The Implementation of Robotic Surgery in Israel

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ABSTRACT: **Background:** In the last decade the number of robotic devices and the medical procedures utilizing them increased significantly around the world.

Objective: To evaluate the implementation of robotic surgeries in Israel in various surgical disciplines.

Methods: We conducted a retrospective study accessing information about the annual purchases of robots, the number of physicians trained for their use, and the number of robotic surgeries performed each year, according to indications of surgery and the disciplines of the operating medical staff. The data were taken from the database of Intuitive Surgical Inc.

Results: Six robots were purchased by six medical centers in Israel during the years 2008–2013. There are currently 150 physicians trained to use the robot in one of the simulators of Intuitive Surgical Inc. Of them, 104 are listed as active robotic surgeons. Most of these physicians are urologists, gynecologists, or general surgeons. The number of robotic surgeries increased each year in all fields in which it was implemented. In 2013, 975 robotic surgeries were performed in Israel. Of them, 52% were performed by urologists; 89% of them were radical prostatectomy.

Conclusions: The use of robotic surgery increased considerably in Israel over recent years, in urology, gynecology, general surgery, and otolaryngology. Despite the lack of conclusive evidence of the advantages of robotic surgery over the laparoscopic approach, the market power and the desire to be at the technological forefront drive many medical centers to purchase the robot and to train physicians in its use.

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Robotic surgery, as one development in the progress of reduced-size invasive operations, has evolved gradually and significantly over the last decade. During the past 5 years, hundreds of articles have been published that involve the theoretical and practical aspects of surgical robotics as aids to surgery. The first robotic surgical operation was described nearly 30 years ago, in 1985. During that procedure, Kwoh and his associates performed a brain biopsy with a robotic arm PUMA560. With the guidance of computed tomography (CT), the biopsy was taken successfully without complications [1]. The development of robotic surgery has advanced towards Telerobotics and remote control over the course of real-time surgery. The idea was taken from NASA's use of robotics and presented to the Pentagon as a developmental project in the early 1990s to enable treatment of injured soldiers on the battlefield without jeopardizing the medical crew. The robotic system developed for that purpose was called Mobile Advanced Surgical Hospital (MASH). Although there was no real-time usage in the MASH system, the field of robotics in medicine gained momentum and was eventually implemented in the daily clinic [2]. In 1992 the Robodec was introduced as a tool to aid hip replacement surgery. A year later it was the first robot to be granted Food and Drug Administration (FDA) approval for these types of procedures.

In 2001 a cholecystectomy was performed by a New York-based surgeon in a patient living in France. This first Telerobotic procedure was performed successfully with the ZEUS robot, without complications. Nevertheless, the technology did not succeed due to technical limitations within the system [3]. The company Intuitive Surgical Inc., which purchased the ZEUS Company, continued to forge developments and breakthroughs in the field, among them, the da Vinci model. The number of robotic devices transplanted around the world and of surgical procedures performed using the robot increased significantly over the last decade. According to a report by Intuitive Surgical Inc., 1,500,000 operations were performed around the world by 2013, with the help of the da Vinci system. During the years 2007–2013, the number of robotic systems in the United States rose from 800 to 2001 and in Europe from 200 to 443. Robotic surgery was introduced in Israel in 2008, with the purchase of a da Vinci robot by Hadassah University Hospital (Ein Kerem campus) [4].

The goal of this study was to assess the implementation process of robotic surgery in Israel, in the different surgical disciplines.

METHODS

The company Intuitive Surgical Inc. documents all procedures that are performed by robots in Israel. Data were collected from their database regarding the purchase dates of all robotic devices in the medical centers in Israel; the number of physicians who were trained to operate this technology, annually and according to medical disciplines; and the number of surgical procedures performed annually, according to specialty and medical indication. Ethics committee approval was not required since the study did not involve patient chart reviews.

STATISTICS

The data were inserted into the SPSS 19 software (SPSS Inc., Chicago, IL) and are presented as percentages grouped by category.

RESULTS

During the years 2008–2013, six robots were purchased in medical centers in Israel: Hadassah in 2008, Sheba Tel Hashomer in 2009, Rambam Health Care Campus in 2010, Rabin Medical Center in 2010, Assaf Harofeh Medical Center in 2010, and Assuta Hospital in 2012. Parallel to the increase in the number of robotic devices in Israel, the number of surgeons trained to operate these devices also increased [Table 1]. According to the information provided by Intuitive Surgical Inc., at the end of 2013 there were 150 physicians in Israel who had completed a 2 day course at one of the company's training facilities. During this training process, physicians learn to operate the da Vinci surgical system, using animal laboratory and computerized stimulators. Attendees have the opportunity to practice various surgical skills and to do live surgical procedures on animals. On completion of the course, all physicians receive a document of attendance. The training process is a prerequisite for operating the robot. Of the physicians who received training, 104 are listed in the database as surgeons who operate using the robot. Urology, followed by gynecology, is the field with the highest number of surgeons trained to use the robot [Table 1]. For all specialties the numbers of surgeons increased each year [Table 1].

