	1	.094	-.015	.061	-.092	.165
	.017	.007		.370	.888	.561	.384	.116
	92	90	95	93	91	93	92	92
What do you think the robot's involvement is in the control of robotic assisted surgery?	-.258*	.072	.094	1	.262*	.144	-.090	.062
	.014	.502	.370		.012	.170	.393	.558
	90	88	93	93	91	93	92	92
How do you think the overall cost of robotic surgery compares to traditional treatment options for a hospital?	-.171	-.108	-.015	.262*	1	.011	.147	.302**
	.110	.322	.888	.012		.920	.167	.004
	88	86	91	91	91	91	90	90
How do you think robotic surgery influences patient recovery time?	.009	-.060	.061	.144	.011	1	.442**	.155
	.932	.581	.561	.170	.920		.000	.140
	90	88	93	93	91	93	92	92
How do you think robotic surgery influences the length of a typical operation?	.140	-.070	-.092	-.090	.147	.442**	1	.169
	.189	.519	.384	.393	.167	.000		.110
	89	88	92	92	90	92	92	91
How many procedures do you think a surgeon needs to perform before they become highly skilled at robotic assisted surgery?	-.091	-.060	.165	.062	.302**	.155	.169	1
	.394	.579	.116	.558	.004	.140	.110	
	89	88	92	92	90	92	91	92

Appendix F SPSS Commands

These scripts can be used to reproduce some of the data presented in this project, and can be used as a model for modification. To execute these scripts in SPSS, select File->New->Syntax and paste the code. Then select Run->All. To retrieve these scripts, select the “Paste” option before generating the table or graph.

Figure 1:

```
GGRAPH

     /GRAPHDATASET  NAME="graphdataset"  VARIABLES=MEANCI(Q29,  95)  MEANCI(Q30,
   95) MEANCI(Q31, 95) MEANCI(Q32, 95) MEANCI(Q33, 95) MEANCI
      (Q34, 95) MISSING=LISTWISE REPORTMISSING=NO
       TRANSFORM=VARSTOCASES(SUMMARY="#SUMMARY"    INDEX="#INDEX"    LOW="#LOW"
   HIGH="#HIGH")
     /GRAPHSPEC SOURCE=INLINE.
   BEGIN GPL
     SOURCE: s=userSource(id("graphdataset"))
     DATA: SUMMARY=col(source(s), name("#SUMMARY"))
     DATA: INDEX=col(source(s), name("#INDEX"), unit.category())
     DATA: LOW=col(source(s), name("#LOW"))
     DATA: HIGH=col(source(s), name("#HIGH"))
     GUIDE: axis(dim(1), label("Decision Factor"))
     GUIDE: axis(dim(2), label("Mean"))
     SCALE: cat(dim(1), include("0", "1", "2", "3", "4", "5"))
     SCALE: linear(dim(2), min(3))
     ELEMENT: point(position(INDEX*SUMMARY))
     ELEMENT:        interval(position(region.spread.range(INDEX*(LOW+HIGH))),
   shape.interior(shape.ibeam))
   END GPL.
```

Patient Post-Op Correlations:

```
CORRELATIONS
  /VARIABLES=Q1 Q6 Education Q29 Q30 Q31 Q32 Q33 Q26
  /PRINT=TWOTAIL NOSIG
  /MISSING=PAIRWISE.
```

General Population Correlations:

```
CORRELATIONS
  /VARIABLES=Q4 Q9 Q11 Q16 Q18 Q20 Q21 Q22
  /PRINT=TWOTAIL NOSIG
  /MISSING=PAIRWISE.
```

Appendix G Journal Paper

Journal of Robotic Surgery manuscript No.
(will be inserted by the editor)

Perceptions of Surgical Robotics

Joel Sutherland · Dr. Gregory S. Fischer

Received: date / Accepted: date

Abstract We present a study to evaluate the perception of surgical robotics with the aim of helping those in the medical field properly communicate and interact with prospective patients. Study populations include post-operative patients, practitioners, and the general population. The data identifies demographic trends which may help to tailor outreach. It is found that recovery time and success rate are among the most important factors which impact a patient's decision to undergo robotic surgery. We find inconsistent understandings of the advantages and nature of robotic surgery, and suggest the need for better education in these areas.

