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Research Article

Robotic Training in General Surgery Residency: How Early Can We Begin?

Abstract

Background: The increasing demand for robotics in general surgery has prompted academic institutions to train general surgery residents toward the acquisition of basic robotic skills. Our current robotic training curriculum begins in the PGY-3 year and is based on the use of surgical simulators in a risk-free environment, in which each resident must show proficiency prior to advancing to training on an animate model as PGY-4. Our unpublished data on the curriculum indicates that PGY-3s required additional remediation training on the robotic simulator, suggesting room for improvement in our teaching paradigm [8]. Because of resident duty hour restrictions, we could not provide remediation by simply increasing the number of training sessions. We therefore decided to investigate an alternative strategy of shifting the training to an earlier time point in general surgical residency during PGY-1 and PGY-2 years. To explore the feasibility of a new curriculum, we undertook a pilot study to investigate the willingness of residents in their PGY-1 and PGY-2 years to begin robotic training on the robotic simulator, the dV-Trainer (dV-T). We also wanted to see if even minimal early exposure to the dV-T would help overcome residents' initial diffidence in using the daVinci Surgical System (DaVss).

Methods: Ten general surgery residents (seven PGY-1s and three PGY-2s) with no prior exposure to robotic training were randomly distributed into MIMIC (MIM G) and daVinci (DaV G) groups. The MIM G subjects answered a post-exposure questionnaire about their overall experience with the robotic training. The five MIM G subjects performed five basic skills exercises on the dV-T simulator prior to executing the same exercises on the DaVss, while the five DaV G subjects performed the same exercises only on the DaVss. Two blinded robotic proctors scored each subject's performance on the DaVss.

Results: All MIM G subjects found their overall experience constructive and viewed the dV-T as useful in preparing them to complete subsequent tasks on the DaVss. The MIM G subjects also performed better than the DaV G ($p=0.32$) subjects in operation of the da-Vss, although statistical significance could not be achieved. Given the small sample size, statistical significance was unlikely.

Conclusions: The subjective perception of the dV-T experience was strongly positive, as the residents enjoyed the experience and seemed to be open to the possibility of introducing some robotic training with the robotic simulator earlier in their career. We attribute the fact that MIM G residents performed better with the DaVss than the DaV G residents to the value of minimal exposure to dV-T as a way to overcome the discomfort of using the DaVss for the first time.

Introduction

The use of robotics in medicine has increased from 25,000 per year in 2005 to 450,000 per year in 2012 [1]. In particular, surgical robots accounted for over 60% of the largest share in 2014, due to the increasing demand for minimally invasive surgeries and the growing use of surgical robotic equipment in hospitals [1]. In fact, the global market for robotic systems is expected to reach 17.9 billion USD by the year 2022, with an estimated growth rate of 12.7% from 2014 to 2020 [1]. Expanding upon the experience of a group of general surgeons who had previously pioneered the development and implementation of robotic surgery in their field, the use of this technology in general surgery is now catching up to other robotic sub-specialties [2]. A growing number of general surgery procedures, ranging from bariatric procedures to colon resections, are being performed robotically [3,4]. Naturally, the trend of more robotic general surgery cases is accompanied by a requirement for more robotically trained general surgeons. This increasing need for robotic training poses multiple challenges, such as limited hands-on teaching during live surgery, the expense of animal model robotic training,

and the resource- and time-consuming need to train not only surgical residents and fellows, but also seasoned and experienced laparoscopic attending physicians.

The robotic platform is complex, unique and requires dedicated training. The use of surgical simulators in a training environment is ideal because there are no risks imposed upon patients. We use the dV-Trainer (dV-T) surgical simulator for the training of our residents because its user interface, content, and construct validity have been demonstrated by multiple studies and it closely recreates a tridimensional field [5-7].

At our institution, we have implemented a standardized robotic training surgical curriculum in which general surgery PGY-3 residents complete five one-hour training sessions and one final examination prior to advancing to training on an animate model, in which they must complete six one-hour training labs and one final examination. In our curriculum, dV-T training does not commence until the PGY-3 year under the assumption that robotics training is a complex activity that requires at least some degree of prior experience with minimally-invasive surgical techniques. We felt that PGY-

1 and PGY-2 residents, who are just beginning their careers as general surgery trainees, might perceive such additional training as overwhelming,

However, we found that all PGY-3 residents required at least one remediation session before achieving basic robotic competency in the stimulated environment, delaying their advancement to the use of the DaVss on the porcine model [8]. However, due to the 80-hour week duty restrictions in general surgery residency, we struggled to add more training sessions throughout the academic year. Instead, we considered the possibility that PGY-3 may not necessarily be the optimal time to introduce robotics and training and we pursued an alternative strategy of shifting robotics training to an earlier time point in residency. We implemented a pilot study examining PGY-1 and PGY-2 residents' willingness to participate in robotic training with the dV-T simulator. By comparing robotic surgery performance parameters between trainees who participated in simulator training to those who did not, we examined the quantitative and qualitative impact of the simulation training at an early stage of surgical residency on these individuals' subsequent performance on and perception of the DaVss.

