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Robotic Surgery and Successful Set-Up: A Stepwise Approach

Christopher J. Anderson and Hiten R.H. Patel

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Abstract

Robot purchase, implementation, and sustainability require a number of key challenges to overcome. We provide our experience of managing a potentially daunting task, summarizing the key steps to help deliver such an exciting project. We will take you through team approach options for purchase and safe implementation in the current financial climate.

Keywords: robotics, financial planning, sustainability, patient safety, implementation, training

1. Introduction

Minimally invasive surgery has well-established advantages: shorter length of hospital stay, markedly reduced postoperative pain, fast return to preoperative state of activity, lowered postoperative ileus, and a preservation of immune function [1]. Importantly, laparoscopic urology has been superseded by the robot-assisted laparoscopic surgery [2]. The main reasons for this significant change from pure laparoscopic urology to robot-assisted laparoscopy are mainly surgeon factors such as shorter learning curve and less surgeon fatigue [2]. In our opinion, the patient factors as described above are similar.

Importantly, robotic assistance allows all surgeons (open and minimally invasive) to perform advanced laparoscopic surgery. Dual video cameras provide an adjustable magnification within the surgical field, which is 3D. Robotic instruments allow 6 degrees of freedom of movement, which is similar to the human hand. Laparoscopic instruments allow 4 degrees of freedom of movement. The robot removes surgeon tremor, by motion scaling, which allows incredible dexterity and precision during the surgery.

Allowing robotic technologies into the operating room can provide significant advantages. For example, the robot can provide a precise translation of the surgeon hand movements, through the robotic instruments during the actual surgery. Importantly, the robot facilitates surgeons without advanced laparoscopic skills to perform complex surgeries with short/limited training. In addition, the robotic technology has increased the types of surgeries undertaken. The endo-wristed tools with motion scaling (avoids tremor) and 3D zoomed operative fields promote the ability of the surgeon to undertake microdissection and intra-abdominal suturing with great accuracy [3].

The rapid rise of robotic technologies has allowed more complex reconstructive surgeries to be performed even in children [4]. Instruments such as 3–5 mm trocars have aided robotic surgery in children. Importantly, single-port and multi-arm (non-central) platforms are becoming commercially accessible.

As this advancement continues, the financial and clinical issues surrounding the employment of a robotic system within any hospital require planning. This planning starts from identifying the finances (business planning) through to purchase, and identifying key members of the team who will provide training to the team as a whole and oversee clinical and financial governance of the system.

2. Clinical to hospital administration collaboration

Surgical outcomes are determined by high levels of competence of the team and optimal team working. Therefore, surgeons rely on the team. Robotic surgery is no exception, particularly as the surgeon works at a console and therefore relies on the team which includes the bedside assistant who performs important tasks at the patient bedside. Educating the robotic (or other) operating room team of nurses, anesthesia staff, and bedside assistant is crucial for patient outcome success. It is crucial that the team and team leader communicate with other staff and mentors to provide the support and guidance needed during the training stage.

Administrators and surgeons must work together to define the needs of the hospital, when developing a robotic programme. A surgeon with administrator can develop a programme which is often more patient-centric and deployable. Interestingly, robotic use can improve patient referrals, which is often the reason the administrators are supportive. The best situation is for the surgical teams and administrators to co-plan and co-deliver robotics within a hospital or strategic health partnership.

In a teaching hospital, teams generally work cohesively, allowing intellectual debate, particularly around new technologies such as robotics. They usually find funding through academic pathways or sizeable donors. This is important for training the next generation of surgeons, and improving our understanding of where robotic surgery can take us. As robotics develop in this way through research and resident training, these programmes can be delivered into more peripheral centres. Once this occurs, a close "hub-and-spoke"

relationship between the teaching centre and the peripheral hospital is important if the latter wishes to improve robotic programmes and assist with the financial planning of such programmes.

Business plan and timeline development require robust data collection, concerning business planning. A reduction in length of stay with faster recovery has cost benefits as well as an increase in patient volume from increased referrals. Part of this calculation will of course be the recurring costs (disposables, instruments, maintenance) of robotics in addition to the capital outlay. As with any negotiation, one should show non-clinical administrators that robotics will benefit patient care and improve hospital income, plus reputation.

