Review Article

ANNALS OF MEDICINE & SURGERY

OPEN

The role of Da Vinci Xi robotic simulation curriculum in enhancing skills in robotic colorectal surgery

Sabah Uddin Saqib, FRCS[a,*], Adeel Ahmad Bajwa, FRCS[b]

Abstract

Robotic surgery in comparison to open and laparoscopic surgery allows better ergonomics, three-dimensional vision, and seven-degree freedom of movement. This ensures fast recovery, fewer postoperative complications, and safe oncological resections. Robotic surgery has revolutionized the field of colorectal surgery, providing surgeons with enhanced precision, dexterity, and visualization. To ensure safe and successful outcomes, surgeons must acquire competency and proficiency in robotic surgical techniques. Robotic simulation exercises have emerged as a valuable tool for training and skill development in robotic colorectal surgery. This research paper explores the importance and relationship between robotic simulation exercises and the acquisition of skills and competency required for carrying out safe colorectal surgery using a robotic platform. The authors discuss the benefits of virtual simulation-based training using the Da Vinci Xi skill simulator, and the evidence supporting its effectiveness in colorectal surgery. In this article, emphasis has been made on some important Da Vinci Xi skill simulator exercises for enhancing skills in robotic colorectal surgery.

Keywords: colorectal, da vinci xi robot, robotic surgery, simulation, surgical training

Introduction

The short-term benefits of a minimally invasive colorectal surgery with regards to reduced length of stay, less pain, and faster recovery are well established, with evidence supporting longer-term benefits including reduced risk of incisional hernia and adhesive bowel obstruction when compared to an open approach[1]. Robotic surgery in comparison to laparoscopic surgery allows better ergonomics, superior retraction, and fine controlled movements[2]. This seems very helpful, especially during hepatic and splenic flexure mobilization, kocherisation of the duodenum, ureter preservation, and identification of hypogastric nerves during complex colorectal resections. The first rectal surgery using the Intuitive Da Vinci system was performed in 2001[3]. Since then there has been rapid adoption of robotic platforms by colorectal surgeons all over the world. Robotic total mesorectal excision (TME) for rectal cancer, beyond TME for locally advanced rectal cancer, lateral pelvic lymph node dissection in the narrow pelvis, and complete mesocolic excision for colon cancer have revolutionized treatment for colorectal cancer. Alongside its adoption in colorectal cancer surgery, robotic surgery has gained popularity in the treatment of benign disease, which is sometimes more complex and challenging than its malignant counterpart such as diverticular disease, inflammatory bowel disease, and rectal prolapse[4].

With the rapid adoption of robots in colorectal surgery, there has been growing interest in the pace at which surgeons gain competency, as it may aid in self-assessment, proficiency, or credentialing. Currently, SAGES guidelines recommend online training (Intuitive provides free of cost), Console-based simulation training, bedside training and preferably operating at dual console as a minimum basic training requirement in robotic surgery[5]. Different institutes and surgical societies offer fellowship programs in robotic colorectal surgery alongside makers of modern robots like Intuitive. Although person specification for such fellowships has yet to be standardized, currently candidates in their last years of training, post-certificate of completion of training fellows, or early-year consultants are considered as the fittest candidates to learn robotic colorectal surgery.

HIGHLIGHTS

- Robotic surgery has revolutionized the field of colorectal surgery, providing surgeons with enhanced precision, dexterity, and visualization.
- This Narrative review has highlighted the benefits of the Da Vinci skills simulator in enhancing skills in robotic colorectal surgery.
- We discuss the benefits of virtual simulation-based training using the Da Vinci Xi skill simulator, and the evidence supporting its effectiveness in colorectal surgery.

[a]Senior clinical fellow Colorectal surgery, University hospital Coventry and warwickshire trust and [b]Consultant colorectal surgery, University Hospital Coventry and Warwickshire Trust, Coventry, UK

Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article

*Corresponding author. Address: Senior Clinical Fellow, Colorectal surgery, University Hospital Coventry and Warwickshire Trust, Coventry, UK. Tel.: +44 786 169 1474 E-mail: drsabahsaqib@hotmail.com (S. U. Saqib).

Annals of Medicine & Surgery (2023) 85:6001–6007

Received 25 July 2023; Accepted 11 September 2023

Published online 20 September 2023

http://dx.doi.org/10.1097/MS9.0000000000001342

Figure 1. (A) Shows the Da Vinci surgical simulator attached to the Surgeon console through a blue cable and. (B) Shows the dVSS exercise curriculum. dVSS, Da Vinci Xi skill simulator.

