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Robotic4all project: Results of a hands-on robotic surgery training program

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ABSTRACT

Objective: Although robotic surgery adoption and its indications are growing worldwide, for multiple factors, including costs, there is a lack of training and experience. Our aim was to study the impact of a robotic introduction training program on gesture performance, such as suturing, in robot-naive individuals.

Methods: Using the DaVinci robot, a 2-hour program was based on virtual reality and anatomical model exercises. All participants performed 3 repetitions of virtual reality exercises on the virtual simulator, and then performed and were assessed on 2 tests, ie robot and laparoscopic training box. After the course, the participants were surveyed for this training program.

Results: Twenty-seven residents and surgeons were enrolled in the training program. With only 2 hours of training, all of the participants were able to complete the training program, thus learning generic and specific skills in robotic surgery. In virtual reality exercise, the scores of the 3 exercises increased significantly with every repetition ($p < 0.001$) and the size of the increase was large. The completion time on the robot platform was 2.6 times faster (169.33 ± 28.28 s vs. 447.96 ± 156.55 s, $p < 0.001$) than that in the laparoscopic box, and the difference between both types of tests was large ($_p\eta^2 = 0.797$). The centralization and passage of the needle were significantly better on the robot platform (5 vs. 3, $p < 0.001$, $r = 0.47$; 5 vs. 4, $p < 0.001$, $r = 0.59$) than in the laparoscopic box. For the intracorporeal stitch+knot test, every participant was able to perform the exercise on the robot but only 85.2% (23/27) in the laparoscopic box. Twenty-one participants answered the survey, and 13 (61.9%) of them considered robotic performance independent of laparoscopic experience.

Conclusions: Surgeons are interested and seek training in robotic surgery. We implemented the first hands-on robotic surgery training program in Portugal and participants considered it was important and adequate for its purpose. All participants, even without robotic experience, learned quicker, performed better, faster and more precisely on the robot over laparoscopy.

1. Introduction

Minimally invasive surgery (MIS) is widely adopted worldwide and in various specialties, such as general surgery, gynecology and urology. Since its beginnings, laparoscopy has shown some advantages, such as less invasive procedures, less pain and quicker

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recovery to an active life.[1,2] Robotic surgery is facing the same trajectory as laparoscopy, with increasing usage. Although it is becoming a standard approach in some surgical procedures, training is lacking in quantity and quality.[3–6] By the end of 2017, more than 4400 platforms were installed globally.[4] This increase in usage and access results in growing needs for training and accreditation.[7] For this reason, some groups have described and evaluated robotic surgery training programs, with positive results, showing that the majority of participants can operate at the surgeon console after these courses/programs.[8] Although some initial training curricula are published in the literature, such as the Fundamental Skills of Robotic Surgery Curriculum,[9] there are not enough validated and standardized introductions of robotic surgery courses and programs widely available to residents and surgeons across different countries.[10–12] Additionally, robotic training itself is very limited to institutions and surgical teams that already have or plan to invest in robotic platforms in their hospitals, and there are some factors that limit training, such as costs, availability of robots and logistics related to this minimally invasive approach.[13] Because of these barriers, there is an increasing interest in surgical simulation and robotic training platforms that mimic the robotic surgery system, mainly for the DaVinci™ system, such as the dV-Trainer™.[14,15] There are some face, content and construct-validated robotic surgery simulators in the market,[16] but some still have limitations, such as the lack of the robot console and interface. They depend on virtual models/exercises without the possibility of being used with dry-lab models or animals. Recent simulators solved some of these limitations by incorporating the DaVinci™ console as a human/robot interface.[17]

With this in mind, we used the DaVinci simulator and a real, full DaVinci System, so we could use dry-lab, ex-vivo or animal models for simulation in our course. Although simulation with live animals is very important and high fidelity, it has issues such as ethics, costs and logistics that, if possible, should be replaced by ex-vivo or dry-lab models, such as silicone models, especially for novice trainees as we did in this course.[18] In fact, we decided to use these anatomical silicone models to add to the anatomical context of surgical techniques to increase adherence and understanding of the differences, capabilities and limitations of the device, as concluded by Green and colleagues.[11] Following these principles, we designed and implemented a 2-hour training curriculum, based on simulation with virtual exercises and dry-lab silicone anatomical models to provide a brief standardized introductory training in robotic surgery to as many individuals as possible during the limited time that we had the DaVinci™ in our surgical simulation center. Aimed at general surgeons and general surgery residents without previous knowledge or experience in robotic surgery, our training program distinguishes itself by being the first hands-on robotic surgery training program in Portugal. In this study, we aim to evaluate the impact of the Robotic4all project on advanced gestures and procedures for surgeons and residents without previous contact with the robot.