3. Financial implications

Currently, the average cost of the da Vinci robotic system is $1.4–1.9 million, and the annual maintenance is approximately $240,000. Link et al. [5] suggest an increase in robotic surgery volume which can counter for the depreciation and maintenance costs. They showed that robotic pyeloplasty (RLP) is more expensive than laparoscopic pyeloplasty, if performed by a surgeon competent in intracorporeal suturing. The study also concluded that the combined longer operative time and substantial expense for robot depreciation and consumables made RLP a much more expensive procedure (2.7 times more than laparoscopic pyeloplasty). Importantly, increasing the number of robotic procedures can neutralize the cost imbalance, such as performing 10 robotic prostate surgeries per week (cost neutral compared to open prostate surgery) [6].

These debates are important to be aware of, but the main issues are the steep learning curve for the average surgeon using pure laparoscopy and thus greater risk to the patient. The robotic platform offers a truncated learning curve, and therefore the financial burden becomes more acceptable. A further point is that, as the robotic surgeons gain more experience, the robotic

Figure 1. Robotic Urology Surgery Training Centre Accreditation (European) and Royal College of Surgeons of England.

operative times diminish considerably and in many institutions may be quicker than the equivalent operation performed laparoscopically. The economic arguments are not therefore constant or static but an ever-changing field.

Importantly, once the hospital has agreed that a budget is available and a sensible financial plan is in place, the early adopters of the robotic technology need to be identified and offered a curriculum-based training programme [7] (**Figure 1**).

4. Robotic surgeon training

Robot-assisted surgery is rapidly gaining popularity among urologists and is becoming subspecialised. Generally the three main categories that need fellowship or hands-on training are prostatectomy, partial nephrectomy, and radical cystectomy. It is not acceptable to begin robotic surgery without the appropriate training [7]. Currently, robot-assisted radical prostatectomy is the most commonly performed robotic procedure worldwide. There is mounting evidence that the robot assistance provides significant benefits to the patient and surgeon, especially shortening operating time and surgeon fatigue [2]. There has been a major shift of treatment of prostate cancer by surgery in wealthier countries from open to a laparoscopic approach, and now robotic. A modern comparison is with radical nephrectomy in the 1990s.

The learning curve to deliver laparoscopic radical prostatectomy (LRP) is estimated at 40–60 cases with skilled surgeons and 80–100 cases, with inexperienced surgeons. The robot shortens the prostatectomy learning curve for all surgeons, particularly experienced open prostatectomists. Interestingly, a surgeon skilled in open surgery was able to transfer his open skills to robotic surgery in 8–12 cases [8]. However, currently we recommend fellowship training such as the ERUS-approved programmes (**Figure 1**).

A fellowship-trained laparoscopic surgeon has a similar, short learning curve for robotic prostatectomy compared to an experienced open surgeon. The data showed a safe and reproducible surgery, interestingly even during the learning curve. Importantly, the outcomes were the same for early robotic surgery and a large cohort of open prostate surgery [8]. There was an emphasis on having a good mentor, experienced in robotics being present during the initiation of the programme.

5. Animal model and training

Animal model training in robotics, prior to human application, is effective. Most of all robotic surgeries were initially tested in an animal model. Sung et al. [9] in 1995 performed a porcine robotic pyeloplasty. As the learning curve associated with surgical robotic use is unknown, a safe and modular training programme in an animal model would result in measurable improvement in robotic surgical skills.

Robotic (ZEUS; Computer Motion) and laparoscopic instrument learning curves were compared within inanimate models and showed a greater learning curve with robotics [10]. Another animal study showed that multiple surgical disciplines in a "near hospital operating room" environment with same-member healthcare teams improved their average set-up times by 30%, each time they prepared the robot [11]. In addition, the console operators improved their operation times by over 20% each time they practiced. They showed that in-house training saved them significant monies (approximately $52,895) and improved operative and set-up times by 40–50%.

6. Training the robotic surgical team

Curiosity and commitment to robotics are helpful when motivating a team. However, it helps to have the support and enthusiasm of your hospital, including the management through your clinical colleagues and team leaders (**Figure 2**).

The primary group to get on board are the surgeons committed to robotics. Importantly, robotic surgery programmes develop purposefully and often slowly. Each step requires audit cycles, critically analysing the robotic team performance and not simply the surgeon. Team leaders in the operating room should be empowered to feedback performance values at each step of the process for safe and effective outcomes. Once the team engages in this process, it is the most rewarding experience.

