**Name of Journal:** *World Journal of Gastrointestinal Surgery*

**Manuscript NO:** 82730

**Manuscript Type:** MINIREVIEWS

**Robotic surgery in elderly patients with colorectal cancer: Review of the current literature**

Teo NZ *et al*. Robotic colorectal surgery in the elderly

Nan Zun Teo, James Chi Yong Ngu

**Nan Zun Teo, James Chi Yong Ngu,** Department of General Surgery, Changi General Hospital, Singapore 529889, Singapore

**Author contributions:** Teo NZ and Ngu JCY involved in the concept and design of the study, drafting article and critical revision, and final approval.

**Corresponding author: Nan Zun Teo, FRCS (Ed), MBBS, MMed, Assistant Professor,** Department of General Surgery, Changi General Hospital, 2 Simei Street 3, Singapore 529889, Singapore. teo.nan.zun@singhealth.com.sg

**Received:** December 27, 2022

**Revised:** February 4, 2023

**Accepted:** April 19, 2023

**Published online:**

**Abstract**

With an ageing global population, we will see an increasing number of elderly patients with colorectal cancer (CRC) requiring surgery. However, it should be recognized that the elderly are a heterogenous group, with varying physiological and functional status. While traditionally viewed to be associated with frailty, comorbidities, and a higher risk of post operative morbidity, the advancements in minimally invasive surgery (MIS) and improvements in perioperative care have allowed CRC surgery to be safe and feasible in the elderly - chronological age alone should therefore not strictly be an exclusion criterion for curative surgery. However, as a form of MIS, laparoscopic assisted colorectal surgery (LACS) has the inherent disadvantages of: (1) Dependence on a trained assistant for retraction and laparoscope control; (2) The loss of wristed movement with reduced dexterity and suboptimal ergonomics; (3) A lack of intuitive movement due to the levering effect of trocars; and (4) An amplification of physiological tremors. Representing a technical evolution of LACS, robotic assisted colorectal surgery was introduced to overcome these limitations. In this minireview, we examine the evidence for robotic surgery in the elderly with CRC.

**Key Words:** Robotic surgery; Minimally invasive surgery; Colorectal cancer; Elderly; Geriatric; Frailty

Teo NZ, Ngu JCY. Robotic surgery in elderly patients with colorectal cancer: Review of the current literature. *World J Gastrointest Surg* 2023; In press

**Core Tip:** Robotic assisted colorectal surgery (RACS) is safe and feasible in the elderly. Despite an increased operative time, it potentially confers the benefit of lower conversion, earlier return of gut function and shorter length of stay with comparable oncological outcomes. As such, age alone should not be a specific exclusion criterion for RACS.

**INTRODUCTION**

Globally, life expectancy has increased by more than 6 years between 2000 and 2019 - from 66.8 years in 2000 to 73.4 years in 2019. As such, the geriatric (age 65 and older) population is expected to expand exponentially[1].The incidence of colorectal cancer (CRC) increases with age and the peak incidence has been reported to be between the 7th and 8th decade of life[2]. An estimate from the Surveillance, Epidemiology, and End Results database shows that approximately 70% of CRC develop over the age of 65, and about 40% of patients are over 75 years old[3]. Combining this age-specific incidence with a rapidly ageing population will result in a growing number of elderly patients with newly diagnosed CRC requiring surgery.

Despite being associated with multiple comorbidities[4], frailty[5], and sarcopenia[6], improvements in surgical technique and peri-operative care have made curative resection in the elderly safe and feasible[7]. One of these technological advancements is minimally invasive surgery (MIS). Studies have shown that the benefits of laparoscopy over open colorectal surgery are more pronounced in the elderly and the former has now become the standard of care in many countries[8,9]. However, the data for robotic colorectal surgery in the elderly remains comparatively scarce due to its slower uptake. This is partly due to concerns of adverse outcomes in the elderly from increased operative time and prolonged pneumoperitoneum associated with robotic surgery. In this review, we examine the operative and oncological outcomes for robotic colorectal surgery in elderly patients with CRC. Literature search was performed electronically using PubMed (MEDLINE) and the *Reference Citation Analysis* (<https://www.referencecitationanalysis.com>) was applied. The search terms were as follows: Elderly or old, CRC or colon cancer, and robotic surgery or robotic colectomy in combination with Boolean operators AND or OR. All studies published in English were extracted for review by the authors.