2. Materials and methods

2.1. Study design

The present study is a prospective observational study based on performance assessment and opinions/perspectives about robotic surgery. Course registration was free and on a first-come first-served basis, so participants were not actively selected by our team. Using the DaVinci robot (ROB), a 2-hour program was based on virtual reality and anatomical model exercises. All participants performed 3 repetitions of virtual reality exercises (VRe) on the virtual simulator, and then performed and were assessed on 2 tests, ie ROB and laparoscopic training box (LAP). Data were obtained during an introduction to the robotic surgery course, which took place at the Surgical Simulation Center, University of Beira Interior, in April 2022. After the course, the participants were surveyed for this training program.

2.2. Participants

Thirty-two general surgery residents and surgeons with different levels of laparoscopic experience were enrolled, and 27 completed the full training program and were assessed at the end of the program. The rest of the participants were not included in the study because 3 surgeons could not attend the course and 2 surgeons did not have a total time of 2 hours to complete the program. Twenty-one general surgery residents and 6 specialists with no previous robotic surgery participated in this study. Regarding previous experience in laparoscopy, 96.3% (26/27) performed laparoscopy on a weekly basis as a surgeon/assistant. The 21 residents were from the first year ($n = 1$), second year ($n = 2$), third year ($n = 5$), fourth year ($n = 3$), fifth year ($n = 7$) and sixth year ($n = 3$). The sample was divided into 3 groups: novice (1–3 years), intermediate (4–5 years) and expert (6 year and specialists) based on their residency year/specialist/experience in laparoscopy, with 8 (29.6%), 10 (37.0%) and 9 (33.3%) participants in each group, respectively.

2.3. Description of the training program

Our introduction to the robotic surgery program had a duration of 2 hours and used 2 surgeon consoles and 1 DaVinci Surgical Robot™ (Xi Model™). The activity starts with a talk on basic theoretical knowledge of the robotic equipment and instruments and its most common maneuvers and gestures, as well as docking of the robot, positioning of the patient, ergonomy and position of the surgeon at the console. The program was divided into two parts: one hour to perform 3 repetitions of VRe on the DaVinci virtual simulator[14] and 1 hour to perform specific gestures using silicone anatomical models (ventral hernia and small bowel) in the full robotic system.

2.3.1. Session 1: Virtual reality exercises and generic gestures

All participants performed a pre-established sequence of 3 hands-on VRe on the DaVinci SimNow™ virtual simulator (1 h): “sea spikes 1” (Fig. 1A), “energy pedal 1” (Fig. 1B), and “three arm relay” (Fig. 1C). This sequence was repeated 3 times. The overall performance of the virtual simulator was recorded for every exercise and repetition, using the DaVinci assessment system. The selection of exercises, vastly validated in the literature,[19,20] was defined by the skills and movements that each exercise comprises (Table 1).

2.3.2. Session 2: Simulated procedures and specific gestures

Once these 3 generic exercise sequences were completed and performance was recorded, the participants passed on to perform hands-on exercises in the real console in silicone anatomical models - abdominal wall and small bowel silicone models - using the 4 arms of the robot. These models were designed and produced by our team focusing on allowing trainees to perform all the usual gestures in surgery (grasping, cutting, dissecting and suturing) and adding anatomical and procedural context to training. Before starting the exercises, the faculty transmitted and reviewed technical aspects of the gestures, the procedures and suturing with each participant (Table 2, Fig. 2).

