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Recent Advances in Minimal Access Surgery-5

Special Edition
Benign Coloproctology

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CHAPTER

Robotics in Benign Coloproctology: Current Status and Future Directions

Venkatesh Munikrishnan, Aarti Kalyanaraman

INTRODUCTION

Robot-assisted surgery (RAS) is increasingly being recognized as a viable alternative to conventional open and laparoscopic surgery for both benign and malignant colorectal disease. This expansion can be credited to increasing availability of more cost-effective platforms and the distinct technical advantages of robotic surgery in particular precision, clarity of vision, and improved dexterity. Given the increasing recognition of the advantages of robotic surgery noted with malignant disease including reduced morbidity, risk of conversion to open, and shorter length of stay,[1] it is feasible to extend the same technological advantages to the management of benign diseases as well. In this chapter, we will take a closer look at the role of robotics across the benign spectrum of colorectal diseases as well as provides some insights that we have gained from our experience as a tertiary unit dedicated to management of colorectal pathology.

DIVERTICULAR DISEASE

Diverticular disease is common especially in the over 60s, in Western society. The prevalence in India, although relatively low, has however been increasing. While it is a surprisingly indolent condition, the decision to operate is dictated either by the degree of sepsis at the time of acute presentation or by chronicity and symptom presentation, which require careful and individual assessment. Recent reviews have shown that there is a role for RAS in the acute as well as elective surgical management of complicated diverticulitis, not only due to its technical advantages but also due to a lower risk of conversion to open, shorter length of stay and improved postoperative outcomes.[2]

In an emergent setting, open surgery has been the traditional option often due to the degree of sepsis, contamination, and/or hemodynamic instability, often resulting in an end colostomy. However, with increasing awareness of this pathology, earlier diagnosis and improving surgical expertise, in select patients it is feasible to perform robotic-assisted resections in an acute setting.[2] Recent studies have shown that it is also possible to perform robot-assisted primary anastomosis in an acute setting in hemodynamically stable and immune competent patients[3-6] with intracorporeal anastomosis.

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In an elective setting, resection for complicated diverticular disease can be challenging due to surrounding inflammation and fibrosis. Robotic platforms offer advantages such as better visualization, range of movements, and ureteric identification through use of ICG (indocyanine green). On a similar note, reversal of Hartmann's procedure also benefits from robotic assistance even in the face of extensive adhesions.[7] Therefore in comparison to laparoscopic techniques, robot-assisted diverticular resection offers significant advantage in terms of rates of conversion to open and a shorter length of stay.[8]

INFLAMMATORY BOWEL DISEASE

The diagnosis of inflammatory bowel disease (IBD) is on the rise[9] and requires a multidisciplinary management. Despite the significant advances made in the medical management of IBD, these patients often require surgery due to its relapsing nature. Operatively the most performed surgeries are ileocolic resection, subtotal colectomy, completion proctectomy, total proctocolectomy (TPC), and ileal pouch anal anastomosis (IPAA).

Acutely, subtotal colectomy is typically done for ulcerative colitis following failure of medical management of an acute flare. RAS, aside from allowing better visualization (of the ureter and pelvic nerves), can potentially reduce length of stay due to smaller wounds and earlier mobilization with secondary results comparable to laparoscopic surgery.[10] While RAS can take longer for multiquadrant surgery due to the need for redocking, it is arguably less traumatic, especially for younger patients as a consequence of smaller wounds, quicker postoperative recovery and fewer adhesions which is of importance in those undergoing multistage surgery for restoration of anatomical continuity.[11]

Electively and despite the successful use of biological agents, the 10-year risk of surgical resection from initial diagnosis of Crohn's disease remains nearly 50%.[12] While there is still limited evidence for RAS in Crohn's disease, European Crohn's and Colitis Organization (ECCO) guidelines support laparoscopic resection of limited ileocecal disease as an alternative to infliximab therapy.[13] In the absence of any clear contraindication, one can presumably extend the indication to RAS.[14] Other procedures such as completion proctectomy, total proctocolectomy, and IPAA can also benefit from RAS with better visualization and dexterity. Further the MIRCAST[15] study has shown a positive trend toward robotic intracorporeal anastomosis in right hemicolectomies and these can be potentially extrapolated to other IBD surgery.

