Model of a training program in robotic surgery and its initial results

Modelo de programa de treinamento em cirurgia robótica e resultados iniciais

Fernando Athayde Veloso Madureira, TCBC-RJ[1,2]; José Luís Souza Varela, TCBC-RJ[1]; Delta Madureira Filho, ECBC-RJ[1]; Luis Alfredo Vieira D`Almeida[1]; Fábio Athayde Veloso Madureira, TCBC-RJ[1]; Alexandre Miranda Duarte, TCBC-RJ[1]; Otávio Pires Vaz[1]; José Reinan Ramos, TCBC-RJ[1].

ABSTRACT

Objective: *to describe the implementation of a training program in robotic surgery and to point the General Surgery procedures that can be performed with advantages using the robotic platform.* **Methods:** *we conducted a retrospective analysis of data collected prospectively from the robotic surgery group in General and Colo-Retal Surgery at the Samaritan Hospital (Rio de Janeiro, Brazil), from October 2012 to December 2015. We describe the training stages and particularities.* **Results**: *two hundred and ninety three robotic operations were performed in general surgery: 108 procedures for morbid obesity, 59 colorectal surgeries, 55 procedures in the esophago-gastric transition area, 16 cholecystectomies, 27 abdominal wall hernioplasties, 13 inguinal hernioplasties, two gastrectomies with D2 lymphadenectomy, one vagotomy, two diaphragmatic hernioplasties, four liver surgeries, two adrenalectomies, two splenectomies, one pancreatectomy and one bilio-digestive anastomosis. The complication rate was 2.4%, with no major complications.* **Conclusion:** *the robotic surgery program of the Samaritan Hospital was safely implemented and with initial results better than the ones described in the current literature. There seems to be benefits in using the robotic platform in super-obese patients, re-operations of obesity surgery and hiatus hernias, giant and paraesophageal hiatus hernias, ventral hernias with multiple defects and rectal resections.*

Keywords: *Robotic Surgical Procedures. Inservice Training. Learning Curve. Laparoscopy. General Surgery.*

INTRODUCTION

Since the 1990s, the laparoscopic approach has been gaining ground in relation to open surgery, mainly after the evolution of technique and materials. It is minimally invasive character and has the advantages of lower postoperative pain, faster return to labor activities, lower rates of wall infection and incisional hernias, and a better cosmetic appearance[1].

Since the early 2000s, the robotic platform has been used to assist operations. The Da Vinci Surgical System platform has been the most active and most studied robotic system[2,3]. This system consists of a tower with four robotic arms, one of them with an installed high-resolution 3D camera and the other three to couple with various instruments such as graspers, scissors, clip applicators, needle holders, among others[1-3].

Robotic surgery is on course to be the new revolution in modern surgery, combining all the benefits of minimally invasive surgery with the advantage of image stability, three dimensions (3D), and the mobility of intracorporeal instrumentation, mainly in operative fields of more restricted spaces[3].

In the first years of the robotic access route, prostate surgery was the most cost-effective[4]. With the passage of years and dilution of implantation costs, other procedures are beginning to prove adequate: operations in super obese individuals, esophageal procedures, low rectal resections, enlarged hysterectomies with pelvic lymphadenectomy, surgery to treat endometriosis and others. The main criticism of this new access route is still the high cost per procedure. In first world countries the surgeries by robot and the number of implanted systems grow at a fast pace[3-5].

Normally, during training, surgeons are tutored for a short time and in few cases, which increases the learning curve and leads to questionable results in terms of complications and morbidity[6].

1 - Samaritan Hospital, Robotic Surgery Group, Rio de Janeiro, Rio de Janeiro State, Brazil. 2 - Gaffrée Guinle University Hospital, Federal University of the State of Rio de Janeiro (UNIRIO), Rio de Janeiro, Rio de Janeiro State, Brazil.

Concurrently, a parallel industry of legal suits against medical malpractice grows, trying to explore unsuccessful cases. Two questions need to be asked: how to implement this new system, with training that exploits the advantages of robotic surgery, but in a safe way for the patient and the Institution, and which procedures in General Surgery have the cost / benefit ratio adequate for Brazil.

The purpose of this study is to describe the implementation of a successful training program in robotic surgery and to present the initial results of the series of operations in General Surgery using the robotic platform.