The role of simulation is gaining tremendous popularity and acceptance in robotic surgery training. Patient safety remains the most important factor in the conceptualization, development, integration, and implementation of simulation in robotic surgical training. The robotic simulator provides repeated attempts to master surgical skills, ensuring the achievement of competence in a particular skill before actually performing on real patients. Robotic Surgical training on a virtual simulator promises better patient outcomes with lower complication rates. Simulation allows for progress through the learning curve and is transferable to the clinical setting[6].

Robotic skills can effectively be acquired through training on virtual simulators. There are currently four robotic surgical simulators are commercially available:

(1) Da Vinci skills simulator (dVSS)—Intuitive Surgical
(2) Mimic dVTrainer (Dv-Trainer)—Mimic Technologies, Inc.
(3) Robotic surgical simulator (RoSS)—Simulated Surgical Systems
(4) Sim-Surgery Educational platform (SEP)—SimSurgery

A recent review of virtual reality (VR) simulators showed that the dVSS, dV-trainer, and RoSS platforms demonstrated the ability of a VR training curriculum to improve basic robotic skills, with proficiency-based training being the most effective training style[7]. In many instances, a performance score of 80% in each exercise has been used to define proficiency. There is no formula as to why 80% was set as a threshold, but rather it is based on expert consensus from high-volume robotic surgeons.

This Narrative review has highlighted the benefits of the dVSS in enhancing skills in robotic colorectal surgery. The effectiveness and utilization of skills gained by completing some important dVSS exercises have been discussed in detail with special emphasis on the importance of those skills in robotic colorectal surgery.

An overview of dVSS and its curriculum

Virtual simulators in the recent past have shown many promises with room for further advancements and technological excellence. Those very factors like patient safety, ethical concerns, and transparency which initially introduced and advocated the role of simulation in surgical training are pushing the industry and technology for more creativity in simulation[8]. Stegemann et al

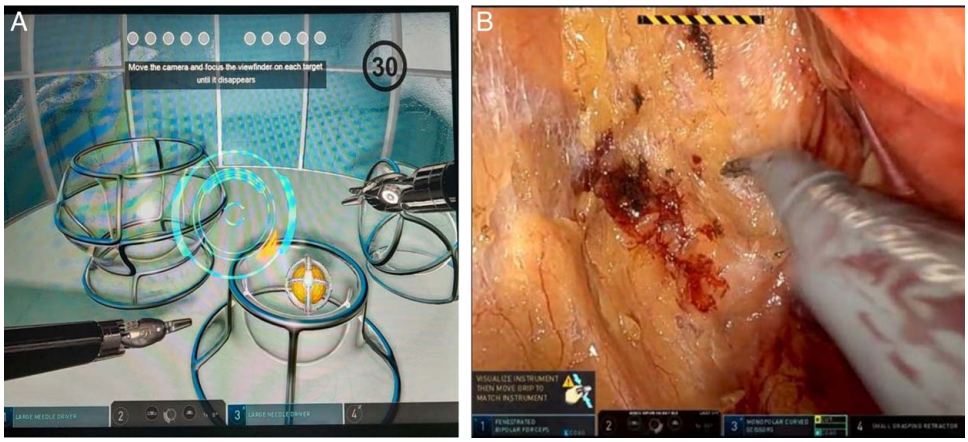

Figure 2. (A) Shows the camera control exercise on dVSS and (B) shows a close view of the dissecting plane under good camera control during high anterior resection. dVSS, Da Vinci Xi skill simulator.

