REVIEW

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Does Prior Laparoscopic and Open Surgery Experience Have Any Impact on Learning Curve in Transition to Robotic Surgery?

Robotik Cerrahiye Dönüşümde Laparoskopik ve Açık Cerrahi Geçmişinin Öğrenme Eğrisi Üzerine Etkisi Var mıdır?

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ABSTRACT

It has been 15 years since the Food And Drug Administration approved the Da Vinci® robotic surgery system. Robotic applications are being used extensively in urology, particularly in radical prostatectomy. Like all high-tech products, this system also has a high cost and a steep learning curve, therefore, preventing it from becoming widespread. There are various studies on the effect of open surgery or laparoscopy experience on the learning curve of robotic surgery. Analyzing these interactions well will provide valuable information on making the training period of robotic system more efficient.

Keywords

Robotic surgery, laparoscopy, prostatectomy, learning curve

ÖZ

Da Vinci® robotik cerrahi sistemin Gıda ve İlaç Dairesi onayı almasının üzerinden 15 yıl geçti. Robotik uygulamalar, başta radikal prostatektomi olmak üzere ürolojide gittikçe artan yaygınlıkta kullanılmaya başlamıştır. Tüm ileri teknoloji ürünleri gibi bu sistemin de pahalı olmasının yanında öğrenme süresinin uzun olması, yaygınlaşmasının önündeki en önemli engellerdendir. Uygulayıcının açık cerrahi veya laparoskopi deneyiminin robotik sistemi öğrenme süresini ne şekilde etkilediğiyle ilgili farklı çalışmalar mevcuttur. Bu etkileşimin iyi analiz edilmesi, robotik sisteme ait eğitim sürecinin daha etkinleştirilmesi konusunda değerli bilgiler verecektir.

Anahtar Kelimeler

Robotik cerrahi, laparoskopi, prostatektomi, öğrenme eğrisi

Introduction

It has been more than 30 years since the first utilization of robotic technology with Puma 560 robot for obtaining a biopsy in neurosurgery in 1985 (1). During this period, robotic platforms, which were used in transurethral prostate resection and percutaneous renal entry in the beginning, could not find a distinctive place in urology practice due to being offline systems and working outside the surgeon's guidance and skills (2,3). Online robotic systems on the other hand, have the ability to mimic the surgeon's movements in real time during surgery. Since the Food And Drug Administration (FDA) approved the Zeus and Da Vinci® robotic platforms, which are controlled by a surgeon from a console, in 2000 and 2001, these systems are utilized in increasing frequency. According to a research performed in 2007, robotic radical prostatectomy (RRP) with Da Vinci®, pioneered in Vattikuti Urology Clinic, comprises 60% of all radical prostatectomies in the United States of America (4). Surely the number has increased today and it would not be wrong to assume that RRP replaced open prostatectomy.

Robotic surgery provides a 3D magnified image via a camera, therefore marking a prominent advantage. More importantly, special jointed robot arms (EndoWrist), inspired by human's wrist, allow hand motions in 7 different axes. Therefore, this enables the surgeon to perform various manipulations which are not possible in videoendoscopic surgery. Additionally, the system prevents the amplification of low amplitude movements caused by surgeon's tremor, thus eliminating one of the foremost disadvantages of laparoscopy. Costly installation and maintenance of the system, lack of tactile sense and a steeper learning curve compared to open surgery are the largest obstacles of robotic surgery, standing before its popularization.

Several years before the FDA's approval of robotic surgery applications, Clayman, Kavoussi and Schuessler took heart from the advantages of laparoscopic nephrectomy over open surgery, such as a reduced amount of blood loss, pain and reduced time of admission and they attempted laparoscopy in radical prostatectomy (5), however, the first results were rather discouraging. Working with rigid instruments in two dimensional images, prolonged surgery duration and increased perioperative complication rates have not given the impression that this method would be a viable alternative to open prostatectomy. Despite these, when Montsouris shared the oncological and functional results of 120 laparoscopic radical prostatectomy (LRP) cases in following years (2000), it is understood that the efficiency

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of this method could be increased in experienced hands, despite the prolonged surgery duration (6). In the succeeding years, this method has generated an increased interest and enthusiasm when the results of positive laparoscopic prostatectomy surgeries from different institutions arrived; but it was expressed that acceptable results could only be obtained after 80-100 cases for urologists with limited laparoscopic experience (7). Different methods have been attempted to resolve the long learning curve problem and it was stated that results obtained by open surgery can be achieved after performing 30-50 cases with practicing with training boxes and under the guidance of an experienced laparoscopist (8). Similarly, Menon et al. (9) have tried a different method and reported that an experienced open surgeon without any previous laparoscopic experience can work with robotic system to ease the steep learning curve of laparoscopy. In this study, after 40 robotic prostatectomy experiences the surgeon could achieve very good results such as an average of 256 ml blood loss, 0% transfusion rate, 17% positive surgical margins and an average surgery duration of four and a half hours which gradually declined.

