The Implementation of Robotic Surgery in Israel

Emad Matanes MD, Sari Boulus MD and Lior Lowenstein MD MS

Department of Obstetrics and Gynecology, Rambam Health Care Campus, affiliated with Rappaport Faculty of Medicine, Technion-Israel Institute of Technology, Haifa, Israel

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 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.

KEY WORDS: robotic surgery, laparoscopy, minimally invasive surgery

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 Robodoc 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 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 physi-
cians 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 Haroefeh 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].

**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>
<thead>
<tr>
<th>Year</th>
<th>Urologists</th>
<th>General surgeons</th>
<th>Gynecologists</th>
<th>ENT physicians</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>2009</td>
<td>1</td>
<td>1.9%</td>
<td>1</td>
<td>2.8%</td>
</tr>
<tr>
<td>2010</td>
<td>5</td>
<td>9.8%</td>
<td>2</td>
<td>5.7%</td>
</tr>
<tr>
<td>2011</td>
<td>10</td>
<td>19.6%</td>
<td>5</td>
<td>14.6%</td>
</tr>
<tr>
<td>2012</td>
<td>15</td>
<td>29.4%</td>
<td>12</td>
<td>34.2%</td>
</tr>
<tr>
<td>2013</td>
<td>20</td>
<td>39.2%</td>
<td>15</td>
<td>42.4%</td>
</tr>
<tr>
<td>Totals</td>
<td>51</td>
<td>100%</td>
<td>35</td>
<td>100%</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Specialty</th>
<th>2011 No.</th>
<th>2011 %</th>
<th>2012 No.</th>
<th>2012 %</th>
<th>2013 No.</th>
<th>2013 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urology (total)</td>
<td>182</td>
<td>57</td>
<td>375</td>
<td>55.2</td>
<td>508</td>
<td>52.1</td>
</tr>
<tr>
<td>Prostatectomy</td>
<td>143</td>
<td>50</td>
<td>295</td>
<td>43.4</td>
<td>390</td>
<td>40</td>
</tr>
<tr>
<td>General surgery</td>
<td>25</td>
<td>8.8</td>
<td>117</td>
<td>17.2</td>
<td>121</td>
<td>12.4</td>
</tr>
<tr>
<td>Otolaryngology</td>
<td>3</td>
<td>1</td>
<td>11</td>
<td>1.6</td>
<td>36</td>
<td>3.6</td>
</tr>
<tr>
<td>Gynecology (total)</td>
<td>94</td>
<td>33</td>
<td>178</td>
<td>25.9</td>
<td>210</td>
<td>21.5</td>
</tr>
<tr>
<td>Hysterectomy- oncology</td>
<td>38</td>
<td>13.3</td>
<td>51</td>
<td>7.5</td>
<td>72</td>
<td>7.3</td>
</tr>
<tr>
<td>Sacrocolpopexy</td>
<td>28</td>
<td>9.8</td>
<td>42</td>
<td>6.1</td>
<td>55</td>
<td>5.6</td>
</tr>
<tr>
<td>Totals</td>
<td>284</td>
<td>100</td>
<td>679</td>
<td>100</td>
<td>975</td>
<td>100</td>
</tr>
</tbody>
</table>
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 mar-
keting 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 stan-
dard 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 perform-
ance 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 complica-
tions. After 15 surgeries with the robotic approach, the length
of the procedure was shortened significantly, by about 50 min-
utes, 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 poten-
tial 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 learn-
ing 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 periopera-
tive 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 laparo-
copy 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 lapa-
roscopic 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 objec-
tive: 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 objec-
tive 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 metic-
ulous 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 func-
tioning (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 incor-
porated 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 laporos-
copy, 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.

Correspondence
Dr. L Lowenstein
Dept. of Obstetrics and Gynecology, Rambam Health Care Campus, Haifa 31096, Israel
Phone: (972-4) 854-2382
Fax: (972-4) 854-3483
email: L_lior@rambam.health.gov.il

Snail1-induced partial epithelial-to-mesenchymal transition drives renal fibrosis in mice and can be targeted to reverse established disease

Progressive kidney fibrosis contributes greatly to end-stage renal failure, and no specific treatment is available to preserve organ function. During renal fibrosis, myofibroblasts accumulate in the interstitium of the kidney, leading to massive deposition of extracellular matrix and organ dysfunction. The origin of myofibroblasts is manifold, but the contribution of an epithelial-to-mesenchymal transition (EMT) undergone by renal epithelial cells during kidney fibrosis is still debated. Grande et al. show that the reactivation of Snail1 (encoding snail family zinc finger 1, known as Snail1) in mouse renal epithelial cells is required for the development of fibrosis in the kidney. Damage-mediated Snail1 reactivation induces a partial EMT in tubular epithelial cells that, without directly contributing to the myofibroblast population, relays signals to the interstitium to promote myofibroblast differentiation and fibrogenesis and to sustain inflammation. The authors also show that Snail1-induced fibrosis can be reversed in vivo and that obstructive nephropathy can be therapeutically ameliorated in mice by targeting Snail1 expression. These results reconcile conflicting data on the role of the EMT in renal fibrosis and provide avenues for the design of novel anti-fibrotic therapies.

Eitan Israeli

References