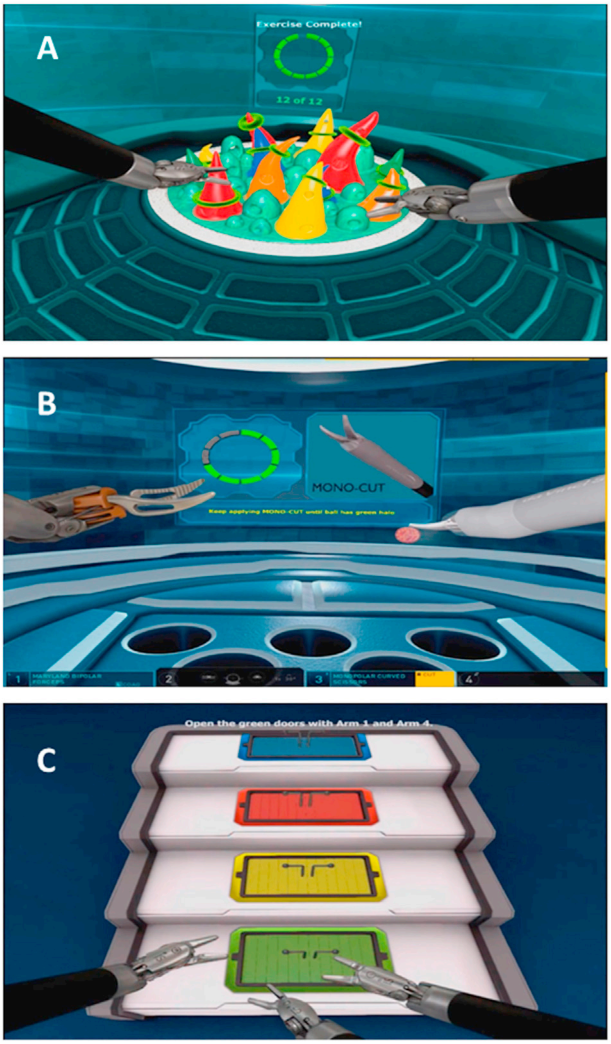

Fig. 1 Images of 3 hands-on virtual reality exercises on virtual simulator
A, The "sea spikes 1" exercise. B, The "energy pedal 1" exercise. C, The "three arm relay" exercise.

2.3.3. Postprogram performance tests

After the conclusion of the activities, all participants were assessed using a 5-step stitch + knot sequence in a silicone suture pad that we designed for this program in the ROB and LAP. Each evaluated sequence (ROB or LAP) is composed of 1 intracorporeal stitch (ICS) on zones 1, 2, 3 and 4 followed by 1 intracorporeal stitch + 1 knot (ICS + K) on zone 6. Before beginning the tests, all participants were instructed about the sequence (Fig. 3. A&B), the quality criteria of the test (Table 3) and the limited time for completion. For ICS (steps 1 to 4), participants should grasp, place and pass a needle through the silicone pad, with each step in one direction. For ICS + K, they should grasp, place and pass a needle through the silicone and finish with the realization of a surgical knot (Fig. 3C).

Participants had a limited time (15 min) to perform the test on each platform. The robotic suture sequence is performed at the console using arm 1 (grasper), arm 2 (camera) and arm 3 (needle-holder) of the robot. The laparoscopic suture sequence is performed using a LAP - the First Trainer - and laparoscopic classic instruments with a curved dissector on the left hand and a needle-holder on the right hand (Fig. 4).

The sequence was considered complete when the participant completed the 5 steps. Completion time (in seconds) was recorded for every participant and for the two sequences (robotic and laparoscopic). Quality criteria were assessed during the realization of the test and confirmed at the end of the test under direct visualization of the silicone model by the faculty (Fig. 5).

2.4. Survey development and distribution

The survey was designed in accordance with the Association for Medical Education to identify the perspectives of surgery residents and surgeons on the current barriers in robotic surgery training, previous MIS experience, opinions on the characteristics of the course, and opinions on robotic and laparoscopic skills acquisition. Survey content was developed and discussed by some of the contributing authors and then reviewed and refined by one expert on curricular design, from the Institute of Education, at the University of Minho, Portugal. The final survey included 24 questions, including Likert-scale, written text and multiple-choice responses and it was administered online at www.lap-school.com, between April 10 and May 15, 2022. Altogether, the survey took approximately 7–10 min to fill.