Keywords Robotic Surgery · Da Vinci · Perceptions

1 Introduction

Robotic Assisted Surgery (RAS) is the next step in the development of surgical techniques. Laparoscopic surgery has been in common use for decades, but surgeons could not achieve the same kind of maneuverability and visibility that were the advantages of open surgery. RAS hopes to solve this problem, providing the convenience of open surgery coupled with the reduced invasiveness of laparoscopic surgery. In 2000, the da Vinci Surgical System was granted FDA approval for general laparoscopic procedures. Since then, over 1,600 systems have been sold[1], and da Vinci now dominates the market for robotic-assisted surgery. This study focuses on the perceptions of and experiences which the Da Vinci system, as well as perceptions of robotics in surgery in general.

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The successful implementation of this promising new technology rests largely on the willingness of the public and the medical establishment to accept and support it, as well as a thorough understanding of its capabilities and shortcomings. To this end, it is necessary to identify the current perceptions of RAS and identify any misconceptions or worries which may be hindering its progress. In this paper, we will discuss work to this end, with the goal of assisting proponents of this technology in addressing the needs and concerns of patients and practitioners alike. In Section 1.1 we will discuss the promise of robotic-assisted surgery and the benefits it presents. In Section 1.2 we will provide a summary of existing work dealing with perceptions of medical and surgical robots.

1.1 The Promise of RAS

Robotic-Assisted Surgery has been widely used to perform laparascopic radical prostatectomies, so much of the data is in this context. The use of the da Vinci system has been shown to reduce the learning curve of experienced open surgeons transitioning to a laparoscopic environment, and also to be accessible to most laparoscopic surgeons[2, 3]. The system is also noted for its relative safety, with reduced blood loss and complication rates[4–6]. RAS has also been shown to be safe and provide advantages for elderly patients [7]. As these procedures become mainstream, it is important to know how such a new technology is received. In this paper, we will discuss existing work done in this area and present new findings. RAS has been under a great deal of criticism for its cost, but reduced recovery times and complications support the economic feasibility of the system[7]. While much of the literature is very positive, there remain worries about the limitations and complications which can arise from transitioning to RAS[8].

1.2 Related Work

Existing literature on the satisfaction of patients and doctors has shown a good deal of satisfaction with complication rates and recovery times for RAS. Bultitude et al. describe increasing interest in robotic procedures, as well as good reception from patients, albeit after initial scepticism[9]. However, many people, especially the elderly, are hesitant to accept robots in medical settings. [10]. Studies have also been done which identify differences in how men and women percieve robots in a medical setting. Kuo et al. found that men were significantly more optimistic and accepting of robots for medical uses than women[11]. Overall, research in this area is thin, and it is important that we collect more data in order to form a clear view of the landscape for RAS. Most of the data concerns patient data, and we propose to analyze that population alongside practitioners as well as the general population.

2 Objectives

Our research aims at understanding the perceptions of RAS from the perspectives of three subject groups: *practitioners* of robotic surgical systems, *patients* who have undergone robotic-assisted surgery, and members of the *general population*.

Each subject group was evaluated separately, and differences among the populations were also studied. Our objectives were as follows:

1. Determine the overall perception of robots in surgery from each perspective
2. Discover common misconceptions and areas of concern which need to be addressed
3. Identify demographic trends in order to better understand how to communicate effectively to different groups of people

This information is to be used to design better surveys for future research, and to help practitioners and hospitals better understand the issues which matter to patients, potential patients, and other practitioners.