Methods and Materials

Curriculum

In our proposed early introduction to robotics, PGY-1 and PGY-2 residents performed five basic skills exercises on the dV-T and/or the DaVss, depending on the study group. The five exercises included overview of controls with special emphasis on the use of robotic gimbals, camera and clutch pedals, camera targeting, pick and place, and ring and rope walk.

Subjects

The research activities conducted at our surgical skills laboratory involving training and surgical simulation are covered with approval from our Institutional Review Board.

We recruited ten general surgery residents, seven PGY-1s and three PGY-2s, without prior experience in robotic surgery, and randomly distributed them into two groups. Five subjects were assigned to the MIMIC group (MIM G); these subjects performed the five exercises that comprised the curriculum on the dV-T simulator, and subsequently executed the same tasks in the daVss dry lab. The other five subjects were assigned to the daVinci group (DaV G); these subjects performed the five exercises on the DaVss without prior exposure to the dV-T simulator.

Qualitative assessment

The MIM G residents were queried about their perception of their dV-T experience. They completed a six-question Self-Assessment Questionnaire about MIMC Experience, in which each question was answered on a five-point analog scale (Figure 1).

Quantitative assessment

The dV-T software assessed the residents' performances using its built-in MScore system, which factors comprehensive metrics and

1. How closely do you think the virtual surgical field of the simulator represents the DaVinci surgical field?
2. Did the use of the simulator facilitate your confidence with the use of the DaVinci's clutch and camera pedals?
3. Did the simulator facilitate the use of wrist range of motion rather than your entire arm while performing the surgical tasks on the DaVinci?
4. Did the simulator help you to avoid unnecessary collisions between instruments while performing task on the DaVinci?
5. Overall how helpful was the simulator in improving your confidence when using the DaVinci the first time?
6. Do you think that additional exposure to the simulator would further improve your

Figure 1: Self-Assessment Questionnaire about MIMIC Experience (Analog Scale 0-5).

experiential data from more than 100 surgeons in order to provide a parameter on which to grade users of the simulator. The assessment was designed so that the resident had to achieve a proficiency score of $\geq 80\%$ in a task set before proceeding to the next task set.

The performance of both the MIM G and DaV G groups on the DaVss was assessed by two general surgery proctors, both formally trained in robotics and minimally invasive surgery and both with at least one year of experience teaching in the robotics lab. The proctors were blinded to whether the subjects had prior training on the dV-T simulator. The two raters were trained on the use of the assessment tool, which was a rubric extrapolated from the validated Global Evaluative Assessment of Robotic Skills (GEARS) tool [9], (Figure 2). This tool addressed the subjects' depth perception, efficiency, and other skills. We also included a final question addressing the potential of the trainee as a future robotic trainee.

Statistical analysis

For the GEARS tool quantitative assessment, the mean values for the dependent variables were compared with one-way repeated measures ANOVA. Bonferroni corrections were performed when factors were significant. All statistical analyses were performed using the SPSS. The significance level was set at $p \leq 0.05$.

Results

Qualitative assessment

The MIM G subjects reported a positive perception of their experience with the dV-T prior to operation of DaVss. 80% of the residents scored their overall perception of the dV-T as extremely helpful. These residents reported that the virtual field of the MIMIC simulator was very close (80%) or extremely close (20%) to the daVss field, and 80% of them reported that the dV-T was either extremely (60%) or very helpful (20%) in improving their confidence with the use of the DaVss pedals. 80% of the interviewed subjects reported that the dV-T was extremely helpful in preventing unnecessary collisions while using the DaVss for the first time. Interestingly, only 20% of them believed that no additional exposure would be necessary to further improve their confidence while approaching the DaVss, suggesting that most residents believed more practice would be beneficial.

| Depth perception | | | | |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| Constantly overshoots target, wide swings, slow to correct | | Some overshooting or missing of target, but quick to correct | | Accurately directs instruments in the correct plane to target |
| Bimanual dexterity | | | | |
| 1 | 2 | 3 | 4 | 5 |
| Uses only one hand, ignores nondominant hand, poor coordination | | Uses both hands, but does not optimize interaction between hands | | Expertly uses both hands in a complementary way to provide best exposure |
| Efficiency | | | | |
| 1 | 2 | 3 | 4 | 5 |
| Inefficient efforts; many uncertain movements; constantly changing focus or persisting without progress | | Slow, but planned movements are reasonably organized | | Confident, efficient and safe conduct, maintains focus on task, fluid progression |
| Force sensitivity | | | | |
| 1 | 2 | 3 | 4 | 5 |
| Rough moves, tears tissue, injures nearby structures, poor control, frequent suture breakage | | Handles tissues reasonably well, minor trauma to adjacent tissue, rare suture breakage | | Applies appropriate tension, negligible injury to adjacent structures, no suture breakage |
| Autonomy | | | | |
| 1 | 2 | 3 | 4 | 5 |
| Unable to complete entire task, even with verbal guidance | | Able to complete task safely with moderate guidance | | Able to complete task independently without prompting |
| Robotic control | | | | |
| 1 | 2 | 3 | 4 | 5 |
| Consistently does not optimize view, hand position, or repeated collisions even with guidance | | View is sometimes not optimal. Occasionally needs to relocate arms. Occasional collisions and obstruction of assistant. | | Controls camera and hand position optimally and independently. Minimal collisions or obstruction of assistant |

Figure 2: Global Evaluative Assessment of Robotic Skill (GEARS).