2.5. Statistical analysis

All statistical analyses were performed with the software IBM® SPSS Statistics 28 for Windows. The scores in the three exercises and the time of completion of the two tests were inspected

Table 1
Description of the selected exercises and the evaluated metrics

	Description	Evaluated metrics
Exercise 1: Sea Spikes 1	The trainee is presented with some colored rings and a platform with vertical colored spikes.	The trainee is required to pick up the pegs using the instruments and put them on the spikes of the same color. The task is completed when every ring is on the correspondent colored spike. Skills: control of 2 arms and camera; control of pedal for camera/arm 2.
Exercise 2: Energy Pedal 1	A sequence of round objects is presented to the trainee randomly, with instructions to use monopolar/bipolar energy.	The trainee is required to choose arm 1 or 2, and step on the correspondent pedal following the screen instructions. The task is completed when every object/energy is applied. Skills: control of 2 instruments on arms 1 and 2; control of energy pedals.
Exercise 3: Three Arm Relay	The trainee is presented with a sequence of 4 colored closed boxes.	The trainee is required to open box 1, take out the object 1 inside of it; open box 2, place the object 1 inside it; remove the object 2 and repeat these movements on the next 3 boxes. The object 4 must be placed inside box 1 for the exercise to be completed. Skills: control of 3 arms and camera; control of pedal for camera/arm 2; control of clutch for arm 2/3 control

Table 2
Description of the selected anatomical model exercises and the training objectives

	Description	Training objectives
Ventral hernia model	The trainee is presented with a silicone model of the abdominal wall, with rectus muscles, anterior and posterior rectus sheaths and linea alba.	The trainee is required to open the posterior rectus sheath, grasp it and dissect the space, separate the rectus muscle and reach the linea alba. Then a crossover to the contra-lateral muscle should be performed. After that, the trainee should perform the closure of the incision on the posterior rectus sheath. Trainees only had to do each step partially as the objective was to learn and train surgical gestures, not the full procedures. Robotic skills: control of 3 arms and camera; control of pedal for camera/arm 4.
Small bowel model	The trainee is presented with a silicone model of two side-by-side small bowel loops.	The trainee is required to open each loop and then perform an anastomosis between them. Complete anastomosis was not necessary and was not evaluated as the objective was to learn and train surgical gestures, not the full procedures. Robotic skills: control of 3 arms and camera; control of pedal for camera/arm 4.

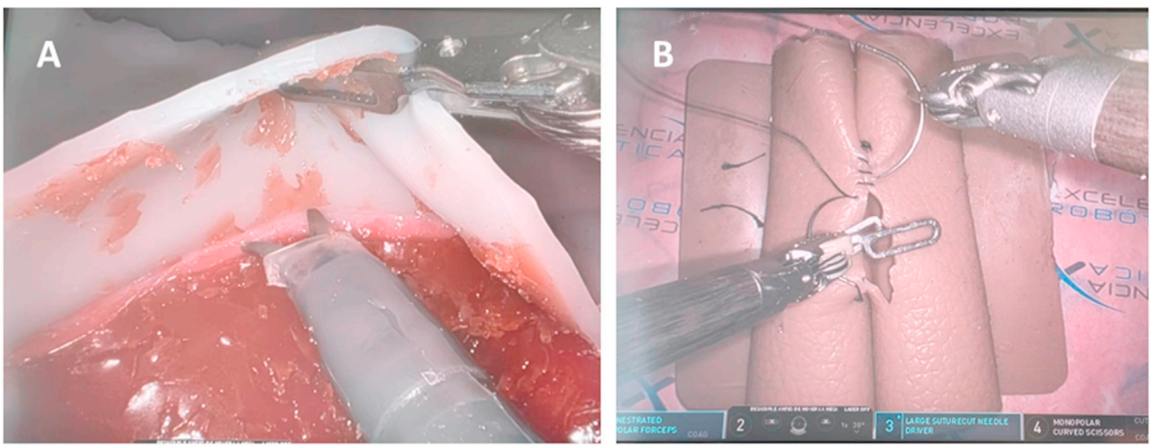

Fig. 2 Images of selected anatomical models exercises
A, Exercise in a silicone model of the abdominal wall. B, Exercise in a silicone model of two side-by-side small bowel loops.