3 Study Design

A survey was designed with the intent of gathering preliminary data about perceptions of RAS which would direct future research. Topics addressed in the survey included:

1. Standard demographic information such as age, race, religion, education, and region
2. Comfort with technology, and use of technology
3. Perceived costs of RAS relative to other forms of surgery
4. Perceived length of RAS operations compared to other forms of surgery
5. Perceived learning curve for surgeons using RAS
6. Factors which affected/would affect the decision to undergo RAS

	Patients	**Practitioners**	**Gen. Pop.**
Number	111	30	93
Gender	92.5% Male	87% Male	61% Male
Age	60 Yrs. (30-78)	47 Yrs. (33-64)	45 Yrs. (16-80)

Table 1 Demographic data from each of the three study populations

Patient data was gathered from post-operative surveys at St. Vincent's hospital in Worcester, MA. Surveys were mailed to patients of at least 18 years of age who had undergone RAS, found from a database of existing patients. Each potential participant was mailed a hard copy of the survey with a return envelope. A total of 111 valid responses have been received.

The practioner survey was distributed randomly to surgeons through contact information on Intuitive Surgical's website. These surgeons are those who have completed a product education course with Intuitive, and chose to be listed. 15 surgeons from each state were contacted, and directed to an online form to answer the survey. A total of 35 responses were received, of which 30 were valid, a total valid response rate of 4%.

General population data was collected through the use of random mailings. A pilot mailing of 50 surveys resulted in a 10% return rate. 1000 surveys were distributed in order to acheive the goal of at least 80 completed surveys. Of the 1000, 63 were returned resulting in a 6.5% total return rate (including the pilot). In order to acheive the goal, additional surveys were distributed through online survey postings on websites and forums. Participants were directed to an online form similar to the practitioner form. This resulted in an additional 32 responses. In total, 93 valid responses were received (5 from pilot + 63 from full mailing + 32 from online - 7 invalid responses).

Table 1 describes demographic data from the three populations. At St. Vincent's, the Da Vinci is used primarily for radical prostatectomies, so patient demographic data is largely middle-aged and male.

4 Results

4.1 Patient Post-Op

Factor	Avg. Rating	Std. Dev.
Recovery Time	4.67	0.73
Success Rate	4.57	0.86
State-of-the-Art Aspect	4.27	1.13
Procedural Time	3.84	1.17
Scarring or Cosmetics	3.79	1.22
Cost	3.51	1.24

Table 2 Post-operative patients were asked to rate the importance of these factors in their decision to undergo robotic surgery, on a scale from 1-5, 5 being the greatest. This table presents the mean and standard deviation of the facrtors in question, ranked from most important to least important.

In Table 2 we show how patient rated various factors into their decision to undergo RAS. "Recovery Time" and "Success Rate" receive the highest ratings. These are followed by the "State-of-the-Art" aspect,"Procedural Time", and "Scarring and Cosmetics". "Cost" is the least important of the factors we had rated.

Correlation	Sig.
Higher education level and valuing "state-of-the-art" aspect more	0.05
Higher income and valuing cost less	0.01
Higher income and higher standards for surgeon experience	0.05

Table 3 Significant correlations found in the patient post-op survey results.

In Table 3 we relevant correlations found in the patient post-op data. We find that the "state-of-the-art" aspect is valued more highly by those who have completed higher levels of education (p = 0.049). Those with a higher income care less about the cost of the operation (p = 0.006), and hold higher expectations for the experience of RAS surgeons (p = 0.031).

In Table 4, we see that an overwhelming majority of respondents (96.2% of patients, and 84.6% of the general populatoin) correctly identified the robot as an "Enhanced Surgical Instrument". However, responses to the questoin of control are much more variable, even in the practitioner population. Opinions on the cost of the procedure are also mixed, with 43.9% of patients and 43.8% of the general population thinking that it costs more. In all three populations, a plurality of respondents think that RAS reduces recovery time, with the patient population being the most confident (67.1%). In all three populations, a majority think that RAS reduces operation times.