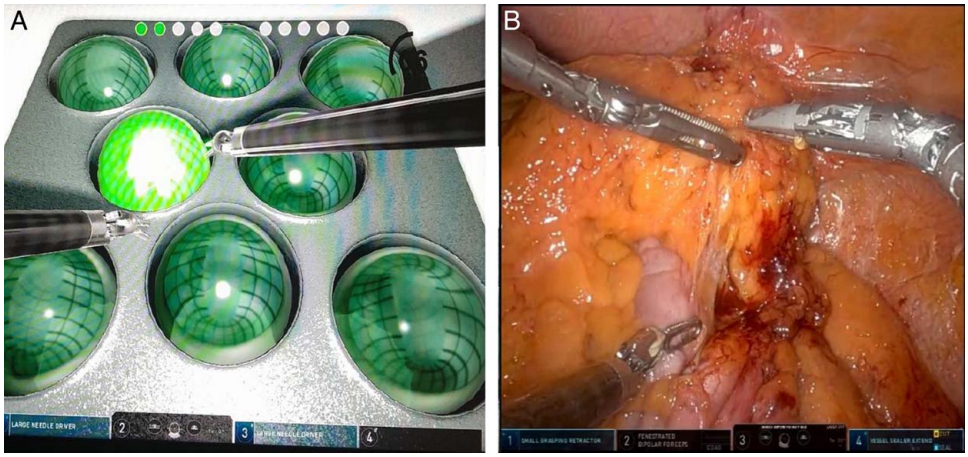

Figure 3. (A) Shows the dVSS clutch control exercise and (B) shows instruments being used in the surgical field by using an effective clutch during robotic right hemicolectomy. dVSS, Da Vinci Xi skill simulator.

developed a validated VR-based skills curriculum using the RoSS platform[9]. Their study emphasized acquiring of following four skills in Robotic simulation training.

(1) Basic console orientation
(2) Psychomotor skills training
(3) Basic surgical skills
(4) Intermediate surgical skills

For the acquisition of these robotic skills, the dVSS can be easily connected to the main console using a cable. Trainees can log in with their usernames and password. dVSS curriculum provides 35 plus exercises in the following five categories to gain the above-mentioned skills as shown in (Fig. 1 A and B). Alongside these exercises, the simulator provides a library of a few extra exercises in each category and specific procedure-related exercises like right hemicolectomy, Intracorporeal anastomosis and closure of enterostomy etc.

(1) Introduction to Da Vinci (DV)
(2) Prepare for multiport training
(3) Skills maintenance
(4) Focus on needle diving
(5) FRS dome (Fundamentals of Robotic Surgery)

Controls awareness exercises for robotic colorectal surgery

The surgeon's console is the control centre of the robotic platform. From the surgeon console, the surgeon can control the endoscope and instruments by using the hand controls and footswitch panel. All actions taken by the surgeon at the console are relayed to the vision system for processing and sent to the patient cart for implementation. Introduction to DV exercises and multiport training helps the trainee to develop a basic awareness of the console and allows the trainee to be familiar with master controls, hand clutch, master clutch, camera pedal, energy pedals, and a footswitch to swap instruments.

Camera controls exercise

Although the main advantage of robotic surgery is to enhance three-dimensional vision using the 30° camera, we often underestimate the ability of camera control in the surgeon's hand. As in laparoscopic surgery, the surgeon has to rely on an assistant for camera control who is often a very junior member of the team; this is not the case in robotic surgery. Camera control exercises on

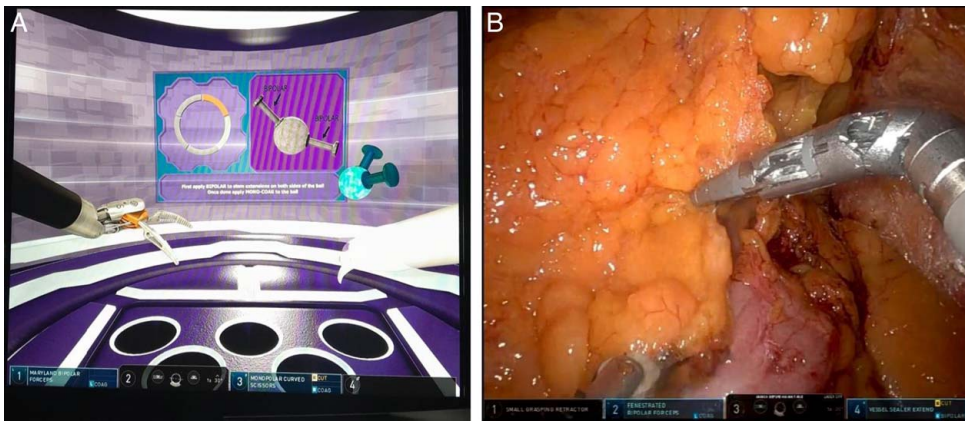

Figure 4. (A) Shows the dVSS energy pedal exercise and (B) shows the sealant device being used to divide omentum during robotic left hemicolectomy. dVSS, Da Vinci Xi skill simulator.