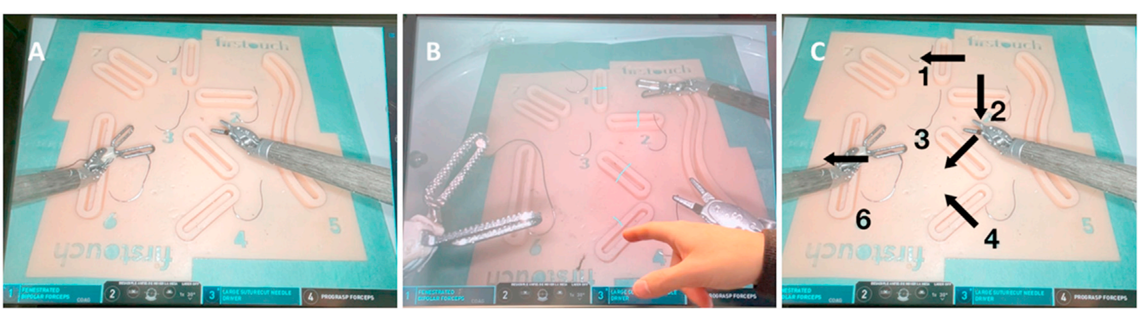

Fig. 3 Images of stitches and knot test in a silicone suture pad
A, The starting point of test: the initial position of the pad, needles and arms/camera of the robot. B, The faculty introduced the objectives and quality criteria of the test on the external monitor. C, The sequence of the test.

Table 3
Quality criteria of the tests

	Description	Quality criteria
Criterion 1	Centralization of the needle	The needle must be centered in the "tissue".
Criterion 2	Passage of the needle	The needle must pass completely on the "tissue".
Criterion 3	The stitch + knot step	The stitch should follow the criteria 1 and 2 and the knot should be technically correct for this step to be completed.

regarding their distribution: values of skewness lower than |3| and values of kurtosis lower than |7| indicated no robust violations to the assumption of normality.[21] For these variables means and standard deviations were calculated as descriptive statistics. Repeated measures analyses of variance were used to assess whether the performance in the three exercises increased with repetitions. To assess the existence of differences in time completion of the tests, a mixed analysis of variance with a within-subjects effect (Type: performance in the ROB versus LAP) and a between-subjects effect (Group: novice versus intermediate versus expert)

Fig. 4 Image of laparoscopic trainer box

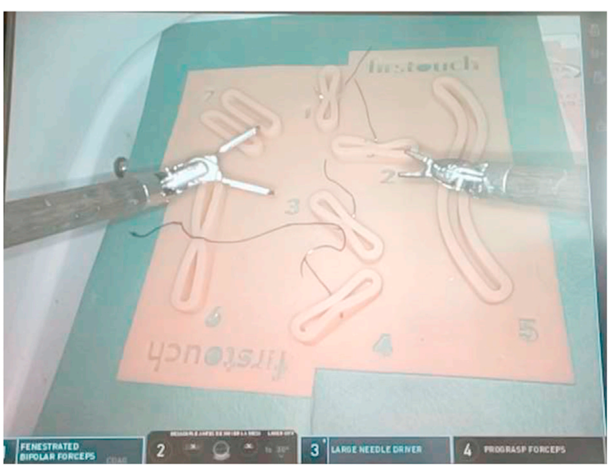

Fig. 5 Image of completed test
ICS sequence on the zones 1, 2, 3, and 4. ICS + K on the zone 6.