During the last 3 years, the number of procedures performed with the robotic approach in Israel increased each year in all fields in which it was implemented [Table 2]. In 2013, 975 robotic surgeries were performed. Of all operations 52% were performed by urologists; of them, 80% were radical prostate removals. This number is equal to almost half of all the radical prostate removals performed in Israel in 2013. Of all the robotic surgeries done in 2013, 21% were performed by gynecologists. Most of them were for benign indications (78%): total hysterectomy, pelvic floor reconstruction, and leiomyoma removals. Compared to the fields of urology and gynecology, implementation of robotic procedures has been lower in general surgery and otolaryngology; however, the increases in the latter from 2011 to 2013 were particularly dramatic [Table 2].

Table 1. Number and percentage of surgeons trained each year, according to specialties

	Urologists		General surgeons		Gynecologists		ENT physicians	
Year	No.	%	No.	%	No.	%	No.	%
2009	1	1.9%	1	2.8%	1	2.1%	1	5.5%
2010	5	9.8%	2	5.7%	5	10%	2	11.1%
2011	10	19.6%	5	14.2%	9	19.5%	2	11.1%
2012	15	29.4%	12	34.2%	14	30.4%	5	27.7%
2013	20	39.2%	15	42.4%	17	36.9%	8	44.4%
Totals	51	100%	35	100%	46	100%	18	100%

ENT = ear nose and throat

DISCUSSION

This study shows the significant increase in Israel during the last 3 years in the use of robots in urology, gynecology, general surgery and otolaryngology. [5] The number of procedures increased in correlation to the number of surgeons who were trained in robotic surgeries and to the number of medical centers in which the robotic system was installed.

The benefits of using a surgical robot as compared to conventional laparoscopy are:

- Avoidance of surgeon hand tremor, granting a more precise performance of complicated operations
- Three-dimensional visions
- Increased agility via the robot's joints, facilitating the accurate performance of complex procedures, such as surgical sutures and dissection of tissues in hard-to-access anatomic areas
- Control by the surgeon over three arms, as well as a camera, enabling almost independent navigation, without the need for an assistant's expertise
- Increased and consistent precision and accuracy in performing operations, without fatigue, due to the elimination of the need for the surgeon, who is not sterile, to stand in uncomfortable positions for long hours. The operation is done while

Table 2. Number and percentage of robotic procedures performed annually during 2011–13 by specialty

	2011		2012		2013	
	No.	%	No.	%	No.	%
Urology (total)	162	57	375	55.2	508	52.1
Prostatectomy	143	50	295	43.4	390	40
General surgery	25	8.8	117	17.2	121	12.4
Otolaryngology	3	1	11	1.6	36	3.6
Gynecology (total)	94	33	176	25.9	210	21.5
Hysterectomy-oncology	38	13.3	51	7.5	72	7.3
Sacrocolpopexy	28	9.8	42	6.1	55	5.6
Totals	284	100	679	100	975	100

sitting and the surgeon enjoys the comfortable ergonomic design of the control unit.

On the other hand, there are a number of disadvantages to the robotic compared to the laparoscopic approach, including the high cost of the robot, the large space occupied by the robot in the operating room, the ongoing maintenance, and the need to purchase disposable equipment [6].