Training within a team is an early and crucial step. Using a standard learning tool such as an objective-based curriculum, which is visual and live, allows for the best results. This should allow foundation building from experiences, in a stepwise manner (modular). For the more specialized team member requiring understanding of specific operative nuances, a more specialized skill set is needed [12].

The generic robotic team should begin the process by understanding the set-up, draping, and both electrical and mechanical troubleshooting. These basic steps would suffice to then return

**Figure 2.** A happy and supportive robotic team is essential!

to the host hospital and apply the knowledge to the local robot surgery. Most teams learn the advanced objectives in their host institution.

Training programmes are now cross-specialty [13], with real surgery observation, didactic sessions, video-based modular training, dry laboratories, and cadaveric training access [14].

Non-technical skills are vitally important to develop as part of the team training programme [15]. These human factors are crucial to running a seamless patient journey through a robotic-assisted surgery (or any other surgery).

7. Resident training

While surgical educators in resident training centres in which robotic surgery has been adopted are still charged with the responsibility of teaching residents the surgical management (see **Figure 3a** and **b**), they now face a new challenge in how to teach a resident to assist at and perform a surgery when not physically standing at the operating room table [16].
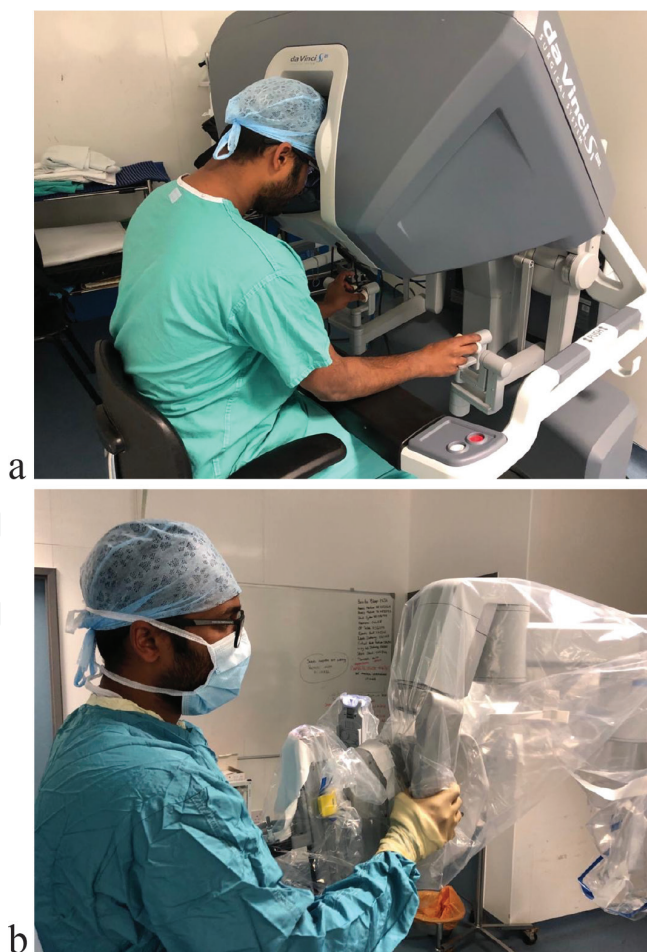
Figure 3. Resident training. (a) Console training for the robot; (b) Patient-side robotic raining.

Trainee surgeons believe that robotic training is necessary to their future [17], although we know that all will not be robotic surgeons in the current climate. Interesting issues are raised when these trainees only work in robotic centres, where they are only exposed to robotic surgery, effectively missing the opportunities to undertake open surgery.

The robot is a relatively easy tool to use, but the resident will still need the trainer and operating room team to support training, particularly with time pressures in a busy operating room. Incorporating training within the training programme is a significant challenge. The aim should be to train the doctor without lowering the standard of patient outcome. Robotics lends itself to this objective, with stepwise training and short learning curves. Currently, surgical training simulators are being used for teaching, but they only allow initial training [18, 19]. Newer, dual-console robots (dual control) allow the teacher a level of comfort while teaching, but without this there are a number of important teaching processes to assure safety, including combining virtual, augmented training with modular training. It is therefore essential that robotic surgical educators have a comfort level both with performing the surgical procedure and communicating with the assistant to teach the procedure [12, 20] (see **Figure 4**).