was computed. An interaction effect Type*Group was also tested to assess whether the differences in the tests were similar across groups. The assumptions of homogeneity of variances (Levene's test: $p > 0.05$) and sphericity (Mauchly's W test: $p > 0.05$) were verified for this analysis. Significance was set at $p < 0.05$. Additionally, for all analyses of variance, eta partial squared ($_{p}\eta^{2}$) was computed as a measure of effect size: $_{p}\eta^{2}>0.14$ indicates a large effect; $_{p}\eta^{2}>0.06$, a medium effect; and $_{p}\eta^{2}>0.01$, a small effect.[22] Regarding the quality of gestures, given this lack of variability in the scores, no group differences (novice, intermediate or expert) were computed. To test for the differences in the quality scores of passage and centralization of the needle between ROB and LAP tests, the Wilcoxon signed-rank test was used, given that these data were nonparametric. For this test, the r value was calculated as a measure of effect size, by dividing the Z statistic by the square root of the number of observations. According to Cohen,[22] r values above 0.1 can be described as small, above 0.3 can be described as medium, and values above 0.5 can be described as large. Medians and interquartile ranges were calculated as descriptive statistics for the quality scores.

3. Results

3.1. Virtual reality exercises

The higher results in the DaVinci™ system performance assessment indicate better performance.

Regarding the VRe, the scores of the 3 exercises increased significantly with every repetition and the size of the increase was large (Table 4).

3.2. Test of robot platform and laparoscopic training box

3.2.1. Completion time

Higher scores in quality evaluation and less completion time on the realization of evaluated sequences indicate better performance. The comparison results among groups and test types for the ICS and ICS + K sequences are depicted in Table 5. Regarding the tests and the entire group, the Test ROB completion was 2.6 times faster (169.33 ± 28.28 s vs. 447.96 ± 156.55 s, $p < 0.001$), and the difference between both types of tests was large ($_{p}\eta^{2} = 0.797$). Time differences on each test between the groups were not significant although the intermediate group had the best results and the novice group had the worst results. There was also no significant interaction effect between the group and type of test, indicating that all groups were equally faster in the ROB completion time than in the LAP.

3.2.2. Quality of gestures

Regarding the quality of gestures, in the ROB test, all participants obtained the maximum score in the quality of the passage of the needle, and only 2 participants failed to obtain the maximum in the quality of the centralization of the needle. The results of the evaluation of the quality of gestures for the suture sequence are presented in Table 6. In this matter, centralization and passage of the needle were significantly better in the ROB test (5 vs. 3, $p < 0.001$, $r = 0.47$; 5 vs. 4, $p < 0.001$, $r = 0.59$) than in the LAP test.

For the ICS + K only, every participant was able to perform the exercise on the robot (100%) in contrast with only 85.2% (23/27) on the LAP. None of the participants had better quality in the laparoscopic sequence compared to the robotic sequence. In fact, 88.9% (24/27) of the participants obtained worse quality in the centralization of the needle, and 55.6% (15/27) obtained worse quality in the passage of the needle in the laparoscopic ICS sequence. The remaining participants (3/27 and 12/27) had equal quality in centralization and passage of the needle in both sequences.

3.3. Survey results

Twenty-one of the 27 (77.8%) attendants answered the anonymous online survey after the course.

3.3.1. Practice sessions

The virtual exercise session and the anatomical model session were considered "good" or "excellent" in 100.0% (21/21) and 95.2% (20/21) participants, respectively. More than 95% (20/21) considered the virtual exercise sequence to be "very adequate" for training and for learning generic robotic gestures and functions. Silicone pad fidelity to organic tissue (face validation) and purpose/quality of training (content validation) for the silicone suture pad were

Table 4
Virtual exercise performance

	Exercise 1 ($n = 27$)	Exercise 2 ($n = 27$)	Exercise 3 ($n = 27$)
Repetition 1, mean ± SD	51.11 ± 18.41	85.67 ± 10.94	55.33 ± 20.74
Repetition 2, mean ± SD	68.85 ± 14.80	90.67 ± 12.02	71.15 ± 21.41
Repetition 3, mean ± SD	74.33 ± 13.49	95.89 ± 5.44	79.15 ± 15.26
p value	<0.001	<0.001	<0.001
$_p\eta^2$	0.702	0.541	0.588

