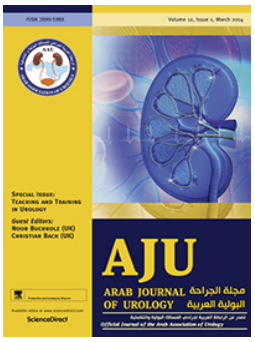

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MINI-REVIEW

Training in robotics: The learning curve and contemporary concepts in training

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KEYWORDS

Robotic assisted;
Laparoscopic surgery;
Training;
Learning curve;
Parallel learning

ABBREVIATIONS

RALP, robot-assisted laparoscopic prostatectomy;
OT, operating time;
PSM, positive surgical margin;
RPN, robot-assisted partial nephrectomy;
RAA, robot-assisted adrenalectomy;
VR, virtual reality

Abstract ***Objective:*** To define the learning curve of robot-assisted laparoscopic surgery for prostatectomy (RALP) and upper tract procedures, and show the differences between the classical approach to training and the new concept of parallel learning.

Methods: This mini-review is based on the results of a Medline search using the keywords 'da Vinci', 'robot-assisted laparoscopic surgery', 'training', 'teaching' and 'learning curve'.

Results: For RALP and robot-assisted upper tract surgery, a learning curve of 8–150 procedures is quoted, with most articles proposing that 30–40 cases are needed to carry out the procedure safely. There is no consensus about which endpoints should be measured. In the traditional proctored training model, the surgeon learns the procedure linearly, following the sequential order of the surgical steps. A more recent approach is to specify the relative difficulty of each step and to train the surgeon simultaneously in several steps of equal difficulty. The entire procedure is only performed after all the steps are mastered in a timely manner. Recently, a 'warm-up' before robotic surgery has been shown to be beneficial for successful surgery in the operating room.

Conclusion: There is no clear definition of the duration of the effective learning curve for RALP and robotic upper tract surgery. The concept of stepwise, parallel learning has the potential to accelerate the learning process and to make sure that

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initial cases are not too long. It can also be assumed that a preoperative ‘warm up’ could help significantly to improve the progress of the trainee.

Introduction

The concept of the learning curve

The idea of measuring the improvement in a repeated task over time was first described in 1885 by the German psychologist Herman Ebbinghaus [1]. The term ‘learning curve’ was first used in 1909 by Bryan and Harter, referring to a diagram plotting the acquisition of a telegraphic language over time. Their curve showed an initial steep rise, followed by a flattening, and was thereby convex to the vertical axis.

Widespread attention was given to the concept of the learning curve in 1936, as it was used by Wright [2] to measure the effect of learning on production costs in the aircraft industry. He showed that the cost of aeroplanes decreased with the increase in the number manufactured and based his idea on the hypothesis that if an operation is repeated it would take less time to perform. The curve itself was therefore a representation of the number of repetitions needed to decrease the time spent to complete the task.

A popular understanding of the speed of acquisition of a complex task is that it follows a sigmoid shape. It has a slow rise at the beginning, where the operator becomes accustomed to the equipment. This initial phase of slow learning is followed by a steep rise of the curve with a phase of quick learning, which reaches a plateau after expertise has been gained, and further progress then becomes difficult and slow. However, this sigmoid shape has not been reproduced in relevant reports, as the speed at which the skill is acquired has not been measured, but several other surrogate variables are assessed, as discussed below.

The learning curve for robot-assisted laparoscopic radical prostatectomy (RALP) and cystectomy

RALP has become a widely accepted therapeutic option for organ-confined prostate cancer and is replacing conventional open surgery and laparoscopy [3]. Despite many publications there is still no consensus on how many procedures are needed to overcome the initial learning period, and totals of 8–150 have been reported [4,5], with most estimating that an experienced open surgeon needs 18–45 cases to safely perform RALP independently [6]. This great variability is due to the lack of a standard definition of the appropriate outcome measure [7]. For example, one commonly used endpoint is attaining the ability to perform the procedure safely regardless of the time needed. This can lead to unfavourably long operating times (OTs) for the initial patients, with the inherent disadvantages. Therefore, in some studies a 4-h period has been used as an acceptable endpoint [4,8]. Other endpoints commonly used are oncological and functional outcomes, estimated blood loss, the rate of complications, or the surgeon’s subjective feeling of being comfortable and proficient with the procedure. Interestingly, when assessing the learning curve as defined by the rate of positive surgical margins (PSMs) and the OT, many procedures seem to be needed to reach a minimum. In a recent publication the mean OT reached a plateau only after 750 procedures, and it took 1600 operations to reach a PSM rate of $<10\%$ [9].

Robot-assisted radical cystectomy is less common than RALP, but worldwide its use is increasing. Reports on the learning curve remain sparse. Interestingly, despite being a highly complex procedure, the International Radical Cystectomy Consortium reported a mean of only 30 procedures needed to reach standard endpoints of OTs, node counts and PSM rates [10].