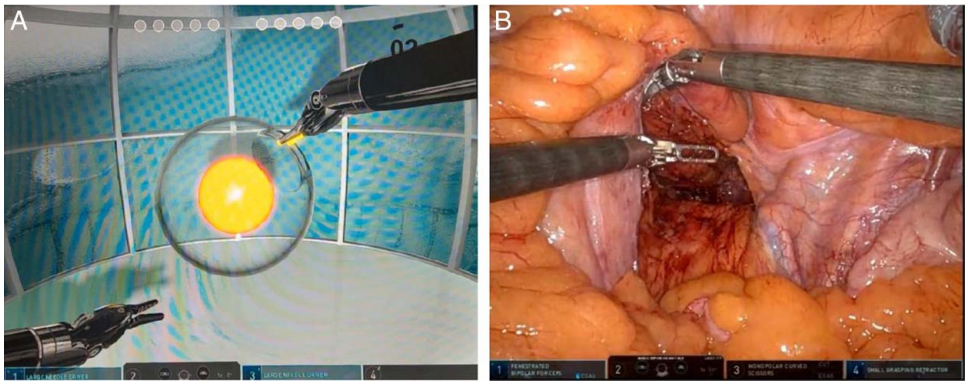

Figure 5. (A) Shows the dVSS wrist articulation exercise and (B) shows robotic instrument articulation using seven-degree freedom in the pelvis during APR. APR, abdominoperineal resection; dVSS, Da Vinci Xi skill simulator.

the simulator allow the trainee to effectively move the camera and simultaneously zoom in and zoom out for the targets located in or VR simulator using the camera pedal on the left side of the footswitch panel components (Fig. 2A and B). Scores are given on completing the task in the allocated time while keeping both instruments in vision without having a collision with the camera. Robotic surgery allows work in the narrow anatomy of the pelvis with clear vision in most TME dissections. Effective camera control also helps to stay in avascular planes which allows lifting of the colon mesentery with a cover of visceral peritoneum which is the main concept of complete mesocolic excision. Off-camera injuries are possible due to the distance of the operating surgeon from the patient and the lack of tactile feedback[10]. Tunnel vision, incorrect use of robotic arms, and intervention by the bedside assistant without a view of their instruments are factors that can contribute to off-camera injury.

Clutch control exercise

Clutch control is an imperative feature of master controllers which allows surgeons to move the instruments in the surgical field. Once the surgeon clutches any robotic instrument, it stops the movement of the robotic instrument in the surgical field; meanwhile, master controllers can be repositioned back to neutral. Both controllers can be clutched simultaneously using the master clutch pedal on the footswitch panel component or clutched individually using the clutch on each master control. Clutch exercises on dVSS help in developing basic psychomotor skills to move the instruments under vision without any collision (Fig. 3A and B). Scores in this exercise are given based on the economy of movement and time required to complete the exercise. A slow and fine movement of endo wrist instruments is the hallmark of safe dissection in robotic colorectal surgery. This can be achieved by using an adequate clutch. Good control of the clutch allows the surgeon to follow traction and counter-traction principles while performing robotic colorectal surgery (Fig. 3 B).

Energy pedal exercise

On the footswitch panel of a Xi console, pedals on the right half are used to activate the coagulation function (blue) and the cutting function (Yellow). Coagulation and cutting pedals on the extreme right activate endo wrist instruments docked on the right of the camera while those which are on the left side activate instruments docked on the left of the camera port. These energy pedals are also used for vessel sealers and sureform stapling devices. VR simulator energy pedal exercises build up reflexes and muscle memory to correctly use energy pedals (Fig. 4A and