Role	Patients	Gen. Pop.	Pract.
I'm not sure	01.3%	07.7%	–
Enhanced Surgical Instrument	96.2%	84.6%	–
Independently-Thinking Surgeon	01.3%	01.1%	–
Diagnostic Tool	01.3%	05.5%	–
Control	**Patients**	**Gen. Pop.**	**Pract.**
I'm not sure	06.3%	15.4%	10.3%
No Involvment	19.0%	04.4%	44.8%
Minimal Involvement	29.1%	36.6%	17.2%
Major Involvement	38.0%	36.6%	27.6%
Complete Involvement	07.6%	05.5%	00.0%
Factor	**Patients**	**Gen. Pop.**	**Pract.**
Cost			
More	43.9%	43.8%	–
Less	37.8%	25.8%	–
Same	18.2%	28.1%	–
Recovery Time			
More	26.3%	22.0%	22.0%
Less	67.1%	42.9%	41.8%
Same	06.6%	34.1%	34.1%
Procedure Length			
More	23.6%	10.0%	10.0%
Less	55.5%	68.9%	67.8%
Same	20.8%	18.9%	18.9%

Table 4 In "Role", patient post-op and general population participants were asked to indicate the role of the robot in RAS, from the listed possibilities. In "Control", patient post-op and general population participants were asked to indicate the level of control the robot has, from the listed possibilities. In "Factor", participants in the patient post-op and general population groups were asked to indicate the relative cost, recovery time, and procedure length of RAS compared to other forms of surgery. The frequency of each response for the two populations is presented here.

4.2 General Population

Correlation	Sig.
Preferece for RAS decreases with age	0.05
Men more likely to choose RAS	0.05

Table 5 Significant correlations found in the general population survey results.

As shown in Table 5 Men were significantly more likely to choose RAS over traditional forms of surgery (p = 0.028). We also observed a negative correlation between age and willingness to undergo RAS (p = 0.039). 62.5% of total respondents to the general population survey said they would choose RAS over other forms of treatment if it was available.

Learning Curve	Preference for RAS
No Response	50.0% (n = 4)
0-5	33.3% (n = 3)
5-10	85.7% (n = 7)
10-20	52.6% (n = 19)
20-30	58.8% (n = 18)
30-50	76.9% (n = 13)
50+	62.5% (n = 24)

Table 6 Among the general population, the rate a which participants would choose RAS over traditional forms of surgery, based on their respons to the question "How many procedures do you think a surgeon needs to perform before they become highly skilled at robotic assisted surgery?"

Perceived Control	Preference for RAS
No Response	50.0% (n = 2)
I'm not sure	50.0% (n = 14)
No involvement	75.0% (n = 4)
Minimal involvement	53.3% (n = 30)
Major involvement	72.7% (n = 34)
Complete involvement	80.0% (n = 5)

Table 7 Among the general population, the rate a which participants would choose RAS over traditional forms of surgery, based on their respons to the question "What do you think the robot's involvement is in the control of robotic assisted surgery?"

4.3 Practitioners

Of the practitioners surveyed, 4 (13%) would prefer to spend more time discussing RAS with patients, and 1 (3%) would like to spend less.

4.4 Cross-Population

In Table 4, we find that patients as well as the general population understand the nature of RAS systems, with fewer than 10% misidentifying the role of the robot in surgery.