METHODS

This is a retrospective analysis of a prospectively collected database of patients operated from October 2012 to December 2015 at the robotic surgical training program of the General and Colorectal Surgery group of the Samaritan Hospital (Rio de Janeiro, RJ, Brazil). The Study was submitted to the Ethics in Research Committee of the Gaffré & Guinle University Hospital, UNIRIO, and carried out in accordance with its recommendations.

When the Robotic Surgery program was implemented, the Da Vinci Si operating system was chosen and a training plan was drawn up for eight general surgeons and five urologists. Initially, the mandatory training required by the manufacturer of the Da Vinci robotic system, the Intuitive Surgical, consisted of four steps: 1) digital training on the Intuitive Company's website with a focus on the robot's operation, its components and main functions; 2) training on the Mimic simulator to gain proficiency in performance and dexterity exercises; 3) training in the dry laboratory, with exercises in the surgical robot itself, using models (performed abroad in different places according to the choice of Intuitive Surgical); and 4) training in cadavers or live animals at Intuitive Surgical training centers in the United States of America as the last step prior to human operations. Surgeons who passed these steps received a certification from the company, and from that moment on, they were able to use the robot in human operations with the supervision of more experienced surgeons (proctors).

In the program conducted at the Samaritan Hospital, in addition to the training proposed by the manufacturer of the Da Vinci system, an agreement was made with the Robotic Surgery Service of the Celebration Hospital, in Orlando, United States. Proctors from that hospital were present in the first 20 operations of each training surgeon for possible assistance or even substitution.

Surgeons were divided into two specialties: Urology and General Surgery, with specific proctors in each. Training surgeons worked in pairs: one on the console and another as an assistant next to the patient, the proctor always being present in the operating room. All other service surgeons who were not operating were committed to attending the surgeries scheduled for that training round. Five to six surgeries were scheduled for each training stage and divided in two days, each month.

For the Urology group, the instructors were the professors Dr. Vipul Patel and Dr. Keneth Palmer. For the General Surgery group, the instructors were the professors Dr. Eduardo Parra D'Ávila and Dr. Keith Kim. After the 20 cases performed, the training surgeons were evaluated by the proctor and, if considered fit, were allowed to operate with the robot without mentoring.

The patients chosen to be operated on in the robotics program came from each surgeon's office and were selected by the surgeon with prior consent from the proctor and Hospital Director. Surgeries with a greater degree of technical difficulty were previously discussed in the Service and submitted to the proctor authorization. The patients undergoing the procedures were informed about the new technology that would be employed and signed an informed consent form at the time of admission.

We analyzed the type of operation, complications, length of hospital stay, morbidity and mortality only in the General Surgery operations.

Table 1 - *Robotic Operations, reoperations and complications.*

Procedure	n	Reoperations	Complications
Bariatric Surgery	108	0	1 Hematoma in mesentery in the first trocar insertion
Rectosigmoidectomy	44	2	2 Early small bowel obstruction; anastomotic dehiscence
Hiatus hernia	43	0	2 Punctate esophagus perforation, recognized and treated during the procedure; Pneumothorax requiring drainage
Cholecystectomy	16	0	0
Ventral Hernia	27	0	0
Inguinal Hernia	13	0	0
Achalasia	12	0	1 Punctate esophageal mucosa perforation, recognized and treated during surgery
Right colectomy	9	1	1 Bowel obstruction
Milles Procedure	4	0	0
Adrenalectomy	2	0	0
Gastrectomy D2	2	0	0
Splenectomy	2	0	0
Liver Surgery	4	0	0
Pancreatectomy	1	0	0
Bilio-Digestive Anastomosis	1	1	1 Choleperitoneum that was drained

RESULTS

A total of 293 robotic operations were performed in General Surgery. Table 1 shows the most performed operations.

A total of 108 surgeries were performed for morbid obesity, 59 colorectal surgeries, 55 surgeries in the gastro-esophageal transition, 16 cholecystectomies, 27 abdominal wall hernioplasties, two gastrectomies with D2 lymphadenectomy, one vagotomy, two diaphragmatic hernioplasties, four liver surgeries, two adrenalectomies, two splenectomies, one pancreatectomy and one bilio-digestive surgery. The total morbidity rate was 2.4%, with no major complications (Table 1). We reoperated 1.4% of the patients. The length of hospital stay is shown in table 2. There were no deaths.