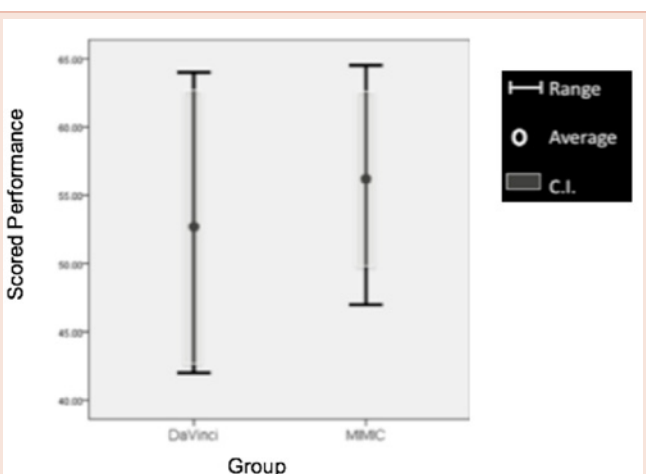


Figure 3: Assessment of Trainees on DaVss.

Quantitative assessment

When comparing the performance of both MIM G and DaV G subjects on the DaVss, a positive trend was noted relating the experience of robotic simulation with dV-T to subsequent achievement when operating the DaVss (Figure 3). The MIM G subjects, on average, scored higher when using the DaVss. Although this did not reach statistical significance ($p=0.32$), the small sample size likely represented the main limiting factor.

Discussion

The gap between demand for robotic surgical procedures and availability for robotic training is growing [10]. An investigative survey found that although more than 96% of participating residents reported that their institutions had a surgical robotic system, only 18% of these individuals reported experience with operating the robotic console [11]. 60% of the residents also indicated that they received no education or training prior to their first robotic case [11].

We believe it is important that academic institutions begin to train general surgery residents toward the acquisition of at least the basic robotic skills in a risk-free environment prior to exposing them to real life patients. This conviction is in accordance to the approach that has already been largely validated in other medical and non-medical fields, such as civil and military aviation [12].

Based on time restrictions, we currently offer our PGY-3 and PGY-4 residents only five or six one-hour sessions for robotic simulator training, which are scheduled on Saturdays in order to prevent schedule conflict with clinical duties, throughout the year. However, our unpublished data has suggested that this number of sessions is insufficient in achieving proficiency as documented by the number of remediation session required by our residents [8]. To investigate whether introducing robotic training earlier in residents' career is a feasible solution, we assessed the responses of PGY-1 and PYG-2 residents to first time exposure to robotic training simulation. It is worth noting that our intent was not to prove face validity of the robotic simulator, but instead we meant to sample intern and junior residents' perception of the robotic experience earlier in their surgical career than had been done with our prior training curriculum. We were pleased by the enthusiasm of our novice residents, who expressed an overall strongly positive perception of the virtual reality robotic training. These results are promising and perhaps indicate that novices have a more open-minded approach to robotic training than we had previously assumed.

In addition, quantitative assessment showed a positive trend relating minimal exposure to the dV-T and more successful operation of the Da-Vss. We do not believe that this positive correlation can be explained by the formal benefit of a single exposure to the dV-T. Instead, we interpret this result to mean that only minimal exposure to the dV-T might be sufficient to overcome the initial diffidence related to the first time use of the DaVss. We hope that this study can provide guidance to other academic institutions interested in either implementing or fine-tuning an existing robotic training curriculum. We also hope that this study can prime growing interest among other general surgery residency programs in the conversation regarding robotic surgery and the future it holds.

Our study was mainly limited by its small sample size, which does not allow us to draw definitive conclusions about our results. Furthermore, the Self-Assessment Questionnaire was created 'ad hoc' to sample our novice residents' about their initial experience with robotic surgery training, and we acknowledge that this is not a validated survey. However, we had to make a strategic decision regarding our curriculum for the upcoming academic year, so it was important for us to gather residents' feedback in an efficient way. We would have liked to adopt a previously validated survey, but to our knowledge, there are no similar initiatives available in literature.

Conclusions

PGY-1 and PGY-2 residents' subjective perception of the dV-T experience was overall strongly favorable. The results also showed a higher level of performance by first-time users of the DaVss after minimal exposure to dV-T, as compared to subjects without previous exposure to dV-T. The small study sample size did not allow us to draw any definitive conclusions, but our results suggest potential feasibility and benefit in the implementation of a robotic simulation curriculum early (PGY-1 and PYG-2 years) in the training of general surgery residents.

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