Although there is inadequate evidence favoring RAS over conventional laparoscopy in surgical management of IBD, increasing surgeon experience and more cost-effective platforms may help offset longer operating times and costs associated with RAS.[10] Future studies specifically focusing on IBD-related metrics may therefore be of benefit **(Figs. 1A to D)**.

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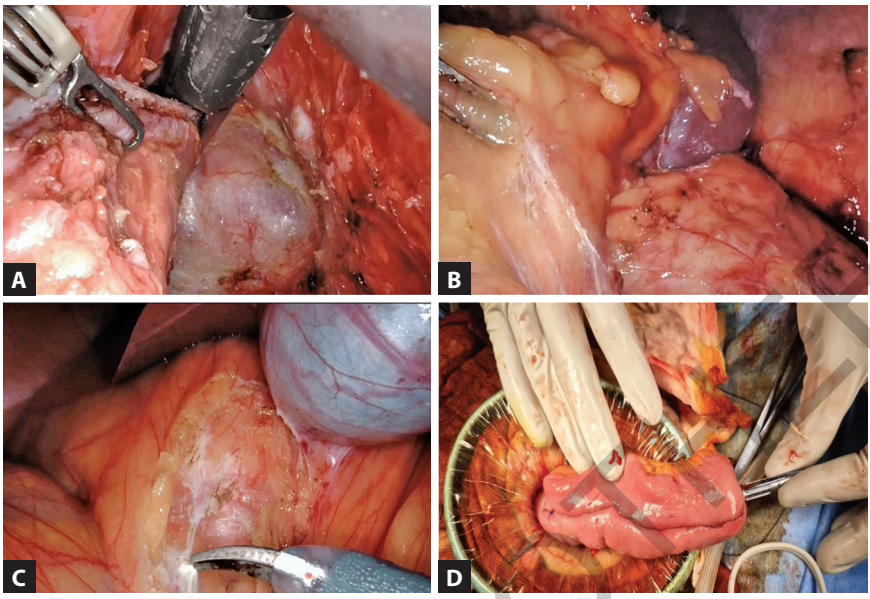

Figs. 1A to D: (A) Distal rectal stapling in total proctocolectomy (TPC); (B) Splenic flexure mobilization in TPC; (C) Hepatic flexure mobilization in TPC; and (D) Ileal pouch.

TRANSANAL MINIMALLY INVASIVE SURGERY

Transanal minimally invasive surgery (TAMIS) is a technique available for management of rectal neoplasia, both benign and malignant. Its use has been extended to early rectal cancers as a means of organ preservation and as an alternative to total mesorectal excision (TME) in frail and elderly patients.[16] Robotic TAMIS was introduced in 2012 and has the advantage over conventional laparoscopic TAMIS of better dexterity within a narrow operating field with the potential for better surgical precision, thereby allowing for more controlled dissection, hemostasis, and ease of suturing. Further with the advent of single port robotic surgery, this technical advantage has been amplified with the possibility opening for utilization of this technique in larger and more proximal lesions.[17]

Although more research is required, available data so far suggests that in regard to margin negativity, complication, and recurrence rates, robotic TAMIS is comparable to laparoscopic TAMIS[16] with the added advantage of improved dexterity and views **(Figs. 2A and B)**.

PELVIC FLOOR DYSFUNCTION (RECTAL PROLAPSE)

Robotic surgery for pelvic floor reconstruction is a potential application due to the ergonomic and visual advantage provided by a stable robotic platform in a narrow operating field that is also multicompartmental.