**The frail elderly and risk of surgery**

Most reports concur that CRC surgery in the elderly is associated with greater risks than in younger patients. The CRC Collaborative Group found that compared with their younger counterparts, the elderly tend to have more comorbidities and are more likely to present with late-stage disease requiring emergency surgery. These risk factors contribute to post operative morbidity and mortality[10]. They are also more likely to have had previous abdominal surgery, resulting in intra-abdominal adhesions that prolong operative time and increase the risk of iatrogenic injury[11].

Frailty is common in the elderly and is associated with an increased incidence of post-operative complications, prolonged hospitalization, greater 30-d mortality, and poorer overall survival (OS)[12]. Though there is no consensus definition of frailty, it is used to describe the syndrome of multisystem decline in physiological reserve which results in general debility, cognitive impairment, fatigue, weight loss, sarcopenia, low levels of physical activity, and progressive decline in body function and consequently the increased susceptibility of the patient to stress which can result in poor health outcomes[13-15].

However, it is important to note that frailty goes beyond age. Although it has been previously reported that advanced age itself is an independent risk factor for adverse outcomes, recent evidence suggests that it is not the chronological age of the patient but rather the quality of aging and the functional status that defines frailty and constitute a risk for surgery[16]. There is significant heterogeneity in the elderly with varying functional and physiological reserve and co-morbid states, hence tolerance to surgical stress can vary[17].

Comprehensive metrics have been used to distinguish between ‘‘frail’’ and ‘‘non-frail’’ patients to risk stratify elderly patients for surgery. At present, the Comprehensive Geriatric Assessment (CGA) is viewed as the gold standard for diagnosing frailty[18], and is recommended by the International Society of Geriatric Oncology. However, the CGA is time consuming and requires special training to assess. Other rapid frailty screening tools such as the image based Canadian Study of Health and Aging-Clinical Frailty Scale have been developed and can be utilized in the routine outpatient setting[19]. Risk stratification and medical optimization are important because it has been shown that a complicated postoperative course in the elderly has an adverse impact on survival in the first year after surgery[20], and for survivors of this early post-operative period of 1 year, cancer-related survival of the elderly is comparable to their younger counterparts[21,22].

While chronological age should not be a strict exclusion criterion for curative surgery in elderly patients with CRC, it should be recognized that the elderly patient has a more diverse and complex range of problems that puts him or her at an increased risk for surgery. As such, the importance of patient selection and treatment individualization cannot be overemphasized. For the frail elderly with limited life expectancy and poor functional reserve, it is perhaps reasonable to adopt a less aggressive approach to avoid the risks associated with radical surgery. Examples include palliative stoma or stenting for malignant large bowel obstruction, a watch and wait strategy after chemoradiation for rectal cancer, or surveillance in lieu of surgery for those with complete endoscopic removal of a malignant polyp. However, for those with a reasonable life expectancy and functional status, there is no compelling reason to deny them curative surgery based on age alone. If planned for surgery, this group of patients will benefit from multidisciplinary collaborative care involving geriatricians, anaesthetists, rehabilitation physicians, dieticians, and physiotherapists to deliver frailty targeted intervention programs to achieve better outcomes[23].

**Surgical options for CRC in elderly patients**

The adage “Nothing beats good surgery!” holds true particularly for the elderly. The ideal operation for CRC would be one that: (1) Expedient; (2) Low morbidity; (3) Early return of gut function; (4) Acceptable pain profile that allows early ambulation; and (5) Good oncological outcome. When compared to open surgery, laparoscopic assisted colorectal surgery (LACS) for the elderly has been shown to be safe and feasible. Notwithstanding longer operative times, LACS conferred the benefits of less blood loss, reduced morbidity, faster return of bowel function and a shorter length of stay[24,25]. There was no difference in lymph node yield, disease specific survival and OS[25]. Studies by Frasson *et al*[8] and Hamaker *et al*[9] showed that the benefits of LACS were more pronounced in the elderly.