DISCUSSION

Robotics comes from the word ROBOT, the Czech word for "forced labor." The term ROBOT was used for the first time in history by the Czech Karel Capek, in a play of 1921 in the city of Prague. Leonardo Da Vinci was responsible for the first project of a humanoid automaton in 1495, with drawings of a knight able to sit, move his arms, head and jaw[2].

Table 2 - *Mean time of hospitalization of the main procedures.*

Procedures	Average length of stay
Bariatric	2.2 days
Hiatus hernia	1.6 days
Rectosigmoidectomy	3.4 days
Ventral hernias	1.4 days
Achalasia	1.6 days

By concept, robots were created to facilitate human life. They have application in the domestic use to facilitate daily tasks, in the military use to carry out risky tasks, in the industrial use to perform automated tasks aiming at the increase of productivity and the reduction of costs, and in medicine, supporting tasks of the elderly and disabled, replacing members and organs and participating in surgeries, making them more precise. The robots participate in telemedicine with the concepts of telepresence and telecolaboration, with the possibility of performing surgeries at a distance and with the aid of a more experienced surgeon assisting in the procedure and aiming at a better final result.

The initial concept of robotics in surgery began in the 1980s and involved the idea of performing an operation at a location far from where the surgeon was. This possibility attracted the American military, who began the development of robots aimed at performing surgeries on the battlefield, through remote control by the doctor.

Between the late 1990s and the early 21st century, surgical robots have been improved. The first system for robotic surgery was AESOP, represented by a mechanical arm that held the laparoscopic optics and could be controlled by the surgeon with pedals or voice command. In 1995, the same company developed the Zeus robot, which had three arms, two to handle the instruments and a third to operate the camera[2]. With the development of Da Vinci, this became the most complete active robotic system, since it evolved from Improvements of its antecedents.

The Da Vinci system is connected to a command console that receives the images generated by the 3D camera and emits the movements of the surgeon's hand in a joystick for the robotic arms with the coupled instruments, allowing wide and precise movements in the surgery, with high performance[2].

Robotic surgery has a number of advantages over laparotomic and laparoscopic surgery, incorporating all the positive aspects of a minimally invasive surgery and supplanting it in terms of ergonomics, operative field control, high resolution image in three dimensions (3D), freedom of movement of the instruments, reduction of tremors, performance of risky tasks for the surgeon (exposure to radiation, for example), greater autonomy of the surgeon with the lesser use of auxiliaries and, especially, precision[1].

Nowadays we still face some disadvantages in the use of robotic surgery, especially in terms of costs and lack of tactile feedback, which in our opinion, with the popularization of this type of surgical approach and the technological advances already underway by the manufacturing industry, tend to be resolved quickly, as have been the difficulty of accessing multiple quadrants, performing irrigation, suctioning and stapling and the sealing of large blood vessels.

In planning the deployment of a new technology, in the case of the Da Vinci Si robotic system, the challenge was to train a group of surgeons with the greatest efficiency, the least complications and costs appropriate to the national reality, understanding that this access route was not widespread in Brazil, unlike the USA and Europe, and that its implementation would also imply new concepts and community acceptance[6,7].

By the end of 2012, surgeons were usually tutored briefly and in a few cases. During training, five cases were required for the surgeon to be "cleared" to operate. This may have been one of the reasons for a high learning curve and early questionable results in terms of complications and morbidity in programs implemented in the early and mid 2000s[6,7].

The strategy adopted was to associate with the group of surgeons at Celebration Hospital in Orlando, United States, in the person of its head, Dr. Vipul Patel, a renowned urological surgeon and holder of the world's largest experience in the treatment of prostate cancer by robotic surgery. The objective of this agreement was to incorporate the experience acquired by that success group, minimizing complications, unnecessary costs and reaching the outlined objectives more quickly[8-13].

The profile of chosen surgeons took into account extensive experience in laparoscopic surgery and they were given freedom to choose the procedures. The recommendation was that they focus on operations with which they were familiar to reach better performance and accelerate learning on the new platform. The chosen group consisted of younger and more experienced surgeons. At first, what seemed to be a reason for difficulty, proved very correct, since the generations were complementary, exchanging experiences and gaining aptitude. The requirement that all training surgeons be present in the operations of others has greatly accelerated the group's experience. Although each has done 20 to 35 operations, they were present in about 200 cases of other colleagues.