Table 5
Completion time for ROB and LAP tests

	Novice group ($n = 8$)	Intermediate group ($n = 10$)		Expert group ($n = 9$)	Total sample ($n = 27$)
ROB, mean ± SD, s	186.63 ± 39.61	156.00 ± 22.96		168.78 ± 10.56	169.33 ± 28.28
LAP, mean ± SD, s	492.00 ± 176.42	404.40 ± 147.23		457.22 ± 153.71	447.96 ± 156.55
p values					
Type			<.001		
Group			0.355		
Type*Group			0.707		
$_p\eta^2$					
Type			0.797		
Group			0.083		
Type*Group			0.028		

Table 6
Differences in the quality of the ROB and LAP tests

	ROB ($n = 27$)	LAP ($n = 27$)	Negative ranks	Ties	p value	r
Passage, median (IQR)	5.00 (0.00)	4.00 (2.00)	15	12	<0.001	0.47
Centralization, median (IQR)	5.00 (0.00)	3.00 (2.00)	24	3	<0.001	0.59

Negative ranks: quality of the passage or centralization of the needle in LAP test < quality of the passage or centralization in ROB test. Ties: equal quality in both tests.

considered “good” or “excellent” by 90.5% (19/21) and 100.0% (21/21) of the attendants, respectively.

3.3.2. *Learning and skills training*

Learning, skills acquisition and training on the ROB is “intuitive” or “very intuitive” for the 95.2% (20/21) of the participants. Regarding to suturing, 95.2% (20/21) of the participants considered robotic suturing easier and more intuitive than laparoscopic suturing. The majority of them (61.9%, 13/21) said that performance and learning of robotic suturing is independent of previous suture experience; and for the 33.3% (7/21) of the participants, robotic surgery performance and learning, in general, is considered to be completely independent of any previous laparoscopic experience.

3.3.3. *Organizational aspects of the course*

More than 66% (14/21) of the attendants were in agreement with the duration of the course, classifying it as “adequate” given the purposes of this introduction training program (and the rest would like it to be longer). The quality of the course was classified as good (23.8%, 5/21) or excellent (76.2%, 16/21). All of the attendants would repeat the course and would recommend this course to colleagues, and all stated that this kind of program and course increase interest in robotic surgery (100.0%, 21/21).

4. Discussion

MIS has revolutionized surgery in recent decades as it allows for faster and better postoperative recovery, with less pain and better outcomes, and is recognized as the gold standard in some surgical procedures in various surgical specialties.[2,5] In the last 2 decades, since its presentation and approval of the US Food and Drug Administration, the DaVinci™ (Intuitive Surgical, Inc.™) robotic system has been increasing its presence worldwide, mainly in high income countries. In recent years, more companies have become interested in robotic surgery and developed other systems. Some of them have already been approved for clinical usage, such as Versius™ (CMRobotis™) and Hugo RAS™ (Medtronic™).[23−25]

Despite its increasing adoption, robotic surgery faces some limitations to its implementation, mainly costs, logistics (size, weight), education and training.[26] Training in MIS is widely available all over the world, namely, in the case of laparoscopy, even if some structured and national training programs are lacking; in the case of robotic surgery, training is clearly insufficient and there are only a few structured programs in some countries where robotic surgery is more widespread.[27] Mostly, robotic surgery training is accessible only to surgeons and residents whose hospitals have or plan to have a robotic surgery program, which is a huge limitation for robotic surgery adoption and for training with this new technology. In Portugal, this is especially true as there are only 6 robots (4 of them in Lisbon, all for human usage, 0 for training) and only some sparse commercial activities show the robot to surgeons. There is no record of a structured and standardized hands-on training program for robotic surgery in Portugal, and our program is the first one. Most of these training programs are simulation-based with all the known advantages, including secure environment, capacity for unlimited repetition, capacity for briefing and debriefing, etc.[28] Live animal training is very high fidelity and has many advantages, but it should be avoided as much as possible and, when possible, substituted by virtual exercises and silicone anatomical models, as in the present case.[29]

As availability for the robotic system is limited, we designed a 2-hour program with two parts: one hour for the virtual exercises using the console and the SimNow simulator; and the other hour, for using the anatomical models on the complete DaVinci system.