Unfortunately, there are inherent disadvantages in LACS. These include an unstable assistant-dependant view, loss of wristed movement with reduced dexterity, lack of intuitive movement due to the levering effect of trocars, and the amplification of tremors[26]. Also reported are poor ergonomic positions resulting in operator strain and lack of control over assistant’s traction[27]. These drawbacks are particularly apparent when performing total mesorectal excision (TME) in the narrow confines of the pelvis, resulting in a high rate of open conversion and potentially negating the benefits of MIS[28].

Representing a technical evolution of LACS, robotic assisted colorectal surgery (RACS) overcame many of its limitations. These include a stable surgeon-controlled 3D view, tremor elimination, increased manoeuvrability with EndoWrist technology, fixed stable traction, less physical strain and movement scaling which allows for greater precision in dissection and improved ergonomics for the surgeon[29,30]. Applied to TME, these advantages have been shown to reduce the risk of open conversion, post-operative complication, and length of stay[31]. Other studies have also shown that RACS provides superior visualization and more dynamic assistance than conventional laparoscopy in hemicolectomies[32]. It is therefore unsurprising that the uptake of RACS has increased dramatically over the past decade[33,34].

However, when compared to the general population, the uptake of RACS in the elderly has not been as rapid. This is due to concerns of the elderly being more susceptible to the stress of prolonged pneumoperitoneum from the increased operative time. Coupled with the steep Trendelenburg position required for rectal surgery, this can potentially result in adverse cardiovascular and respiratory complications[35]. Prolonged steep Trendelenburg has also been reported to result in ischemic optic neuropathy and raised intraocular pressure that potentially increase the risk of vision loss, especially in the elderly with pre-existing glaucoma[36].

**Surgical outcomes of RACS in the elderly**

Despite these concerns, contemporary data seem to suggest that they are unfounded. We summarize the post operative outcomes of the available comparative studies between RACS and LACS in the elderly in Table 1[37,38] and with their younger counterparts in Table 2[39-42]. de’Angelis *et al*[38] reported that RACS took longer but Palomba *et al*[37] found that when subdivided by procedure, only colectomies had a longer operative time and there was no difference when TME was required. Despite this increase in operative time, no commensurate rise in intraoperative or postoperative cardio-respiratory complications or reports of vision loss were noted[37,38]. Furthermore, when compared to their younger counterparts, the elderly did not have a more complicated post operative course and there was no difference in 30-d mortality between the groups[39-42]. It is however important to note that these studies were limited by their retrospective nature and small numbers and were prone to bias. Till more conclusive data is available, it is prudent to ensure careful patient selection and medical optimization in the elderly.

Although not statistically significant, the open conversion rate was 4 times more for LACS (13.7% *vs* 3.1%) in Palomba *et al*[37]’s series. Similar trends have also been reported in the general adult population[26,31]. Intra-abdominal adhesions are often cited as a common reason for open conversion. In addition, adhesions increase operative time and the risk of iatrogenic bowel injury[11]. In this aspect, the elderly patient is particularly disadvantaged. Firstly, they are more likely to have had previous open surgery given that MIS was only mainstream in the past couple of decades, and secondly, they have an increased risk of adverse outcomes in the event of surgical complications and open conversion[20]. RACS has been shown to reduce the rates of open conversion in both colectomies[26] and TME surgery[31], especially in the setting of patients with intra-abdominal adhesions[43]. This potentially allows more elderly patients to benefit from MIS.

Compared to LACS, Palomba *et al*[37] reported a faster return of bowel function and reduced length of stay for left sided resection and those requiring TME. This is consistent with the results seen in the general adult population[31] and is probably a reflection of the superiority of the robotic platform in the narrow confines of the pelvis. These benefits have also been reported in robotic hemicolectomies and are theorized to be a consequence of greater precision of dissection, less bowel manipulation, and reduced tissue trauma when compared to the open or laparoscopic approaches. Furthermore, the reduced pain associated with more pivotal rather than tractional port manipulation results in less opiate use in RACS, allowing for an earlier recovery of gut function. The advantages of the robotic platform also lend itself well to intracorporeal anastomosis, which has been shown to reduce extraction site morbidity and shorten the length of stay[44].