The learning curve for robot-assisted upper tract surgery

For small renal masses, nephron-sparing surgery has become the standard treatment, and the number of centres reporting their experience with robotic partial nephrectomy (RPN) is steadily increasing. The technical advantages of the da Vinci system (Sunnyvale, CA, USA) are regarded as similarly beneficial for the precise excision of the sometimes difficult-to-reach renal masses as they are for pelvic surgery. The oncological and functional outcomes of the first published case series have been reported to be equivalent to the established techniques [11,12]. In reports assessing the learning curve of RPN the commonly used endpoints are the OT, warm ischaemia time and PSM rate, and 20–30 procedures are proposed as enough to become proficient, at least for surgeons experienced in minimally invasive procedures [13,14].

For other upper tract procedures data remain sparse but for robotic paediatric pyeloplasty, Sorensen et al. [15] showed that for experienced open surgeons there was a continued decrease of the OT with increasing experience, which became similar to that of open pyeloplasty after 15–20 procedures.

For robot-assisted adrenalectomy (RAA) there was only one report specifically assessing the learning curve. In a prospective study, 50 patients who underwent unilateral RAA were compared to 59 who underwent unilateral laparoscopic adrenalectomy [16]. After 20 procedures RAA had similar outcomes to those of a lateral transperitoneal laparoscopic approach for the experienced laparoscopic surgeons. The authors showed that factors like previous laparoscopic expertise, the skills of the first assistant and tumour side strongly influenced the OT.

The classical approach to training vs. the new concept of parallel learning

In the traditional approach to training in robotic surgery [17] the first step is usually to attend a training course to become familiar with the set-up of the system and to learn basic tasks, such as the safe manoeuvring of instruments, suturing and knot tying. Accompanying this training, observing several procedures and studying videotapes of entire procedures are recommended. After this preclinical phase, the phase of proctoring begins, where the trainee accompanies the procedure as a bedside assistant before starting to perform entire procedures (or at least major parts) under the supervision of the mentor [18]. With this approach the early cases take usually significantly longer than the desired 3–4 h OT, and only highly selected patients are suitable. After this initial phase of proctoring, the surgeon is usually left to undertake the procedures alone, with more or less frequent input by the mentor.

A more modern approach is to follow the concept of parallel learning. This is not only suitable for surgeons who can afford to invest some time in a Fellowship, but also for surgeons who need to learn RALP according to the traditional method described above. The underlying principle is that the procedure is divided into different steps, which need to be practised repeatedly until the operator is proficient. This division into different steps is not new and was proposed previously [19]. However, the essential refinement is to specify the relative difficulty of each step and to define a sequential order of training, which should be strictly followed in a structured mentoring programme [20]. This allows sequential learning, following complexity rather than the linear order of the surgical procedure. In addition, the trainee can begin with practising the several simpler surgical steps in the same session, and become proficient in large parts of the operation before proceeding to the more difficult parts, which themselves can be trained in parallel again. Once the trainee is proficient in all steps and can perform them in a timely manner, they can be put together and the whole procedure can be completed. According to the author's personal experience, such parallel learning, going from easy to difficult, can considerably accelerate the learning process, and proficiency in RALP can be reached without jeopardising the oncological or functional outcome, and with an OT of 3–4 h.

How to further shorten the learning curve

In addition to this strategy of parallel learning to become rapidly proficient in robotic surgery, we highlight the benefits of the preoperative 'warm-up'. For open surgery and laparoscopy it is well known that preoperative warm-up exercises can improve the performance and reduce errors, in beginners as well as in experienced surgeons [21–23]. Recently, the same was shown for a brief, preoperative simulation warm-up in a virtual reality (VR) environment [24]. In a randomised trial, 51 candidates (residents and experienced minimally invasive surgeons) went through a validated curriculum for proficiency in robotic surgery until they reached the required benchmarks. They were then randomised to either a short VR simulator warm-up or to read a leisure book for 10 min before performing robotic surgery tasks like intracorporeal suturing. There was a significant improvement in performance and a reduction in errors among the surgeons of different degrees of experience who had done the warm-up exercises. This shows that even proficient surgeons can still increase their performance in the operating room by adequate warm-up exercises. Seeing the initial difficulties of trainees in the proper handling and manoeuvring of the complex robotic system we assume that such a warm-up could help to significantly improve their progress.

Summary

The term 'learning curve' describes a graph where the proficiency in a specific task is measured over time. For RALP and robot-assisted upper tract surgery the length of the learning curve has not yet been clearly defined, and which indicators of proficiency should be measured. However, there seems to be a consensus that a surgeon can safely perform those procedures after 30–40 cases. If assessed by optimising oncological outcomes, the learning curve, especially for RALP, seems to be considerably longer. Traditionally, robotic surgeons have been proctored for a few procedures before proceeding without or with only a little mentoring. A new, more promising, approach is the concept of stepwise parallel learning, where the parts of the procedure are taught in parallel according to their difficulty. In addition, we strongly recommend preoperative warm-up exercises, as they could improve a surgeon's performance, and it can be assumed that they could also help to shorten the trainees' learning curve.

Conflict of interest

None disclosed.