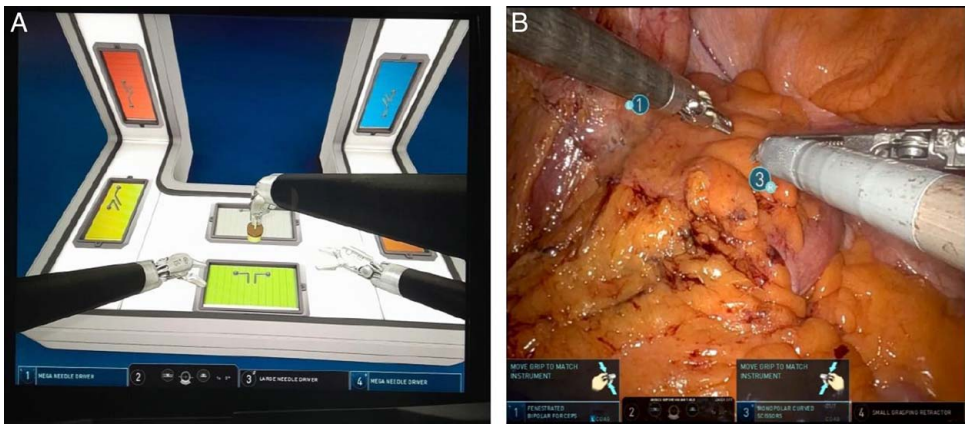

Figure 6. (A) Shows dVSS three-arm simulator exercise and (B) shows all three robotic arms in use during right hemicolectomy. dVSS, Da Vinci Xi skill simulator.

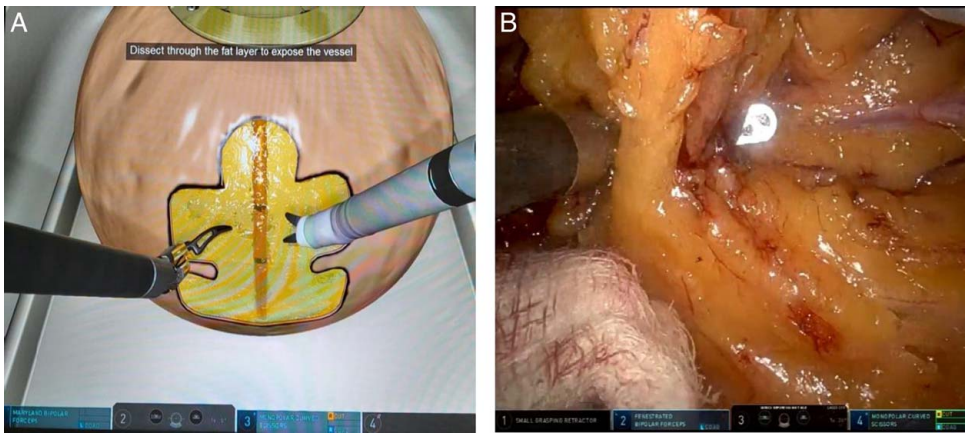

Figure 7. (A) Shows the dVSS vessel dissecting exercise and (B) shows Inferior mesenteric artery is dissected out during low anterior resection. dVSS, Da Vinci Xi skill simulator.

B). Robotic colorectal surgery mostly follows dissection in avascular planes which is only possible if the surgeon is trained enough to use activated monopolar endo wrist scissors and bipolar instruments. Incorrect use of energy pedals can easily result in a thermal burn to any part of a very long small bowel during robotic colorectal surgery. This can be easily missed during the surgery and can result in significant morbidity in the immediate postoperative period.

Wrist articulating exercise

Most of the robotic instruments are designed with seven degrees of freedom (insertion, external pitch, external yaw, rotation, wristed pitch, wristed yaw, and grasp). This feature makes robotic colorectal surgery unique as compared to laparoscopic colorectal surgery as this may lower the learning curve for colorectal surgeons and allows them to do complex pelvic dissection which is not possible laparoscopically[11]. The endo wrist instruments are designed to mimic the dexterity of the human wrist. dVSS provides a quite challenging exercise that requires movement of both instruments' arms using seven-degree freedom. As shown in Figure 5A and B, Good wrist articulation enhances the exposure and leads to safe dissection in robotic colorectal surgery.

Skills maintaining exercises and gaining advanced skills in robotic colorectal surgery

Training of new robotic surgeons should entail both technical and non-technical skills, including decision-making, troubleshooting, and effective communication[6]. After the acquisition of psychomotor skills and basic console orientation, the dVSS curriculum provides more complex exercises. These exercises help in maintaining already gained skills and also help in learning advanced skills. A few important exercises and their effectiveness in robotic colorectal surgery have been described below.

Three-arm relay exercise

In this exercise, trainees learn how to use the fourth arm of a Da Vinci robot. Specific tasks in this exercise can only be performed by using a third-arm instrument. The left lateral pedal on the footswitch panel allows users to swap control of instrument arms so the user can control a different instrument with one of their

Figure 8. (A) Shows a vertical needle driving exercise and (B) shows a knot tying exercise.