Oncological surgery should not be compromised in the elderly. In fact, some may argue that it is perhaps more essential given that pre-existing comorbidities may preclude them from adjuvant systemic therapy. The adequacy of resection for RACS is comparable to LACS in terms of lymph node yield and the percentage of R0 resections in the elderly[37,38]. de’Angelis *et al*[38] also reported no differences in OS and disease-free survival (DFS) up till 3 years. This is in keeping with current evidence for RACS in the adult population, which show no difference in terms of 5-year OS, DFS and local recurrence[45,46]. Complete mesocolic excision (CME) with central vascular ligation (CVL) for colonic cancer was first described by Hohenberger *et al*[47] and has been shown to have better quality surgical specimens and is associated with superior long term oncological outcomes[48]. The superior optics, stable retraction and dexterous dissection provided by the robotic platform makes it well suited to perform CME and CVL safely[49].

**CONCLUSION**

Early results from comparative studies show that RACS is safe and feasible in the elderly and despite an increased operative time, it potentially confers the benefit of lower conversion, earlier return of gut function and shorter length of stay with comparable oncological outcomes. As such, age alone should not be a strict exclusion criterion for RACS.

**REFERENCES**

1 **World Health Organization**. GHE: Life expectancy and healthy life expectancy. [cited 25 November 2022]. Available from: https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/ghe-life-expectancy-and-healthy-life-expectancy

2 **Torre LA**, Bray F, Siegel RL, Ferlay J, Lortet-Tieulent J, Jemal A. Global cancer statistics, 2012. *CA Cancer J Clin* 2015; **65**: 87-108 [PMID: 25651787 DOI: 10.3322/caac.21262]

3 **NIH**. Previous Version: SEER Cancer Statistics Review, 1975-2011. [cited 3 February 2023]. Available from: http://seer.cancer.gov/csr/1975\_2011

4 **Wenkstetten-Holub A**, Fangmeyer-Binder M, Fasching P. Prevalence of comorbidities in elderly cancer patients. *memo* 2021; **14**: 15-19 [DOI: 10.1007/s12254-020-00657-2]

5 **Tolley APL**, Ramsey KA, Rojer AGM, Reijnierse EM, Maier AB. Objectively measured physical activity is associated with frailty in community-dwelling older adults: A systematic review. *J Clin Epidemiol* 2021; **137**: 218-230 [PMID: 33915264 DOI: 10.1016/j.jclinepi.2021.04.009]

6 **Cruz-Jentoft AJ**, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, Martin FC, Michel JP, Rolland Y, Schneider SM, Topinková E, Vandewoude M, Zamboni M; European Working Group on Sarcopenia in Older People. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. *Age Ageing* 2010; **39**: 412-423 [PMID: 20392703 DOI: 10.1093/ageing/afq034]

7 **Jafari MD**, Jafari F, Halabi WJ, Nguyen VQ, Pigazzi A, Carmichael JC, Mills SD, Stamos MJ. Colorectal Cancer Resections in the Aging US Population: A Trend Toward Decreasing Rates and Improved Outcomes. *JAMA Surg* 2014; **149**: 557-564 [PMID: 24718844 DOI: 10.1001/jamasurg.2013.4930]

8 **Frasson M**, Braga M, Vignali A, Zuliani W, Di Carlo V. Benefits of laparoscopic colorectal resection are more pronounced in elderly patients. *Dis Colon Rectum* 2008; **51**: 296-300 [PMID: 18197453 DOI: 10.1007/s10350-007-9124-0]

9 **Hamaker ME**, Schiphorst AH, Verweij NM, Pronk A. Improved survival for older patients undergoing surgery for colorectal cancer between 2008 and 2011. *Int J Colorectal Dis* 2014; **29**: 1231-1236 [PMID: 25024043 DOI: 10.1007/s00384-014-1959-y]