References

[1] Ebbinghaus H. Memory: a Contribution to Experimental Psychology. Teachers College, Columbia University, 1913.

[2] Wright TP. Factors effecting the cost of airplanes. *J Aeronaut Sci* 1936;**3**:122–8.

[3] Group PCA. Advice on the Development of Robotic Assisted Radical Prostatectomy in England, 2011.

[4] Ahlering TE, Skarecky D, Lee D, Clayman RV. Successful transfer of open surgical skills to a laparoscopic environment using a robotic interface: initial experience with laparoscopic radical prostatectomy. *J Urol* 2003;**170**:1738–41.

[5] Herrell SD, Smith JAJ. Robotic-assisted laparoscopic prostatectomy: what is the learning curve? *Urology* 2005;**66**:105–7.

[6] Sammon J, Perry A, Beaule L, Kinkead T, Clark D, Hansen M. Robot-assisted radical prostatectomy. Learning rate analysis as an objective measure of the acquisition of surgical skill. *BJU Int* 2010;**106**:855–60.

[7] Orvieto MA, Patel VR. Evolution of robot-assisted radical prostatectomy. *Scand J Surg* 2009;**98**:76–88.

[8] Patel VR, Tully AS, Holmes R, Lindsay J. Robotic radical prostatectomy in the community setting – the learning curve and beyond: initial 200 cases. *J Urol* 2005;**174**:269–72.

[9] Sooriakumaran P, John M, Wiklund P, Lee D, Nilsson A, Tewari AK. Learning curve for robotic assisted laparoscopic prostatectomy. A multi-institutional study of 3794 patients. *Minerva Urol Nefrol* 2011;**63**:191–8.

[10] Hayn MH, Hussain A, Mansour AM, Andrews PE, Carpentier P, Castle E, et al. The learning curve of robot-assisted radical cystectomy: results from the International Robotic Cystectomy Consortium. *Eur Urol* 2010;**58**:197–202.

[11] Benway BM, Bhayani SB. Surgical outcomes of robot-assisted partial nephrectomy. *BJU Int* 2011;**108**:955–61.

[12] Rogers CG, Metwalli A, Blatt AM, Bratslavsky G, Menon M, Linehan WM, et al. Robotic partial nephrectomy for renal hilar tumors: a multi-institutional analysis. *J Urol* 2008;**180**:2353–6.

[13] Benway BM, Wang AJ, Cabello JM, Bhayani SB. Robotic partial nephrectomy with sliding-clip renorrhaphy. technique and outcomes. *Eur Urol* 2009;**55**:592–9.

[14] Mottrie A, De Naeyer G, Schatteman P, Carpentier P, Sangalli V, Ficarra V. Impact of the learning curve on perioperative outcomes in patients who underwent robotic partial nephrectomy for parenchymal renal tumours. *Eur Urol* 2010;**58**:127–32.

[15] Sorensen MD, Delostrinos C, Johnson MH, Grady RW, Lendvay TS. Comparison of the learning curve and outcomes of robotic assisted pediatric pyeloplasty. *J Urol* 2011;**185**:2517–22.

[16] Brunaud L, Bresler L, Ayav A, Zarnegar R, Raphoz AL, Levan T, et al. Robotic-assisted adrenalectomy: what advantages compared to lateral transperitoneal laparoscopic adrenalectomy? *Am J Surg* 2008;**195**:433–8.

[17] Orvieto MA, Large M, Gundeti MS. Robotic paediatric urology. *BJU Int* 2012;**110**:2–13.

[18] Kaul SA, Peabody JO, Shah N, Neal D, Menon M. Establishing a robotic prostatectomy programme. The impact of mentoring using a structured approach. *BJU Int* 2006;**97**:1143–4.

[19] Menon M, Tewari A, Peabody J. Vattikuti Institute prostatectomy: technique. *J Urol* 2003;**169**:2289–92.

[20] Dev H, Sharma NL, Dawson SN, Neal DE, Shah N. Detailed analysis of operating time learning curves in robotic prostatectomy by a novice surgeon. *BJU Int* 2012;**109**:1074–80.

[21] Calatayud D, Arora S, Aggarwal R, Kruglikova I, Schulze S, Funch-Jensen P, et al. Warm-up in a virtual reality environment improves performance in the operating room. *Ann Surg* 2010;**251**:1181–5.

[22] Kahol K, Satava RM, Ferrara J, Smith ML. Effect of short-term pretrial practice on surgical proficiency in simulated environments: a randomized trial of the 'preoperative warm-up' effect. *J Am Coll Surg* 2009;**208**:255–68.

[23] Moldovanu R, Tarcoveanu E, Dimofte G, Lupascu C, Bradea C. Preoperative warm-up using a virtual reality simulator. *JSLS* 2011;**15**:533–8.

[24] Lendvay TS, Brand TC, White L, Kowalewski T, Jonnadula S, Mercer LD, et al. Virtual reality robotic surgery warm-up improves task performance in a dry laboratory environment: a prospective randomized controlled study. *J Am Coll Surg* 2013;**216**:1181–92.