This curriculum was constructed to allow for the acquisition of generic gestures in the simulator first, and then for procedure-specific gestures in the robot. For the generic gestures, we selected a sequence of 3 VEs that would allow the acquisition of generic gestures and control of the robot's functions, such as the robot arms, the energy pedals, the clutch, the camera, the surgeon head's and body's position and ergonomic. For the specific gesture learning and training, we used 2 silicone anatomical models developed for MIS simulation in other courses that we organize annually. They were used in the present training program to avoid the sacrifice of live animals, while maintaining the anatomical and surgical context during robotic training and allowing the acquisition of specific gestures and skills. To determine the impact of the curriculum on learning and performance, the differences in the performance of advanced gestures, such as suturing, were compared between robotic and laparoscopic surgery. To do that, all the participants were assessed in 2 tests using the new silicone suture pad in a structured sequence on the robot and LAP.[30] These tests were based on MIS suturing, as it is recognized as an MIS advanced procedure.[31,32]

The VRe sequence was classified as "very adequate" by 95.2% of the participants. All participants could complete and significantly improve their performance from the first repetition to the last repetition. Then, they were able to complete the anatomical model session. These exercises are not procedure-specific, so these facts only demonstrate that the participants were able to learn "generic" gestures, such as the robot functions and mastery of the 3 arms and camera. In fact, as these were the VE session objectives, we can conclude that this 3-exercise sequence may be sufficient to acquire initial and generic skills in the robot and to learn its basic functions and instrument usage. Regarding the final tests, performance on the robot was significantly higher in all the assessed parameters compared to the LAP test. In fact, the whole ICS/ICS + K ROB sequence was more than 2.5 times faster than the LAP sequence. Additionally, every participant could finish the sequence on the ROB test but only 85.2% on the LAP test. These are surprising results as they all had laparoscopic experience but no robotic experience before the course. According to these results, we think that using anatomical models is of great importance, especially for learning "specific" gestures to perform advanced procedures, such as suturing. On the other hand, anatomical models do not seem to have an influence on the results per "type of approach" or "group", as all the participants were able to complete the same sessions and tests, and there were no differences between the three groups. In the LAP test, "centralization" had worse results than "passage of needle", showing that it can be a more precise gesture. In contrast, on the ROB test, quality was identical between the two criteria. All the participants had maximum quality regarding these criteria on the ROB test and none performed better in the LAP, so it is interesting to see that the robot allowed for enhanced performance in the more precise and meticulous gestures compared to laparoscopy. In summary, these findings were aligned with the results of the survey and can explain the participants' opinions on the survey that robotic suture is more intuitive and easier than laparoscopic suturing. This suggests that robotic skills acquisition is independent of previous laparoscopic suturing and laparoscopic experience. Course evaluation by the participants was very positive, and residents and surgeons were very interested in knowing more about robotic surgery and to participating in robotic training programs to be able to adopt this technology.

As new robot systems become available in the market and receive clinical approval, there will be a need to create and adapt training curricula to each of them. Meanwhile, more competition will bring more opportunities and diffusion to robotic surgery. Having these results in mind, with very limited logistics, we think that the present brief and feasible training program can be widely used for robotic initial certification as well as enhance robotic surgery diffusion in many countries, including those where robotic surgery is still in its first steps, such as Portugal.

5. Conclusion

Surgeons are interested and seek training in robotic surgery. We implemented the first hands-on robotic surgery training program in Portugal and participants considered it important and adequate for its purpose. All participants, even without robotic experience, learned quicker, performed better, faster and more precisely on the robot over laparoscopy. Training programs and robots should become widely available to as most surgeons and as soon as possible to achieve better performance and surgical outcomes.

Author contributions

Mário Rui Gonçalves is responsible for the study and the main author regarding all aspects of the manuscript. Miguel Castelo-Branco and José Novo de Matos participated in the data collection, literature review, data analysis, and manuscript review. António Oliveira, Ricardo Marinho, Irene Cadime, Palmira Carlos Alves and Salvador Morales-Conde participated in the data analysis and review of the manuscript.

Conflict of interest

There are no conflicts of interest on the part of any named author.

Ethics approval

Not applicable.

Patient consent for publication

Not applicable.

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