10 Surgery for colorectal cancer in elderly patients: a systematic review. Colorectal Cancer Collaborative Group. *Lancet* 2000; **356**: 968-974 [PMID: 11041397]

11 **ten Broek RP**, Issa Y, van Santbrink EJ, Bouvy ND, Kruitwagen RF, Jeekel J, Bakkum EA, Rovers MM, van Goor H. Burden of adhesions in abdominal and pelvic surgery: systematic review and met-analysis. *BMJ* 2013; **347**: f5588 [PMID: 24092941 DOI: 10.1136/bmj.f5588]

12 **McGovern J**, Dolan RD, Horgan PG, Laird BJ, McMillan DC. The prevalence and prognostic value of frailty screening measures in patients undergoing surgery for colorectal cancer: observations from a systematic review. *BMC Geriatr* 2022; **22**: 260 [PMID: 35351011 DOI: 10.1186/s12877-022-02928-5]

13 **Clegg A**, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. *Lancet* 2013; **381**: 752-762 [PMID: 23395245 DOI: 10.1016/S0140-6736(12)62167-9]

14 **Xue QL**. The frailty syndrome: definition and natural history. *Clin Geriatr Med* 2011; **27**: 1-15 [PMID: 21093718 DOI: 10.1016/j.cger.2010.08.009]

15 **Morley JE**, Vellas B, van Kan GA, Anker SD, Bauer JM, Bernabei R, Cesari M, Chumlea WC, Doehner W, Evans J, Fried LP, Guralnik JM, Katz PR, Malmstrom TK, McCarter RJ, Gutierrez Robledo LM, Rockwood K, von Haehling S, Vandewoude MF, Walston J. Frailty consensus: a call to action. *J Am Med Dir Assoc* 2013; **14**: 392-397 [PMID: 23764209 DOI: 10.1016/j.jamda.2013.03.022]

16 **Duron JJ**, Duron E, Dugue T, Pujol J, Muscari F, Collet D, Pessaux P, Hay JM. Risk factors for mortality in major digestive surgery in the elderly: a multicenter prospective study. *Ann Surg* 2011; **254**: 375-382 [PMID: 21772131 DOI: 10.1097/SLA.0b013e318226a959]

17 **Ngu JC**, Kuo LJ, Teo NZ. Minimally invasive surgery in the geriatric patient with colon cancer. *J Gastrointest Oncol* 2020; **11**: 540-544 [PMID: 32655932 DOI: 10.21037/jgo.2020.02.02]

18 **Parker SG**, McCue P, Phelps K, McCleod A, Arora S, Nockels K, Kennedy S, Roberts H, Conroy S. What is Comprehensive Geriatric Assessment (CGA)? An umbrella review. *Age Ageing* 2018; **47**: 149-155 [PMID: 29206906 DOI: 10.1093/ageing/afx166]

19 **Rockwood K**, Song X, MacKnight C, Bergman H, Hogan DB, McDowell I, Mitnitski A. A global clinical measure of fitness and frailty in elderly people. *CMAJ* 2005; **173**: 489-495 [PMID: 16129869 DOI: 10.1503/cmaj.050051]

20 **Kornmann VNN**, van Vugt JLA, Smits AB, van Ramshorst B, Boerma D. The First Year After Colorectal Surgery in the Elderly. *Ann Coloproctol* 2017; **33**: 134-138 [PMID: 28932722 DOI: 10.3393/ac.2017.33.4.134]

21 **Dekker JW**, van den Broek CB, Bastiaannet E, van de Geest LG, Tollenaar RA, Liefers GJ. Importance of the first postoperative year in the prognosis of elderly colorectal cancer patients. *Ann Surg Oncol* 2011; **18**: 1533-1539 [PMID: 21445672 DOI: 10.1245/s10434-011-1671-x]

22 **Manceau G**, Karoui M, Werner A, Mortensen NJ, Hannoun L. Comparative outcomes of rectal cancer surgery between elderly and non-elderly patients: a systematic review. *Lancet Oncol* 2012; **13**: e525-e536 [PMID: 23182193 DOI: 10.1016/S1470-2045(12)70378-9]

