Contribution of laparoscopic surgical experience to the development of robotic proficiency

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Abstract

Background: *Robotic surgery has diffused into clinical surgical practice and provides a minimally invasive opportunity for several surgical procedures across multiple specialties. It is common for traditional laparoscopic surgeons to train and become privileged to perform robotically-assisted MIS procedures. However, there is some question as to the degree to which experience in laparoscopy will support superior performance in robotic surgery. It would be useful to know whether a surgeon's years of laparoscopic experience are supportive of immediate beneficial performance in robotic-assisted MIS, or whether skills in robotic-assisted surgery must be developed independently once trained in the techniques.*

Methods: *Surgeons were tested in their ability to perform four different simulated robotic surgical skills using the dV-Trainer simulators (Mimic Technologies, Inc., Seattle, WA) of the da Vinci surgical robot (Intuitive Surgical Inc., Sunnyvale, CA). The subjects completed a pre-test questionnaire to provide demographic and surgical experience data, which included the number of years of practice in both laparoscopic and robotic surgery. Each subject performed four skills exercises using the simulator - specifically a pegboard, camera targeting, thread the rings, and energy dissection exercises. The simulator collected multiple performance metrics during each of these exercises. Statistical correlation was computed on the relationship between the number of years of laparoscopic and robotic experience (independent) with the scores achieved in overall proficiency and the time to complete each exercise (dependent). Higher overall proficiency and lower time to completion may indicate increasing skill in performing the exercises and a positive correlation with years of experience.*

Results: *A total of 24 subjects completed all four tasks in the experiment. These subjects self-reported a range of experience in laparoscopic surgery between 4 and 34 years, and robotic surgery between 0 and 4 years. For this analysis those indicating zero years of robotic experience were omitted, reducing the sample size to 19 surgeons. Using the Pearson Product Moment Correlation with 17 degrees of freedom and α=0.05 establishes a significant correlation threshold of 0.456. We found a statistically significant negative correlation between years of laparoscopic experience and the overall proficiency score in three of the four robotic surgery exercises (camera targeting = 0.581; thread rings = 0.474; and energy dissection = 0.513), and a negative correlation with time to complete in one exercise (peg board = 0.543). This data refuted our hypothesis that more years of laparoscopic experience would indicate higher levels of proficiency in robotic skills. Rather than a statistically significant positive correlation, the data showed repeated significant negative correlations between these variables. We also checked for a possible negative correlation between the number of years of laparoscopic and robotic surgical*

experience, which would indicate that surgeons with more laparoscopic experience would consistently have less robotic experience than their peers. However, the correlation between these two variables was 0.039, indicating almost no correlation between the two.

Conclusions: *Using a simulator to measure the proficiency of surgeons with both laparoscopic and robotic surgical experience we found a statistically significant negative correlation between the number of years of laparoscopic experience and proficiency in three of the four exercises. Surgeons with more experience in laparoscopy performed worse than those with less experience in laparoscopy. However, we also found that there was not a statistically significant correlation between years of robotic experience and performance on the exercises.*

This analysis suggests that years of laparoscopic experience may be detrimental to developing expertise in robotic-assisted MIS. However, the lack of correlation between overall score and robotic experience leads us to question whether the exercises have the ability to predict or measure expertise in subjects. Further research is required to determine the effect that years of prior laparoscopic experience will have on learning and performing robotic procedures.

Background:

Robotic surgery has diffused into clinical surgical practice and provides a minimally invasive opportunity for several surgical procedures across multiple specialties. During the last decade, robotic surgery has transitioned through a similar evolution to laparoscopic surgery and is being recognized as an important surgical approach by multiple surgical specialties. Furthermore, it shows every sign of continuing the adoption of more diverse surgical procedures, as manifest by the fact that in calendar year 2011, approximately 350,000 robotic surgical procedures were performed [1].

It is common for traditional laparoscopic surgeons to train and become privileged to perform robotically-assisted MIS procedures. These surgeons often come to this new technology with a number of years of prior experience in traditional laparoscopy. However, there is some question as to the degree to which this experience supports superior performance in robotic surgery. Some maintain that robotic surgery is simply an extension of traditional MIS, hence the common reference to "robotically-assisted MIS". Others however, believe that robotic surgery requires core unique skills which are not common to traditional MIS and that MIS experience provides little advantage in learning robotic techniques. An objective measurement of this relationship would beneficial in designing training programs for surgeons who are converting from traditional MIS.