Robotic system eases surgical interventions greatly compared to the laparoscopic method, thanks to its high-tech instruments. However, despite all that, its learning curve-time is considerably longer compared to open surgery. Although the learning curve does not have a standard description or measurement, it is generally accepted as the duration in which a surgeon completes a surgical intervention longer and harder than its standards because of his/her inexperience without any relationship with that particular surgeon's pre-clinic training and practical applications. The number of cases is used as a measurement rather than duration. End of the learning curve can be described as the surgeon's comfort when performing that procedure and doubtlessly learning speed and previous similar experiences of the surgeon is an aspect that affects the surgery duration as well as the procedure itself. The duration becomes pretty variable when the end of learning curve is defined as the surgeon being comfortable doing the procedure. Therefore, when providing data about learning curve, duration of surgery, amount of blood loss and surgical margin-positive rate in radical prostatectomy, the first and maybe the most frequently used surgical procedure, are used.

Widely accepted opinion point is that a surgeon, who even does not possess any laparoscopic experience, can achieve rather average surgery durations in a short time in robotic surgery. In Vattikuti Urology Institute experience, in which a structured RRP program was introduced in 2000, it took 18 cases to reach the surgery time of LRP (9). Similar results have been reported in succeeding studies. Ahlering et al. (7) reported that a surgeon who has no previous laparoscopic experience could reach 4 hours of RRP surgery time in 12 cases. Study results of wider series started to come out several years later, when the method became popular and the number of cases increased. In the first cases, operative duration for LRP and, after that, duration comparable to that for open radical prostatectomy (ORP) was achieved. Accordingly, it is possible to achieve 200 minutes of operative time after first 50 cases and then, 100 minutes after 150 cases in RRP, which is fairly acceptable (10). Minimum blood loss during surgery is a huge advantage of RRP over ORP, even in the first cases. After limited experience, 150-250 ml blood loss per case which does not require transfusion was reported. Surgical margin-positive rates in first series of RRP are pretty variable (13-45%). Although it is known that pathologic data are much variable in other methods and they are accepted as findings least related to learning time, considering the fact that the work is cancer surgery, the role of cancer control and oncological outcomes are undeniable in the validation of this new method. As much as its relationship with learning curve is little, many reports regarding the decline of surgical margin positivity come out with the increasing number of cases in the literature. In one of these, the first 100 RRP cases were separated into 3 parts each of 33 cases according to their surgery dates and it was detected that surgical margin positivity declines as 45%, 21% and 11%, from the first cases to the last, respectively (11). Badani et al. (12) also reported 7% surgical margin positivity in first 200 cases and 4% in last 200 cases in their T2 patients of over a number of 2700.

It would not be wrong to state that robotic surgery has postoperative oncologic outcomes similar to ORP in experienced hands. Oncological outcomes of series without longer follow-up results in the first years showed satisfying results in recent studies. In a study evaluating 1100 D'Amico high-risk prostate cancer patients, who underwent RRP between 2002 and 2013 at three tertiary care centers, the subjects were stratified into five novel risk groups according to regression tree analysis: very low risk [Gleason score (GS) ≤6], low risk: [prostate-specific antigen (PSA) ≤10 ng/ml; GS=7], moderate risk: (PSA ≤10 ng/ml; GS ≥8), high risk: (PSA >10 ng/ml; GS=7), and very high risk: (PSA >10 ng/ml; GS ≥8) and 10-year biochemical relapse-free survival rates in these groups were 86%, 70%, 36%, 31% and 26% ($p<0.001$), respectively. In the same period, clinical recurrence-free survival rates were 99%, 96%, 85%, 67% and 55%, respectively (13).

When we take a look at the post-RRP functional results, very high rates are observed. In their study including 500 patients who underwent RRP, Patel et al. (14) have reported continence rates of 89% and 95% at 3 and 6 months and a potency rate of 78% at the 12th month. To compare functional results with other methods is difficult due to the standardization of the cases, but it is observed that RRP provided results similar to that with ORP in many studies.

There have been many studies evaluating previous open surgery and laparoscopy experiences in order to obtain the admirable data of prostatectomy procedures performed via robotic surgery in a short time. Generally accepted idea is that a surgeon can achieve good outcomes with robotic surgery in a short time, even though he/she has no previous laparoscopy experience. However, there have been also numerous studies pointing out that a thorough laparoscopic experience curtails the learning period significantly. In a study the perioperative complications and early patient outcomes from initial 100 cases of robot-assisted laparoscopic radical prostatectomy performed by one of two surgeons, each with previous experience of more than 1000 LRP, were compared with LRP cases. Surgery time (153 min vs. 128 min) and blood loss 254 ml vs. 200 ml) were significantly higher in RRP group than in LRP group. All other parameters (catheterization time, positive surgical margins and continence rates) were reported to be similar. The authors commented that a good laparoscopy experience quells a steep learning curve of robotic surgery (15). In another quite similar study, the first 60 RRP and the last 60 LRP results of 3 surgeons with over 200 LRP experience were compared and it was reported that surgery time, blood loss volume and surgical margin positivity were significantly higher in patients who underwent robotic prostatectomy (153 mins-236 mins, 202 ml-244 ml and 12.5-31.6%, respectively). However,