We also find that there is a wide spread for the perceived level of control of the robot, with no answer securing more than 40% in either population. Table 4 shows the relative perception of cost, recovery time,

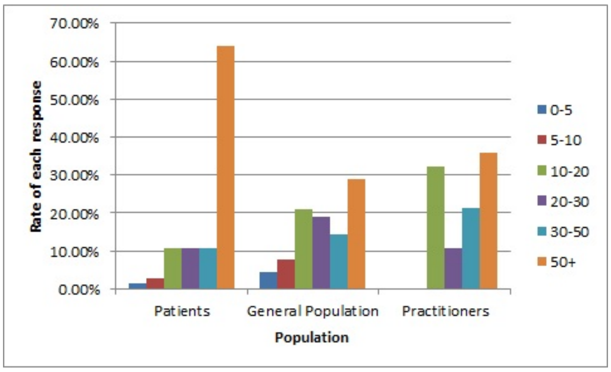

Fig. 1 Participants from each population were asked to estimate the number of procedures required for a surgeon to become "highly skilled" at RAS.

and procedural length of RAS compared to traditional surgery. We find that most patients believe that RAS improves recovery time and procedure length.

Table 1 shows the perceptions of learning curve for each of the three populations. Post-op patients show the highest expectations for surgeon experience, while the other two populations show a wide spread of opinion.

5 Discussion

Preliminary survey data show promising reactions to RAS technology, and optimistic estimations of its benefits. This is reassuring, as in many cases the introduction of robotic systems into sensitive areas of life (such as medicine) has met some resistance.

Factors taken into account when patients are choosing RAS provide much useful information. The results show that the advantages of RAS in terms of recovery time and success rate are resonating well with patients. There also appears to be a strong attraction to RAS from the "state-of-the-art" aspect. It reflects a growing willingness to take advantage of new technology. Our data also shows that women and older persons are more hesitant to choose RAS over traditional surgery. This is consistent with existing studies [11].

Perceptions of the learning curve in RAS was very mixed. It is useful to compare these results with existing data. Ahlering et al. studied a surgeon transitioning from open to robotic-assisted surgery with a learning curve of 12 operations [2]. Lenihan et al. studied the learning curve of gynecological surgery and arrived at a total of 50 procedures needed before stabalization of operation times [3]. Menon et al. compared the results of laparoscopic surgeries and RAS in radical prostatectomies, and found that after 18 surgeries, RAS results reached that of surgeries by experienced laparoscopic surgeons [12]. Giulianotti et al. suggest that 20 operations is sufficient [13]. Conclusions regarding learning curve, however, are mixed and largely anecdotal. Kaul et al. discuss the difficulties in establishing consistent measures of learning curve for RAS [14].

There is still much education needed about the nature and advantages of RAS. Responses about these topics were wide-ranging, and there does not seem to be a firm "common-knowledge" about RAS. In particular, people are not well-informed as to the nature of the system's control during surgery. Labelling the procedure "robotic" gives an impression of automation, which is not appropriate in this case. Those who wish to educate should be firm in making the distinction.

6 Future Work

This work serves as a preliminary study into the perceptions of robotic surgery among various populations. In order to make wide-ranging conclusions, however, this research must be expanded to include a much broader spectrum within these populations and possibly others. Furthermore, these preliminary results will enable us to refine our survey tactics in order to generate more useful data. To this end, an updated survey has been developed from the results of this preliminary study, which will add to the quality of our conclusions. As a part of this, we identified several questions which were ambiguous and could have produced misleading results:

1. The survey failed to distinguish between open and laparoscopic surgery when asking for comparisons to RAS, which is often used when laparoscopic surgery would be the defaul procedure. If participants were making comparisons to open surgery, the differences might be exaggurated and less relevant. Future surveys will separate these two methods when asking for comparisons.
2. The question of "control" was unclear when participants were asked to indicate the level of control of the robot. Future surveys will ask about the robot's role in "decision-making" which is the original intent of the question. We are seeking to determine if there is a widely-held misconception that the robot is acting autonomously or semi-autonomously.

In addition, further research will be needed when new robotic systems come into use in the medical field. This will make it more difficult to generalize to robotic-assisted surgery as a whole, as the new systems might be very different in capabilities and implications. It is also possible that the perceptions of the Da Vinci system will be projected onto future systems, which would make it more difficult to properly communicate the capabilities of new systems.

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