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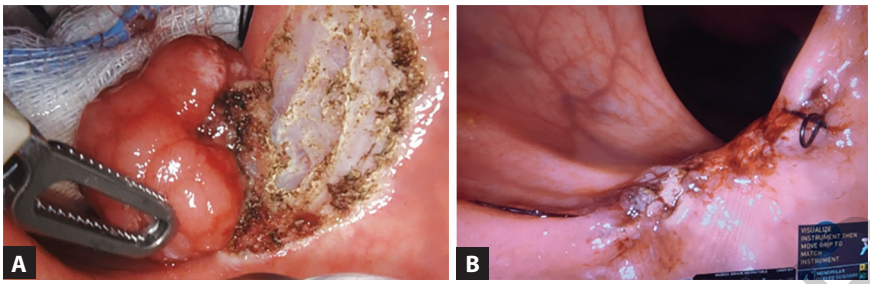
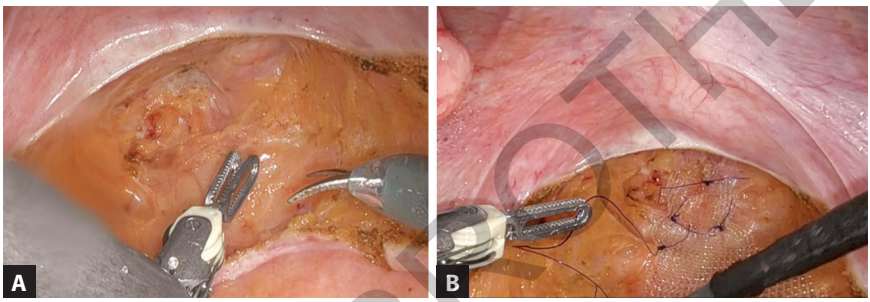


Figs. 2A and B: (A) Transanal minimally invasive surgery (TAMIS) dissection and (B) TAMIS site—post closure.



Figs. 3A and B: (A) Dissecting pouch of Douglas and (B) Suturing mesh to rectum.

While the dexterity provided by robotic platforms is well documented (translating into less surgeon fatigue), there is little evidence that robotic surgery is easier as opposed to a laparoscopic technique. We, however, do know that the risk of conversion to open is lower than with laparoscopy as is the duration of postoperative stay. It is therefore feasible to consider the possibility that increasing surgical expertise could translate into better functional outcomes and for multicompartmental prolapse as opposed to traditional transvaginal and transperineal approaches.[18]

It is outside the remit of this chapter to be able to describe all the potential applications of RAS in pelvic floor dysfunction. We will therefore focus on the most common surgery performed, i.e., *ventral mesh rectopexy* (VMR). VMR remains the gold standard for management of external rectal prolapse. Evidence shows that robotically done VMR has the advantage of a shorter length of stay with no significant difference in complication or conversion rates when compared to laparoscopic VMR.[19] At risk of repetition, it is worth pointing out that the ergonomic advantages of suturing near the pelvic floor are superior with the robotic platform. Further the shorter-term higher costs of robotic VMR are offset by its cost-effectiveness in the longer term **(Figs. 3 and 4)**.[20]

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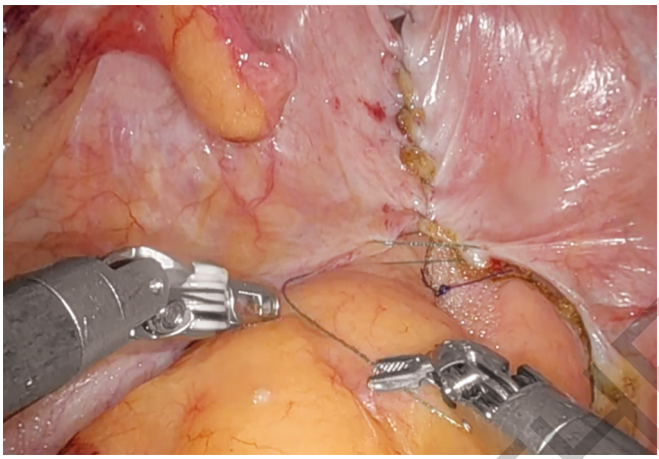

Fig. 4: Closure of peritoneum over mesh.