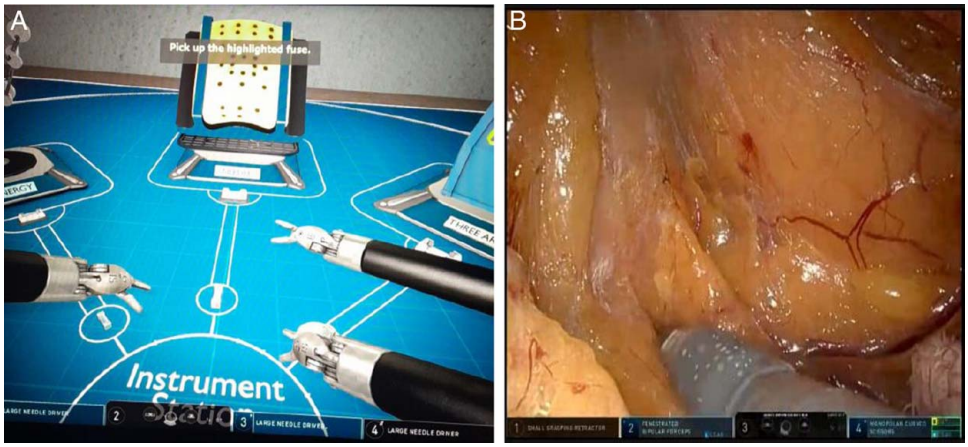

Figure 9. (A) Shows a combo exercise and (B) shows fine dissection in mesocolic planes using a combination of various robotic surgery skills.

master controllers. Instrument swap in this training module is carried out between arms 3 and 4 as shown in Figure 6A and B. Assistant independence is well recognized unique feature of robotic surgery, and a third instrument can effectively be used by the operating surgeon for holding tissue, traction, or counter traction. Remote centre technology provides constant traction and eliminates human fatigue issues in robotic surgery. In robotic colorectal surgery, the third arm is used to lift mesentery, pull up or pull down the mobilized colon, and bring the rectum out of the pelvis while performing TME.

Dissecting a vessel exercise

Division of inferior mesenteric artery, inferior mesenteric vein, and ileocecal pedicle division are key fundamental steps of major colorectal resection. Safe and careful dissection is not only important for maintaining a bloodless field but also has a significant impact on oncological outcomes in colorectal cancer cases. The vessel dissection exercise develops a basic idea of how to use monopolar curved scissors for exposing a vessel after dissecting tissue planes while maintaining good traction and counter traction (Fig. 7A and B). This skill can be replicated later in robotic colorectal surgery during proctored training.

Suturing exercise

The robotic surgery platform provides a variety of instruments for suturing. Two examples are Mega needle driver and Mega suture cut. The former is used solely for suturing while the latter has a built-in scissor in the heel of the instrument so that it can be used for suturing and cutting which decreases the number of instruments exchanged during cases. A variety of suturing exercises are available on dVSS which include suturing in the horizontal plane, suturing in the vertical plane, continuous suturing, and knot tying. Seven-degree freedom of movement in robotic surgery has made suturing much simpler and easier to learn as compared to laparoscopic surgery (Fig. 8A and B). Most robotic colorectal surgeons now prefer intracorporeal anastomosis for right and left hemicolectomies because of enhanced suturing skills.

Combo exercise develops fluency for Robotic colorectal surgery

Once a robotic trainee has attained basic and advanced skills, combo exercise on dVSS allows the use of those skills altogether. This module focuses on arm swap, camera control, energy pedal use, and suturing techniques (Fig. 9A and B). All these skills make the foundation of trainees and prepare them to perform complex tasks simultaneously. Indeed in robotic colorectal surgery, it is imperative to use all these skills, however, in many instances situation demands the take-over of master controls by a proctoring surgeon, especially at the start of a learning curve. Medial to the lateral or lateral mobilization of the colon, splenic and hepatic plexure mobilization, Vessel ligation, and TME all demand effective utilization of basic and advanced skills. Many robotic colorectal surgeons overcome this challenge by using a dual console where they can hand over easy steps to trainees and perform more challenging tasks by themselves.