After performing 20 operations and if considered fit by the program proctors, the surgeons were allowed to operate with the robot without mentoring. Some were elected to act as internal proctors in the program and thereby replicate the knowledge in other services that were starting in Rio de Janeiro and other states in Brazil.

In a rational way and with considerable investment, the most complete Robotic Surgery training system has been safely and efficiently implemented. With around 300 patients operated in three years, with a very low rate of complications and reoperations and no deaths, this new service is credited as a very successful model and ready for new challenges[14,15]. Rocha *et al.*[11] reported that the methodology adopted in radical resection of the prostate (even with the surgeons in training), produced early results similar to groups that had already been established.

In Europe and especially in the USA, robotic technology has been well developed since the early 2000s, where there are more than 1,300 surgical robots installed. Thus, the discussion about training and deployment of the robotic access route has already been made in the residency programs[11-13,16-19]. It is also important to note that not all types of surgeries performed during training have met the criteria found in the literature for the advantageous use of the robotic platform. Lower complexity surgeries were performed to fit the aptitude of the surgeon who presented the greatest difficulty at the beginning of the experiment (learning curve) to be able to operate with the required safety for the patient[3].

With the experience gained from performing various operations, it seems promising to use the robotic platform instead of laparoscopic and open surgery in the following procedures: bariatric surgery in super-obese patients and bariatric reoperations, due to the technical and ergonomic challenges these patients impose; giant hiatus hernias, para-esophageal hernias and their reoperations; low rectal cancer, especially in the narrow pelvis; achalasia surgery; pancreatectomies; complicated diverticulitis, with multiple adhesions and fistulas; lymphadenectomies in general; abdominal wall surgeries mainly in the ventral ones with multiple defects, large defects and in obese patients; and lumbotomy eventrations[3].

The continuity of the experience acquired by the group in the coming years tends to align with the medical literature in this field and a larger number of patients treated should validate this trend favorable to the treatment performed on the robotic platform of the conditions mentioned herein. The modernization of the robot used in this study, as well as new models that will soon enter the market, tend to democratize the use of this fabulous technology and further facilitate the surgeon's work for the patient's benefit.

R E S U M O

Objetivo: descrever a implantação de um programa de treinamento em cirurgia robótica e apontar as operações em Cirurgia Geral que podem ser feitas com vantagens utilizando a plataforma robótica. **Métodos:** estudo prospectivo do Grupo de Cirurgia Robótica em Cirurgia Geral e Colorretal do Hospital Samaritano (Rio de Janeiro, Brasil), de outubro de 2012 a dezembro 2015. São descritas as etapas do treinamento e particularidades. **Resultados:** no período do estudo foram realizadas 293 operações robóticas em Cirurgia Geral: 108 cirurgias para obesidade mórbida, 59 colorretais, 55 cirurgias na área da transição esôfago-gástrica, 16 colecistectomias, 27 hérnias da parede abdominal, 13 hernioplastias inguinais, duas gastrectomias com linfadenectomia à D2, uma vagotomia, duas hernioplastias diafragmáticas, quatro cirurgias hepáticas, duas adrenalectomias, duas esplenectomias, uma pancreatectomia, uma anastomose biliodigestiva. O índice de complicações foi de 2,4% sem complicações maiores. **Conclusão:** o Programa de Cirurgia Robótica do Hospital Samaritano foi implementado de forma segura e com resultados iniciais acima da literatura. Parece haver benefício em se utilizar a plataforma robótica nos super obesos, nas reoperações de cirurgia de obesidade e de hérnias de hiato, hérnias de hiato gigantes e para-esofágicas, hérnias ventrais com múltiplos defeitos e ressecções baixas de reto.

Descritores: Procedimentos Cirúrgicos Robóticos. Capacitação em Serviço. Curva de Aprendizado. Laparoscopia. Cirurgia Geral.