FUTURE APPLICATIONS

Robotic surgery and its application to colorectal surgery is expanding at a rapid rate due to the availability of more cost-effective platforms, increasing understanding of the multitude of its technical and outcome advantages, and increasing surgical expertise and its integration into training.

One outcome of this evolution is the resurgence of *telesurgery*. First introduced in 2001, there was a long lull, thereafter until recently, driven in part by the pandemic-driven interest in telemedicine as well development of 5G communication and an ever-increasing range of compatible platforms. Telesurgery is a surgical technique that combines wireless and robotic technology to allow surgeons to perform safe and effective operations on patients in real time, remotely. It has the advantage of overcoming geographical barriers and encouraging deployment of surgical care even in areas of sparse surgical expertise such as remote and underserved regions, safely. This in turn spares those seeking expert care the need to either travel long distances or go without needed surgery, if they are unable to do so. It also has the potential to reduce healthcare costs by delivering expert care locally and the minimally invasive nature of this technology also means that recovery following surgery is quicker. Another potential application of telesurgery is telementoring.[21] These systems facilitate surgical training through real-time guidance, telestration, and remote access to instruments. It can potentially provide more experiential teaching at advanced levels. However, significant, and evolving challenges remain. Namely financial, technical, ethical, and medicolegal which will need to be addressed effectively in order to expand this technology and utilize it safely.

On a more practical note, we have had the privilege of successfully performing the first ever *telerobotic anterior resection* in India over a distance

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of 2,200 km (between Gurugram and Chennai) with the SSI Mantra 3 platform. This has since been followed by a further two *ultra-low anterior* resections with no significant latency or perioperative complications, thereby providing real world data on telesurgery being a practical application that is deliverable today and not merely an idea for the future.

A second evolving technique is *endoluminal robotics*. This allows flexible robotic systems to operate within natural orifices. A classic example is as an add-on to endoscopic techniques typically in gastrointestinal and urological procedures. This is likely to improve precision, vision, and dexterity for finer tasks. Three categories of system are evolving:[22]

1. Tips equipped with robotic technology added on top of standard endoscopes; these include Robot for Surgical Endoscopy (ROSE) (Endorobotics, Seoul, Korea) and EndoMODRA (Harvard University, Cambridge, MA).
2. New endoscopic platforms based on the principle of soft or flexible endoscopy implemented with some miniaturized surgical instruments; principal ones are EndoMaster EASE system (University of Singapore), EndoLuminal Surgical system (ELS) from EndoQuest Robotics (Houston, TX), Endoluminal Assistant for Surgical Endoscopy (formerly STRAS), i.e., the robotization of the Anubis system, developed by Karl Storz (Tuttlingen, Germany), Flex Robotic System (Medrobotics, Raynham, MA), i^{2}Snake (Hamlyn Centre for Robotic Surgery, London, UK), and The K-FLEX platform (EasyEndo Surgical, Daejeon, Korea).
3. Platforms based on current *transanal endoscopic microsurgery* (TEMS) and TAMIS surgery platforms; these include Da Vinci Single-Port robotic platform (Intuitive Surgical, Sunnyvale, CA) and PROSTAR (Precision Robotics, Hong Kong).

Lastly, it would be amiss not to mention the evolution and integration of *artificial intelligence* (AI) into healthcare in general and surgery in particular. While this application is nascent, its potential is infinite. For surgery, applying machine learning to clinical pathways, decision-making and operative robotics, is likely to change the surgical landscape in unprecedented ways. It is envisioned that its utility can be extended to screening strategies, diagnosis, preoperative risk prediction, intra- and perioperative guidance, operative robotics, and follow-up.[23]

OUR EXPERIENCE (TIPS AND TRICKS)

In our center, we have access to the DaVinci Xi (Intuitive Surgical, Sunnyvale, CA), Medtronic Hugo RAS (Medtronic, Minneapolis, MN), and SSI Mantra 3 (SSI Innovations, Fort Lauderdale, FLO) platforms. We will, however, largely confine ourselves to our experience with the Da Vinci Xi platform given the volume of experience and for brevity.