In assessing the benefits and costs, the question arises as to whether the robot poses a surgical advantage or is a marketing tool that raises the prestige of institutions offering it. Examinations of the efficiency and financial costs of robotic surgeries were beyond the scope of the current study. To assess costs versus benefits, a meta-analysis for each surgical field is required, which will examine and compare the advantages and disadvantages of this surgical approach to that of laparoscopy. Numerous studies have compared the two approaches. The main outcome measures that were examined were: the amount of bleeding, healing times, pain levels after surgery, the rate of transition to open surgery with the laparoscopic approach, financial costs, and the process of implementation [7,8]. Implementation of a surgical procedure is a complicated standard that examines the number of surgical procedures needed to be performed in order to achieve a high surgical proficiency for a specific operation. Quantifying the measure of performance of a surgical procedure is difficult due to the absence of valid tools. It is customary to determine surgical capability from an assessment of complications and the duration to perform the procedure, and to complete it. An earlier study conducted by the authors of the current study compared the implementation process of laparoscopic surgery for pelvic prolapse repair to robotic surgery. The process of implementation was assessed based on the duration of the surgery and the rate of complications. After 15 surgeries with the robotic approach, the length of the procedure was shortened significantly, by about 50 minutes, whereas the duration of laparoscopic surgeries was not shorter even after the surgical team gained experience from the performance of 40 procedures. Moreover, the operating time was significantly less with the robotic than the laparoscopic approach [9]. In that study, no difference was found between the two surgical approaches in rates of complications other than lower amount of bleeding in the robotic arm. The study highlights the relatively quick capability of acquiring surgical proficiency to perform pelvic floor reconstructive surgery using the robotic approach. These findings, together with the other benefits mentioned above, may explain the rapidly increasing popularity of the robot among surgeons in gynecology and other fields.

As mentioned before, the robotic approach has the potential to improve surgical outcomes and reduce the steep learning curve associated with the conventional laparoscopic approach in most fields of surgery. In one study where a total of 200 patients underwent robotic radical prostatectomy, the learning curve was approximately 20 to 25 cases until they could implement robotics safely and effectively into their community practice with minimal patient morbidity and good oncological and functional outcomes [10]. In another study, in the field of colorectal surgeries, the same results were demonstrated using laparoscopic and robotic approaches, and the learning phase was achieved following 15 to 25 surgeries [11].

There are various studies in the literature that compare robotic to laparoscopic surgeries in different fields of surgery and different procedures. One study compared the perioperative results of 27 patients who underwent radical hysterectomy by robotics, laparoscopy and laparotomy. Operating time for robotics was significantly shorter than for laparoscopy. Blood loss and length of hospital stay were similar for both laparoscopy and robotics and less than for laparotomy [12].

A meta-analysis published in the journal *Minimally Invasive Therapy and Allied Technologies* in December 2014 evaluated the short-term outcomes of robotic-assisted compared to laparoscopic gastrectomy. Blood loss was lower and postoperative stay was shorter in the robotic group [13].

In addition to these studies that demonstrated the benefits of robotic surgery for the patient, some studies examined the benefits of robotic technology for surgeons. In one study, 32 surgeons were asked to perform two surgical tasks (a ball pick-and-drop task and a rope-threading task) on both robotic and laparoscopic systems. Workload and mental effort were measured (subjective: rating scale for mental effort, and objective: standard deviation of beat-to-beat intervals). Surgeons performed surgical tasks more quickly and accurately (with fewer errors) with the robotic system. Self-reported measures of workload and mental effort were significantly lower with the robotic system. When using the robotic system, an objective cardiovascular measure of mental effort showed a lower investment. This affords surgeons greater opportunities and resources for dealing with the various demands of surgery such as communication, decision making, and dealing with complex situations in the operating room [14].

The high cost of robotic surgery is a recurring issue. Estimating the cost of a surgical procedure requires a meticulous examination of the initial cost of buying the equipment, the cost of the disposable equipment, the duration of the operation, the rate of complications, the duration of healing and length of hospitalization days, and the time to return to routine functioning (work and everyday activities). Integrating all these data, including an estimate by the surgical team of the length of training time required for each approach, need to be incorporated into a cost-benefit analysis. Technological progress in the field of medicine, as in other areas, is an accelerated process. The authors of this report presume that the robot will undergo many improvements to increase cost-efficiency. Despite the lack of hard evidence for greater efficiency compared to laparoscopy, the ease of operation of robotic surgery, together with market forces and the desire to lead in medical progress seem to be incentives to many medical centers in purchasing robots and training more and more physicians from various fields. In Israel, the extra costs imposed by robotic surgery, beyond those of laparoscopic surgery or an open abdomen approach, are financed by the public hospitals' budget. Robotic operations in all fields, except for radical prostate removal, are presently not recompensed by the insuring health management organizations. In private medicine, on the other hand, the increased costs of the robotic approach are covered by insurance companies or by the patients themselves. Implementing an innovative technology in medicine requires openness among leaders in the department of health and insurance companies, as well as vision on the part of management teams of medical centers who commit themselves to additional investments aimed to advance the field of medicine.

CONCLUSIONS

In recent years the use of robotic surgery has increased considerably in Israel, in the fields of urology, gynecology, general surgery and otolaryngology. The advantages of robotic over laparoscopic surgery have yet to be demonstrated in every field, and the issue of cost must be examined thoroughly. Nevertheless, in this case, the forces of the market seem to exceed those of evidence-based medicine.

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