REFERENCES

1. Barbash GI, Glied SA. New technology and health care costs--the case of robot-assisted surgery. N Engl J Med. 2010;363;(8):701-4.
2. Pugin F, Bucher P, Morel P. History of robotic surgery: From AESOP® and ZEUS® to da Vinci ®. J Visc Surg. 2011;148(5Suppl):e3-8.
3. Szold A, Bergamaschi R, Broeders I, Dankelman J, Forgione A, Langø T, et al. European Association of Endoscopic Surgeons (EAES) consensus statement on the use of robotics in general surgery. Surg Endosc. 2015;29(2):253-88.
4. Montorsi F, Wilson TG, Rosen RC, Ahlering TE, Artibani W, Carroll PR, et al. Best practices in robot-assisted radical prostatectomy: recommendations of the Pasadena Consensus Panel. Eur Urol. 2012;.62(3):368-81.
5. Chitwood WR Jr, Nifong LW, Chapman WH, Felger JE, Bailey BM, Ballint T, et al. Robotic surgical training in an academic institution. Ann Surg. 2001;234(4):475-84; discussion 484-6.
6. Lee JY, Mucksavage P, Sundaram CP, McDougall E. Best practices for robotic surgery training and credentialing. J Urol. 2011;185(4):1191-7.
7. Davis D, O'Brien MAT, Freemantle N, Wolf FM, Mazmanian P, Taylor-Vaisey A. Impact of formal continuing medical education. Do conferences, workshops, rounds, and other traditional continuing education activities change physician behavior or health care outcomes? JAMA. 1999;282(9):867-74.
8. Patel VR. Essential elements to the establishment and design of a successful robotic surgery programme. Int J Med Robot. 2006;2(1):28-35.
9. Rocco B, Lorusso A, Coelho RF, Palmer KJ, Patel VR. Building a robotic program. Scan J Surg. 2009;98(2):72-5
10. Murphy D, Bjartell A, Ficarra V, Graefen M, Haese A, Montironi R, et al. Downsides of robot-assisted laparoscopic radical prostatectomy: limitations and complications. Eur Urol. 2010;57(5):735-46.
11. Zorn KC, Gantam G, Shalhav AL, Clayman RV, Ahlering TE, Albala DM, et al. Training, credentialing, proctoring and medicolegal risks of robotic urological surgery: recommendation of the Society of Urologic Robotic Surgeons. J Urol. 2009;182(3):1126-32.
12. Rocha R, Fiorelli RK, Buogo G, Rubistein M, Mattos RM, Frota R, et al. Robotic-assisted laparoscopic prostatectomy (RALP): a new way to training. J Robot Surg. 2016;10(1):19-25.
13. Gomes PP, Willis RE, Van Sickle KR. Development of a virtual reality robotic surgical curriculum using the Da Vinci Si surgical system. Surg Endosc.2015;29(8):2171-9.
14. Passerotti CC, Franco F, Bissoli JC, Tiseo B, Oliveira CM, Buchalla CA, et al. Comparison of the learning curves and frustration level in performing laparoscopic and robotic training skills by experts and novices. Int Urol Nephrol. 2015;47(7):1075-84.
15. Dulan G, Rege RV, Hogg DC, Gilbert-Fisher KM, Arain NA, Tesfay ST, et al. Developing a comprehensive, proficiency-based training program for robotic surgery. Surgery. 2012;152(3):477-88.
16. Donias HW, Karamanoukian RL, Glick PL, Bergsland J, Karamanoukian HL. Survey of resident training in robotic surgery. Am Surg. 2002;68(2):177-81.
17. Geller EJ, Schuler KM, Boggess JF. Robotic surgical training program in gynecology: how to train residents and fellows. J Minim Invasive Gynecol. 2011;18(2):224-9.
18. Moles JJ, Connelly PE, Sarti EE, Baredes S. Establishing a training program for residents in robotic surgery. Laryngoscope. 2009;119(10):1927-31.
19. Dulan G, Rege RV, Hogg DC, Gilbert-Fisher KK, Tesfay ST, Scott DJ. Content and face validity of a comprehensive robotic skills training program for general surgery, urology, and gynecology. Am J Surg. 2012;203(4):535-9.
20. Patel HR, Linares A, Joseph JV. Robotic and laparoscopic surgery: cost and training. Surg Oncol. 2009;18(3):242-6.

Received in: 23/11/2016
Accepted for publication: 27/01/2017
Conflict of interest: none.
Source of funding: none.

Mailing address:
Fernando Athayde Veloso Madureira
E-mail: drfmadureira@hotmail.com
drfmadureira@gmail.com