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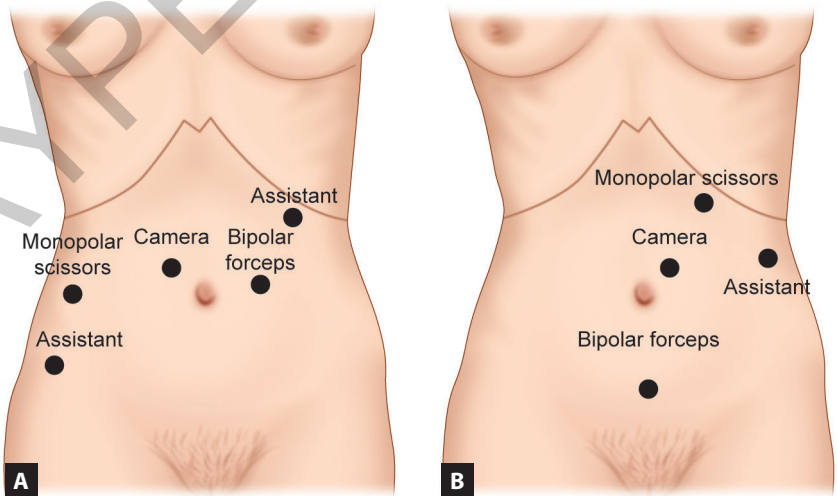
It is our experience that the key to gaining the most out of RAS is standardization. This includes not only surgical technique but also, the theater setup, training of surgical assistants, allied staff, and the scrub team. Having a dedicated team who have been appropriately trained in robotic surgery is a requisite to running a productive robotic surgery unit. This in turn not only contributes to a seamless operative experience but also reduces the operative time and contributes to faster recovery and cost effectiveness.

The standardized steps followed in robotic colonic and rectal surgery in our institute is as described below:

1. *Patient and patient cart position*
   Left colon/rectum: Left side up/steep Trendelenburg (with lithotomy) position; both arms are tucked with all pressure points supported and shoulder support used. The patient cart is positioned on the left side at the caudal end. In the event of *splenic flexure* mobilization being required, redocking to left side up/reverse Trendelenburg position is done **(Fig. 5A)**.
   Right Colon: Right side up/Trendelenburg position; both arms are tucked with all pressure points supported and shoulder support used. The patient cart is positioned on the right side **(Fig. 5B)**.
2. *Port position and instruments*
   Pneumoperitoneum is achieved using Veress needle. We routinely use two assistants with one replacing the fourth arm, to improve cost effectiveness. Also, we limit instrument use to the bipolar forceps and monopolar scissors, with energy devices reserved for multicompartmental surgery.



Figs. 5A and B: (A) Left colon/rectum ports and (B) Right colon ports.

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3. The 8-mm port for the monopolar scissors can be exchanged for a 12-mm port in order to fire the SureForm™ stapler, as needed (in particular for rectal resections).
4. *Mobilization*
   Left colon/rectum: Medial to lateral mobilization of the Left colon is done with inferior mesenteric artery (IMA) ligation. Mobilization of splenic flexure and ligation of inferior mesenteric vein (IMV) is determined on a case-by-case basis.
   Right colon: Medial to lateral mobilization is done and ileocolic/right colic vessels ligated. Hepatic flexure is taken down in all cases with the extent of distal dissection along the transverse colon determined by the location of the malignancy in the right colon.
5. *TME dissection* is performed in the avascular plane, which protects the hypogastric nerves, between the mesorectum and presacral fascia which in turn ensures good functional and oncological outcomes particularly for mid and low rectal malignancies. The exposure for pelvic dissection of TME is augmented by routine use of anterior peritoneal/uterine lift suture.
6. A midline extraction site is used. The vascularity of the remnant colon and anastomosis is routinely evaluated by ICG fluorescence. Our choice of staplers includes CDH29 Circular stapler (Ethicon US, LLC) and TLC75 Linear cutter (Ethicon US, LLC).
7. The *Airseal Valveless Trocar SystemR* (ConMed, Ultica, NY) with laminar flow and CO_2 recirculation is routinely used for rectal surgery, in particular. This decreases the amount of smoke produced during deep pelvic dissection and avoids delays generated by poor views and/or attempts at smoke evacuation.