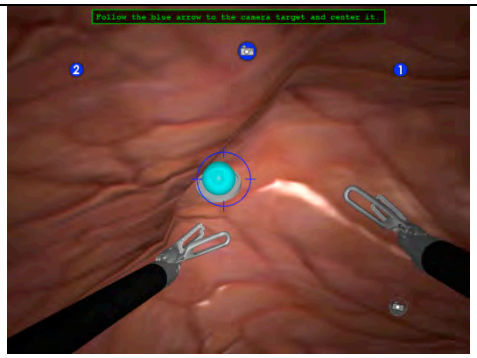
Methods:

Florida Hospital Nicholson Center is conducting multiple research studies into the effectiveness of robotic surgical techniques and various methods to extend these to new applications. One of these is an investigation into the possibility of extending the distance between the surgeon's

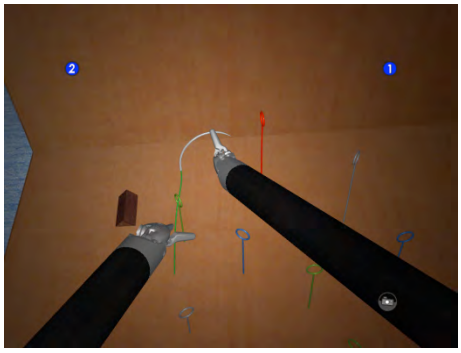
console and the patient so that telesurgery could be performed in a metropolitan area with distances on the order of 100 miles. As part of this experiment, surgeons were tested in their ability to perform four different simulated robotic surgical skills using the dV-Trainer simulators (Mimic Technologies, Inc., Seattle, WA) of the da Vinci surgical robot (Intuitive Surgical Inc., Sunnyvale, CA). Each of these exercises was first performed in the conventional environment with no telesurgery effect -- that is no latency between a surgeon's actions and the response in the simulated surgical field. This data was used to understand the surgeon's level of skill in robotics without the complication of telesurgery. Prior to the experiment, each subject completed a pre-test questionnaire to provide demographic and surgical experience data, which included the surgeon's age, number of years of practice in laparoscopic, and robotic surgery.

Each subject performed four skills exercises using the simulator - specifically a peg board, camera targeting, thread the rings, and energy dissection exercises (Figure 1). The simulator collected multiple performance metrics during each of these exercises. These included a measure of overall proficiency, the time to complete the exercise, and multiple measures of hand movement, instrument collisions, dropping of the object, and field of view of the camera. Based on previous validation studies with this simulator, surgeons who are more proficient with robotic surgery should achieve a higher composite score and a shorter completion time [insert references here].

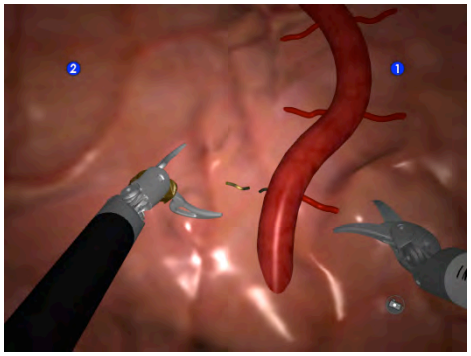
Ring Board



Camera Targeting



Needle Threading



Energy Application

Figure 1. Simulated Robotic Surgical Skills Tasks

During this experiment, the simulator was configured to represent the S model of the da Vinci surgical robot. The primary difference between the S and the more current Si robot is in the method used to clutch the hand controls. The s model clutch is operated via a foot pedal and the Si provides an option to use a finger clutch. The Si also has a different foot pedal for switching between the robotic arms which are controlled, but this operation was not required in any of the four exercises used in this study.

The data from each simulator was blinded from the identity and experience levels of the surgeon participating in the experiment. All association was via subject number.

Pearson's correlation was computed on the relationship between the number of years of laparoscopic and robotic experience (independent variables) with the scores achieved in overall proficiency and the time to complete each exercise (dependent variables). Higher overall proficiency and lower time to completion indicate increasing skill in performing the exercises and a positive correlation with years of robotic experience.

Results:

A total of 24 subjects completed all four tasks in the experiment. These subjects self-reported a range of experience in laparoscopic surgery between 4 and 34 years, and robotic surgery between 0 and 4 years (Table 1).

The analysis for this paper focused on the impact of laparoscopic experience on robotic performance for practicing robotic surgeons. Therefore, those subjects indicating zero years of robotic experience were omitted from the analysis, reducing the sample size to 19 surgeons.

Table 1. Subject Self-Reported Experience Levels

Age	Total Exp (Years)	Laparoscopic Exp (Years)	Robotic Exp (Years)
34	0	0	0
65	27	27	0
41	21	10	0
61	30	30	0
53	25	20	0
49	5	4	1
63	34	34	1
51	22	22	1
56	20	15	1
57	21	21	1
68	37	30	2
51	14	6	2
63	30	34	2
50	24	24	3
45	13	13	3
41	13	13	3

60	20	20	3
62	30	30	3
46	16	13	4
40	10	10	4
35	11	11	4
68	38	30	4
52	25	25	4
63	30	25	4

Using the Pearson Product Moment Correlation with 17 degrees of freedom and α=0.05 establishes a significance threshold of 0.456 for this sample size.

Table 2 provides a correlation between the leading independent variables collected, specifically age, total experience, laparoscopic experience, and robotic experience.