23 **Walston J**, Buta B, Xue QL. Frailty Screening and Interventions: Considerations for Clinical Practice. *Clin Geriatr Med* 2018; **34**: 25-38 [PMID: 29129215 DOI: 10.1016/j.cger.2017.09.004]

24 **Devoto L**, Celentano V, Cohen R, Khan J, Chand M. Colorectal cancer surgery in the very elderly patient: a systematic review of laparoscopic versus open colorectal resection. *Int J Colorectal Dis* 2017; **32**: 1237-1242 [PMID: 28667498 DOI: 10.1007/s00384-017-2848-y]

25 **Fujii S**, Tsukamoto M, Fukushima Y, Shimada R, Okamoto K, Tsuchiya T, Nozawa K, Matsuda K, Hashiguchi Y. Systematic review of laparoscopic *vs* open surgery for colorectal cancer in elderly patients. *World J Gastrointest Oncol* 2016; **8**: 573-582 [PMID: 27559437 DOI: 10.4251/wjgo.v8.i7.573]

26 **Chang YS**, Wang JX, Chang DW. A meta-analysis of robotic versus laparoscopic colectomy. *J Surg Res* 2015; **195**: 465-474 [PMID: 25770742 DOI: 10.1016/j.jss.2015.01.026]

27 **Zhang X**, Wei Z, Bie M, Peng X, Chen C. Robot-assisted versus laparoscopic-assisted surgery for colorectal cancer: a meta-analysis. *Surg Endosc* 2016; **30**: 5601-5614 [PMID: 27402096 DOI: 10.1007/s00464-016-4892-z]

28 **Parascandola SA**, Hota S, Sparks AD, Boulos S, Cavallo K, Kim G, Obias V. Trends in utilization, conversion rates, and outcomes for minimally invasive approaches to non-metastatic rectal cancer: a national cancer database analysis. *Surg Endosc* 2021; **35**: 3154-3165 [PMID: 32601761 DOI: 10.1007/s00464-020-07756-5]

29 **Corcione F**, Esposito C, Cuccurullo D, Settembre A, Miranda N, Amato F, Pirozzi F, Caiazzo P. Advantages and limits of robot-assisted laparoscopic surgery: preliminary experience. *Surg Endosc* 2005; **19**: 117-119 [PMID: 15549629 DOI: 10.1007/s00464-004-9004-9]

30 **Ngu JC**, Teo NZ. A novel method to objectively assess robotic assistance in laparoscopic colorectal surgery. *Int J Med Robot* 2021; **17**: e2251 [PMID: 33686793 DOI: 10.1002/rcs.2251]

31 **Wang X**, Cao G, Mao W, Lao W, He C. Robot-assisted versus laparoscopic surgery for rectal cancer: A systematic review and meta-analysis. *J Cancer Res Ther* 2020; **16**: 979-989 [PMID: 33004738 DOI: 10.4103/jcrt.JCRT\_533\_18]

32 **Ngu JC**, Teo NZ. Robotic assistance is technically superior to conventional laparoscopy in hemicolectomies. *Int J Med Robot* 2022; **18**: e2367 [PMID: 35015929 DOI: 10.1002/rcs.2367]

33 **Schootman M**, Hendren S, Ratnapradipa K, Stringer L, Davidson NO. Adoption of Robotic Technology for Treating Colorectal Cancer. *Dis Colon Rectum* 2016; **59**: 1011-1018 [PMID: 27749475 DOI: 10.1097/DCR.0000000000000688]

34 **Larach JT**, Flynn J, Kong J, Waters PS, McCormick JJ, Murphy D, Stevenson A, Warrier SK, Heriot AG. Robotic colorectal surgery in Australia: evolution over a decade. *ANZ J Surg* 2021; **91**: 2330-2336 [PMID: 33438361 DOI: 10.1111/ans.16554]

35 **Vaknin Z**, Perri T, Lau S, Deland C, Drummond N, Rosberger Z, Gourdji I, Gotlieb WH. Outcome and quality of life in a prospective cohort of the first 100 robotic surgeries for endometrial cancer, with focus on elderly patients. *Int J Gynecol Cancer* 2010; **20**: 1367-1373 [PMID: 21051979 DOI: 10.1111/IGC.0b013e3181f2950a]