Da Vinci simulation exercises for certification and credentialing

Because of the rapid influx of robots in surgery across all specialties, many trainees and residents are fortunate to get early opportunities to become familiar with robotic surgery. Many centres in the United Kingdom and the United States are shifting their elective colorectal stuff onto robots; there is an obvious need to restructure training pathways of robotic colorectal surgery. Currently in the United Kingdom, the most senior candidates after completion of training or early-year consultants are being considered as the first choice to learn robotic colorectal surgery. This idea can harmfully deter young enthusiastic learners with adequate surgical skills from becoming proficient in robotic colorectal surgery. Currently, guidelines are based mostly on recommendations from Intuitive as we described earlier. Intuitive also provides opportunities to make an online account on their app, where completion of learning assignments can lead to certification of various courses. If the candidate is logged in on a virtual simulator with their username, he or she can keep the logs of all simulation exercises which can be used as a certification or an additional criterion before interviewing anyone for robotic colorectal surgery training. In the current scenario where robotic

colorectal surgery seems to be the future, there is a definitive need to develop a curriculum, case logs, and training pathways. Successful completion of simulation exercises with a score of 80 or above should be recommended as part of this curriculum in any robotic colorectal surgery training program.

Conclusion

Robotic simulation exercises play a crucial role in the acquisition of competency and skills in robotic colorectal surgery. dVSS exercises offer a safe and controlled environment to both the colorectal surgery trainees and previously trained Open and laparoscopic colorectal Consultants wishing to adopt a robotic platform due to its effectiveness. Innovative research, technological advancements, and integration of simulation training into the surgical curriculum are essential to maximize the benefits and usefulness of robotic simulation.

Ethical approval

Not required as patient data were not revealed, intraoperative pictures were without any identification.

Consent

Not applicable.

Sources of funding

No funding was involved.

Authors contribution

Both authors contributed to the paper conception and design. S.S. as a robotic colorectal trainee mainly contributed to skill simulator part while A.B. as a proctor robotic colorectal surgery described effectiveness of dVSS exercises in robotic colorectal surgery. Both authors read and approved the final manuscript.

Conflicts of interest disclosure

A.B. is a proctor for robotic teaching and training in the UK with Intuitive. We shared our experience with Da Vinci Xi skill simulator but hold no personal interest with Intuitive®.

Research registration unique identifying number (UIN)

Not applicable.

Guarantor

Sabah uddin saqib.

Provenance and peer review

We have no preference, we will oblige to journal guidelines and recommendations.

Data availability statement

Not applicable.

References

[1] van der Pas MH, Haglind E, Cuesta MA, *et al*. Laparoscopic versus open surgery for rectal cancer (COLOR II): short-term outcomes of a randomized, phase 3 trial. Lancet Oncol 2013;14:210–8.
[2] Lanfranco AR, Castellanos AE, Desai JP, *et al*. Robotic surgery: a current perspective. Ann Surg 2004;239:14.
[3] Akmal Y, Baek J-H, McKenzie S, *et al*. Robot-assisted total mesorectal excision: is there a learning curve? Surg Endosc 2012;26:2471–6.
[4] Bokhari MB, Patel CB, Ramos-Valadez DI, *et al*. Learning curve for robotic-assisted laparoscopic colorectal surgery. Surg Endosc 2011;25:855–60.
[5] Oleynikov. 2018. The SAGES manual of Robotic Surgery Publisher Springer Cham. Published on 14 September 2017. doi:10.1007/978-3-319-51362-1
[6] Zhong W, Mancuso P. Utilization and surgical skill transferability of the simulator robot to the clinical robot for urology surgery. Urol Int 2017;98:1–6.
[7] Bric JD, Lumbard DC, Frelich MJ, *et al*. Current state of virtual reality simulation in robotic surgery training: a review. Surg Endosc 2016;30:2169–78.
[8] Masood Umer, M. Hammad Ather, Syed Ather Enam, *et al* Surgical Education andTraining in Pakistan :Creating a Model; Cambridge Scholars Publishing, 5 Aug 2022 - Medical - 601 pages ISBN 1-5275-8658-8.
[9] Stegemann AP, Ahmed K, Syed JR, *et al*. Fundamental skills of robotic surgery: a multi-institutional randomized controlled trial for validation of a simulation-based curriculum. Urology 2013;81:767–74.
[10] Phillips JL, Grantham EC, Alexander BS. Complications of robotic-assisted laparoscopic surgery: iatrogenic and doulogenic. Complications of Laparoscopic and Robotic Urologic. Surgery 2010:91–9.
[11] Saqib SU, Raza MZ, Evans C, *et al*. The robotic learning curve for a newly appointed colorectal surgeon. J Robot Surg 2023;17:73–8.