The setup for *robotic TAMIS* is different and as below:

1. *Patient and patient cart position*
   The patient is placed in a prone jackknife position. The anal orifice is exposed through a combination of gluteal tapes bilaterally and the use of the Lone Star™ retractor (Cooper Surgical, Trumbull, CT). The patient cart is placed on the left side and targeting done as "upper abdominal".
   In the absence of a Single Port Da Vinci (Intuitive Surgical, Sunnyvale, CA) platform, we utilize the GelPOINT Path Transanal Access platform (Applied Medical, Rancho Santa Margarita, CA) which enables insufflated access to the rectum for surgical procedures **(Fig. 6)**.[24]
2. *Port position (**Figure 7** shows TAMIS port positions)*
   Space is rather limited on the GelPOINT Path Access platform. We have, however, found that the above orientation works best given the limited space both on the platform and in the rectum.

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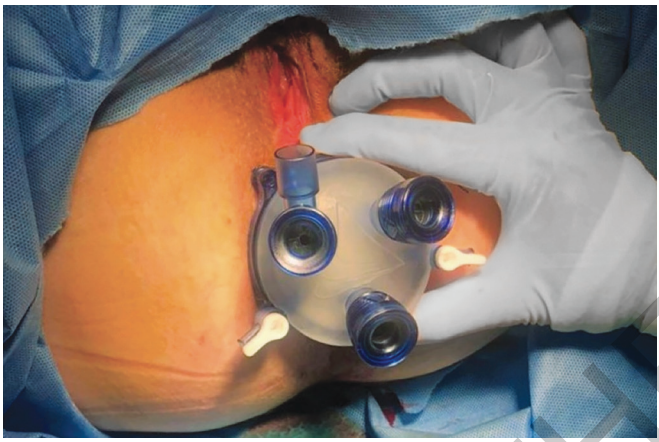

Fig. 6: GelPOINT Path Transanal Access platform (applied medical).[24]

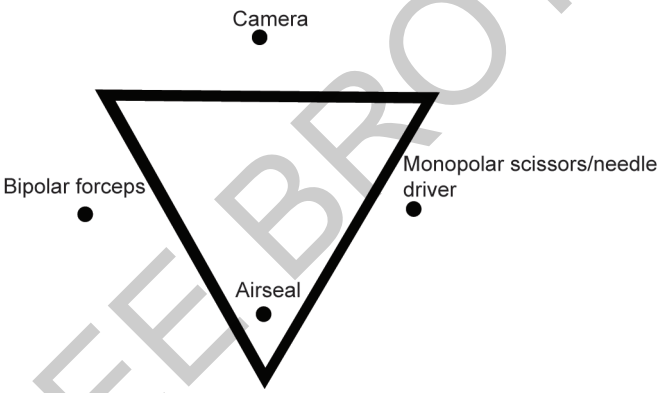

Fig. 7: Transanal minimally invasive surgery (TAMIS) port positions.

3. The *Airseal Valveless Trocar SystemR* (ConMed, Ultica,NY) is invaluable in this surgery. It allows for seamless insufflation in the rectum resulting in uninterrupted and smoke-free views.
4. We prefer to use *V-LocTM* (Medtronic, Minneapolis, MN) suture for closure of the defect.

CONCLUSION

The application of robotic surgery to colorectal surgery started around the early 2000s. Since then, in the last two decades, its role has expanded from that of camera holding to becoming an integral part of complex procedures. The transition from open to laparoscopic surgery took many years and ultimately only prevailed due to the distinct advantages to patients. With increasing use, it became apparent that laparoscopic surgery was being hampered by

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poor ergonomics and rigid instruments. Robotics can potentially combine the advantages of the two approaches by providing 3D vision, precision, and ergonomics. However successful application of robotics will require a certain mindset from the surgeon who will need to train in almost exclusive visual feedback, working within a narrower and magnified field and who will need to be prepared to devote the patience and diligence required to develop this skill.