potency and continence rates were similar with each other or in favor of robotic surgery (16). On the other hand, in another study in which first 50 robot-assisted laparoscopic prostatectomy (ARP) and first 50 open radical retropubic prostatectomy (ORRP) results of a surgeon without previous laparoscopy experience was evaluated, operative time and blood loss volume were found to be lower in ARP than in ORRP, meanwhile complication, surgical margin positivity, continence and potency rates were found to be similar. It was commented that open surgery results can be achieved in first 50 robotic cases (17). The argument of the authors who claim it is not possible for a surgeon with limited open surgery experience to complete the learning curve in a short period of time such as robotic 50 cases is as follows: it is possible for a surgeon with limited number of open prostatectomy experience to achieve a shorter learning period, but this period can be higher for a more experienced surgeon who aims for higher standards to reach his/her older results. In a study, which has the precise results for this comment, an author who had an experience with over 2500 open prostatectomy has stated that he could not achieve similar results before 150 robotic procedures and he could not feel that sense of comfort and confidence comparable to that with open surgery until after 250 robotic procedures (18).

When the effects of open and laparoscopic surgery experiences on the learning time of robotic surgery are assessed separately, it is difficult to claim any positive or negative effect of the presence or absence of any experience over one method. The facts that preoperative data of the cases are non-homogeneous and their personal characteristics are variable (age, hand skill and predisposition to learn, etc.) render this nearly impossible.

Meanwhile, there are well designed studies in urology literature in which the two methods are compared in the same study. In one of these, performance of 10 medical students and 10 surgical trainees and fellows who were given 3 laparoscopic and robotic training box-based tasks was compared. It was found that both groups had better performance with robotic surgery compared to that with laparoscopic surgery, but this result was more significant in medical students without previous laparoscopy experience. Therefore, it was concluded that robotic surgery may be learned easier without laparoscopy experience due to technical advantages (19). A similar study was performed with Da Vinci® simulator by inexperienced assistants, specialists without laparoscopy experience and surgeons with laparoscopy experience have participated in the study. Performance was evaluated by calculating the ratio of the sum of scores for each exercise over the number of repetitions needed to complete the exercise with at least an 80% score. Surgeons with laparoscopy experience performed more repetitions compared to the specialists without laparoscopy experience. In conclusion, the authors stated that laparoscopy experience has a negative effect in robotic surgery learning period (20).

No matter how well they are designed, results of studies performed with training boxes or simulators may differ from the real life. A good example for this fact is a recent study, in which perioperative, oncological, and functional outcomes of 355 RRP performed by 3 surgeons from the same clinic (surgeon A: experienced in open prostatectomy, surgeon B: experienced in both open surgery and laparoscopy and surgeon C: experienced only in laparoscopy) were compared. Although other data were similar, it was stated that surgeon C had the shortest surgery time by far (A: 219 mins, B: 245 mins and C 193 mins), B and C were superior to A according to postoperative 12 months continence rates (A: 61%, B: 83% and C: 85%). At the end, it was concluded that previous laparoscopic experience has positive effect on learning curve parameters of robotic surgery but it is too early to comment on the better continence outcomes (21).

Da Vinci® surgical system gives urologists a chance for a perfect minimally invasive dissection, extirpation and reconstruction in 4 hours surgery time with a short period of learning curve independently from any previous open or laparoscopic surgery experience. Its long-term oncological follow-up outcomes are similar with that of open surgery. Non-homogenous distribution of patient groups makes it harder for a comparative study of the cases with different surgical methods. Postoperative continence and potency rates show significant variability. Maybe the best description of learning and mastering robotic surgery comes from Menon (22): "Robotic radical prostatectomy, like golf, is easy to learn, but hard to master".

Ethics

Informed Consent: Consent form was filled out by all participants.

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Authorship Contributions

Concept: Cüneyt Adayener, Tolga Okutucu, Cemil Uygur, Design: Cüneyt Adayener, Tolga Okutucu, Cemil Uygur,

Data Collection or Processing: Cüneyt Adayener, Tolga Okutucu, Cemil Uygur, Analysis or Interpretation: Cüneyt Adayener, Tolga Okutucu, Cemil Uygur, Literature Search: Cüneyt Adayener, Tolga Okutucu, Cemil Uygur, Writing: Cüneyt Adayener, Tolga Okutucu, Cemil Uygur.

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