Sachdeva et al. [21] summarized three steps involved in trying to train with novel technologies: (i) perceptual awareness, incorporating cognitive understanding of the surgery and visualizing the surgery; (ii) guided learning, in a modular fashion, with immediate mentor feedback, in order to learn correctly; and (iii) autonomous refinement of learning, in which

Figure 4. Planning and training presurgery.

No. of step	Description of surgical procedure	Module 1	2	3	4	5
1	Placing trocar and dissecting the preperitoneal space	X				
2	Pelvic lymphadenectomy		X			
3	Incising the endopelvic fascia and dissecting the puboprostatic ligaments	X				
4	Ligating Santorini's plexus			X		
5	Bladder neck dissection					
	Anterior and lateral bladder neck		X			
	Dorsal bladder neck			X		
6	Identifying and dissecting the vasa deferentia			X		
7	Dissecting the seminal vesicles			X		
8	Incising posterior Denonvilliers' fascia and mobilizing the dorsal surface of the prostate from the rectum			X		
9	Dissecting the prostatic pedicles			X		
10	Nerve-sparing					X
11	Apical dissection				X	
12	Urethro-vesical anastomosis					
	Dorsal circumference (4, 5, 6, 7, 8 o'clock sutures)				X	
	3 and 9 o'clock sutures		X			
	Bladder neck closure and 11 and 1 o'clock sutures			X		

Modified from Ref. [22].

Table 1. Modular steps for RARP.

precision and efficiency are improved. These steps are logical to any expert trainer, and they are incorporated in the ERUS host robotic training centre curriculum, which are based on modular training [22] (**Tables 1** and **2**).

At present, laboratory-based experience is available for training with the da Vinci Surgical System's inanimate, cadaveric, or animate models [23]. Beyond the point of training laboratories, residents are able to be fellowship train, under supervision by experts within real operating rooms, with the consent of the patients.

The ongoing issue about where robotic surgical training should be deployed (e.g. post-basic training or postgraduate training) continues among robotic trainers around the world. However, surgery in general is becoming more subspecialist, and therefore not all trainee doctors need robotic training.

In our opinion, placing robot-assisted surgery as a category like its predecessor, laparoscopy, is not appropriate. The robot is a facilitating tool, for treating a disease. It would be sensible to train surgeons in robotics as part of specializing in a disease process. The difficulty arises when surgery is superseded by the next iteration of treatments.

Step	Module	Description	Competency		Sign off
1a	I	Transperitoneal access—trocar placement, incision of ventral peritoneum, and dissection of Retzius space	Level		
			Date		
1b	II	Extraperitoneal access—trocar placement and dissection of preperitoneal space	Level		
			Date		
2	I	Set-up of da Vinci robot	Level		
			Date		
3	III	Pelvic lymphadenectomy	Level		
			Date		
4	I	Incision of endopelvic fascia and dissection of puboprostatic ligaments	Level		
			Date		
5	II	Anterior and lateral bladder neck dissection	Level		
			Date		
6	III	Posterior bladder neck dissection	Level		
			Date		
7	I	Dissection and division of vas deferens	Level		
			Date		
8	III	Dissection of seminal vesicles	Level		
			Date		
9	III	Incision/dissection of posterior Denonvillier's fascia and mobilization of prostate from the rectum	Level		
			Date		
10a	III	Dissection of prostatic pedicles (non-nerve spare)	Level		
			Date		
10b	V	Dissection of prostatic pedicles (nerve spare)	Level		
			Date		
11	II	DVC ligation	Level		
			Date		
12	IV	Apical dissection	Level		
			Date		
13a	III	Rocco stitch	Level		
			Date		

Step	Module	Description	Competency	Sign off
13b	III	Posterior vesico-urethral anastomosis	Level	
			Date	
13c	II	Lateral and anterior vesico-urethral anastomosis	Level	
			Date	
13d	II	Bladder neck closure	Level	
			Date	

Table 2. Resident diary.

8. Conclusion

Robotic Renal Surgery can be safely adopted and implemented in modern day clinical practice using a team based approach.

Author details

Christopher J. Anderson[1]* and Hiten R.H. Patel[2]

*Address all correspondence to: cja@doctors.org.uk

1 Department of Urology, St Georges University Hospital, ERUS-EAU Host Robotic Training Centre, Accredited Royal College of Surgeons Senior Clinical Robotic Fellowship Centre, London, UK

2 Department of Urology, University Hospital North Norway, Tromso, Norway

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