Comparative studies analyzing the use of laparoscopic and robotic surgery in right and left sided colorectal cancers have shown several advantages such as a shorter length of stay, lower rate of conversion to open, comparable if not fewer postoperative complications, and higher nodal yield rate.[25] With increasing experience and expertise, it is also clear that RAS can be utilized for resection of locally advanced colorectal cancers, which done laparoscopically carries a higher risk of conversion to open. Although there is relatively more limited data available on the use of RAS in benign colorectal resections, it would not be too much of a stretch to extrapolate the findings from oncological resections to its benign counterpart and recognize that the same advantages hold true.

The distinct advantages provided by the robotic platform in a narrow operative field such as the pelvis mean that the use of RAS for rectal cancers is consistently increasing and may well become the operating standard. A recent study has shown that we now have data to show that the oncological outcomes for mid-to-low rectal cancers are better with RAS as compared to laparoscopic surgery.[26] This is likely and at least partly related to the technical advantages provided by the stable robotic platform in the form of superior views, dexterity, and better ergonomics. Given that we are faced with the same challenges in the pelvis during procedures such as VMR, it clear why RAS is a favorable option.

However, it would be disingenuous not to acknowledge that there are disadvantages to RAS. Technical disadvantages include the lack of tactile feedback, logistical, and spatial challenges in setup such as operating room dimensions, docking/undocking, working within a narrow operating field such as transanally, and extended operating time, especially during the initial stages of adopting RAS. From a surgeon's perspective there can potentially be a steep learning curve in part due to the setup process but also attributable to learning to adapt to the lack of tactile feedback and having to rely almost solely on visual feedback. Robotic systems also have higher procurement and operative costs. Nevertheless, with more cost-effective models being available in the market, improving surgical experience and telesurgery opening up the telementoring facility, these disadvantages appear to be surmountable.

In summary, RAS offers significant advantages over traditional surgical techniques in regard to both benign and malignant colorectal pathologies

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but does have its limitations. One would hope that with evolving technology and research addressing these limitations RAS will be adopted on a wider scale and may well become the standard of care in the future.[27]

The future direction of travel would likely then include dedicated centers with expert and multidisciplinary staff that can deliver robotic surgery and training for inexperienced surgeons to achieve robotic surgical proficiency.

EDITORIAL PERSPECTIVE

This chapter provides a contemporary and insightful overview of the expanding role of robotic surgery in benign colorectal disease. While robotic technology is often discussed in the context of colorectal cancer, the authors successfully highlight its growing relevance in the management of benign conditions, including diverticular disease, inflammatory bowel disease, transanal minimally invasive surgery (TAMIS), and pelvic floor disorders.

A notable strength of the chapter is its balanced discussion of both the advantages and current limitations of robotic surgery. The authors clearly explain how enhanced visualization, improved dexterity, ergonomic benefits, and greater precision may translate into better operative performance and patient outcomes, particularly in technically demanding pelvic procedures. The practical sections describing robotic approaches to diverticular disease, inflammatory bowel disease, ventral mesh rectopexy, and TAMIS are especially informative and supported by excellent operative illustrations.

The chapter is further enriched by the authors' personal experience and technical insights. The inclusion of standardized operating room setup, port placement strategies, platform-specific considerations, and practical "tips and tricks" adds substantial real-world value for surgeons seeking to establish or expand a robotic colorectal practice.

Particularly commendable is the forward-looking discussion on telesurgery, tele-mentoring, endoluminal robotics, and artificial intelligence. These sections go beyond current practice and offer readers a glimpse into the future direction of colorectal surgery. The description of successful telerobotic colorectal procedures demonstrates how emerging technologies are already beginning to redefine surgical care delivery.

Overall, this chapter is timely, well-referenced, and highly relevant. It successfully combines evidence-based review with practical surgical experience, making it a valuable resource for colorectal surgeons, robotic surgeons, trainees, and all clinicians interested in the evolving landscape of minimally invasive and robotic colorectal surgery.

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