Table 2. Correlation Coefficients between Independent Variables

	Age	Total Exp	Lap Exp	Rob Exp
Age	1.000	0.868	0.777	-0.257
Total Exp		1.000	0.940	-0.014
Lap Exp			1.000	-0.039
Rob Exp				1.000

It is important to note that there is a very strong and significant correlation between age, total experience, and laparoscopic experience. As one would expect of a surgeon who has primarily been practicing laparoscopy for a career, the experience total and with laparoscopy are very strongly related, as is the connection to age which is almost a surrogate for total years of experience. However, it is also important to notice that for this sample, the correlations between all of those variables and robotic experience is extremely weak and not near statistical significance. This lack of correlation is important in ruling out the possibility that a measurement of the effects of laparoscopic or total experience is actually capturing the effect of more or less robotic experience. Since there is no positive or negative correlation, this means that robotic experience levels are independent of all of those variables.

With this understanding of the relationship between the potential independent variables, we continued with an analysis of the relationship between each of these variables and performance in the dV-Trainer robotic simulator for the four exercises described earlier. The correlations between those variables are shown in Table 3.

Table 3. Correlations between Independent and Dependent Variables for Four Exercises

Pegboard	Age	Total Exp	Lap Exp	Robotic Exp
Overall Score	-0.427	-0.283	-0.339	0.375

Time to Compl	0.451	0.535	0.543	-0.227

Camera Tgt	**Age**	**Total Exp**	**Lap Exp**	**Robotic Exp**
Overall Score	-0.363	-0.434	-0.581	-0.089
Time to Compl	0.349	0.342	0.434	-0.026

Thread Rings	**Age**	**Total Exp**	**Lap Exp**	**Robotic Exp**
Overall Score	-0.711	-0.553	-0.474	0.238
Time to Compl	0.597	0.507	0.407	-0.345

Energy Dissect	**Age**	**Total Exp**	**Lap Exp**	**Robotic Exp**
Overall Score	-0.696	-0.595	-0.515	0.264
Time to Compl	0.474	0.474	0.446	-0.231

Laparoscopic Experience

This data a statistically significant negative correlation between several of the variables. The relationship is not common to all four exercises, nor to all of the reported levels of experience (total, laparoscopic, and robotic). The relationship is significant when comparing laparoscopic experience to overall performance in camera targeting (r=-0.581); thread rings (r=-0.474); and energy dissection (r=-0.515). In the pegboard exercise, there is a positive correlation between laparoscopic experience and time to complete the exercise (r=0.543). Among experienced robotic surgeons, there are different views on whether longer times to complete an exercise or procedure indicate a lower level of expertise, or whether this is really a measure of personal style with some surgeons preferring a slower and more methodical approach regardless of their level of expertise.

Notice that for two of the exercises, subject age and total experience is also negatively correlated to overall performance.

Robotic Experience

It is equally interesting to note that overall performance scores are not significantly correlated to the number of years of robotic experience for subjects reporting between 1 and 4 years of experience with this technology. None of the four exercises showed a significance in the level of performance difference as surgeons became more experienced. In three of the exercises, the relationship is positive, but not statistically significant.

Conclusions

If the relationship between laparoscopic experience and overall performance scores are examined independently, it would appear that more years of experience with traditional laparoscopy would negatively affect performance in robotic surgery, at least during the first four years of robotic practice. Some experienced robotic surgeons have suggested that this might be due to significant differences between the equipment and techniques used in the two approaches. They point specifically to the availability of a wrist joint in robotic instruments which is not available in

laparoscopic equipment. The four exercises used in this experiment do not require or allow the use of the "4th arm" of the da Vinci robot, so its impact could not be measured negatively from lack of experience or positively for those with more robotic experience.

However, before making such a conclusion, we should extend our consideration to the relationship that appeared with total experience, age, and robotic experience as well.

Correlation with Age

The strong correlation between laparoscopic experience, total experience, and age that was shown in Table 2 would lead us to expect that when laparoscopic experience is correlated with overall score or time to complete, that the other two variables are also very likely to be found to have a similar correlation and that that would be significant when the laparoscopic correlation is strongly significant. The results of the experiments do show this exact relationship. It is possible that the experiments are showing a relationship between the age of the subject and their performance on the simulator. There has been much speculation in the simulation literature on the performance of older and younger subjects to be influenced by prior years of experience using similar technologies, such as computer games and video game consoles. Younger subjects may have much more expertise in visually understanding and physically navigating these computer generated spaces. Given the strong correlation between age and laparoscopic experience in this study, such a phenomenon could be the cause of the negative correlation with performance.

Robotic Experience

Finally, we turn our attention to the relationship between robotic experience and overall performance. It is interesting that using a system which is designed to train robotic surgeons in the skills that they will use in real operations, that no correlation was found between the performance of subjects with experience between 1 and 4 years and the scores they are able to achieve in the simulator. These variables are positively correlated, but not at a statistically significant level in this study. This could indicate that the simulator exercises that were chosen for the study are not good surrogates for real surgery. Performance in these is not able to predict years of experience of the subject. It is also important to note that experience in surgery is not just measured in years of practice, but also in the frequency and currency of that practice. So subjects who perform more surgeries per week would be expected to perform better than those who perform fewer even when the former have fewer years of experience than the latter.

In summary, the data from this experiment has raised some interesting questions regarding the effect of both laparoscopic and robotic experience on performance in a simulated environment. But more focused studies are needed to arrive at any firm conclusions on this topic.

References

(Simulator references below. Need other clinical references.)

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