36 **Rupp-Montpetit K**, Moody ML. Visual loss as a complication of nonophthalmologic surgery: a review of the literature. *AANA J* 2004; **72**: 285-292 [PMID: 15354918]

37 **Palomba G**, Dinuzzi VP, Capuano M, Anoldo P, Milone M, De Palma GD, Aprea G. Robotic versus laparoscopic colorectal surgery in elderly patients in terms of recovery time: a monocentric experience. *J Robot Surg* 2022; **16**: 981-987 [PMID: 34743288 DOI: 10.1007/s11701-021-01332-2]

38 **de'Angelis N**, Abdalla S, Bianchi G, Memeo R, Charpy C, Petrucciani N, Sobhani I, Brunetti F. Robotic Versus Laparoscopic Colorectal Cancer Surgery in Elderly Patients: A Propensity Score Match Analysis. *J Laparoendosc Adv Surg Tech A* 2018; **28**: 1334-1345 [PMID: 29851362 DOI: 10.1089/lap.2018.0115]

39 **Hannan E**, Feeney G, Fahad Ullah M, Condon E, Coffey JC, Peirce C. Robotic colorectal surgery in elderly patients: A single-centre experience. *Int J Med Robot* 2022; **18**: e2431 [PMID: 35666815 DOI: 10.1002/rcs.2431]

40 **Su WC**, Huang CW, Ma CJ, Chen PJ, Tsai HL, Chang TK, Chen YC, Li CC, Yeh YS, Wang JY. Feasibility of robot-assisted surgery in elderly patients with rectal cancer. *J Minim Access Surg* 2021; **17**: 165-174 [PMID: 33723180 DOI: 10.4103/jmas.JMAS\_154\_19]

41 **Oldani A**, Bellora P, Monni M, Amato B, Gentilli S. Colorectal surgery in elderly patients: our experience with DaVinci Xi® System. *Aging Clin Exp Res* 2017; **29**: 91-99 [PMID: 27888474 DOI: 10.1007/s40520-016-0670-y]

42 **Cuellar-Gomez H**, Rusli SM, Ocharan-Hernández ME, Lee TH, Piozzi GN, Kim SH, Vargas-De-León C. Operative and Survival Outcomes of Robotic-Assisted Surgery for Colorectal Cancer in Elderly and Very Elderly Patients: A Study in a Tertiary Hospital in South Korea. *J Oncol* 2022; **2022**: 7043380 [PMID: 35140787 DOI: 10.1155/2022/7043380]

43 **Milone M**, Manigrasso M, Anoldo P, D'Amore A, Elmore U, Giglio MC, Rompianesi G, Vertaldi S, Troisi RI, Francis NK, De Palma GD. The Role of Robotic Visceral Surgery in Patients with Adhesions: A Systematic Review and Meta-Analysis. *J Pers Med* 2022; **12** [PMID: 35207795 DOI: 10.3390/jpm12020307]

44 **Waters PS**, Cheung FP, Peacock O, Heriot AG, Warrier SK, O'Riordain DS, Pillinger S, Lynch AC, Stevenson ARL. Successful patient-oriented surgical outcomes in robotic *vs* laparoscopic right hemicolectomy for cancer - a systematic review. *Colorectal Dis* 2020; **22**: 488-499 [PMID: 31400185 DOI: 10.1111/codi.14822]

45 **Park EJ**, Cho MS, Baek SJ, Hur H, Min BS, Baik SH, Lee KY, Kim NK. Long-term oncologic outcomes of robotic low anterior resection for rectal cancer: a comparative study with laparoscopic surgery. *Ann Surg* 2015; **261**: 129-137 [PMID: 24662411 DOI: 10.1097/SLA.0000000000000613]

46 **Park JS**, Kang H, Park SY, Kim HJ, Woo IT, Park IK, Choi GS. Long-term oncologic after robotic versus laparoscopic right colectomy: a prospective randomized study. *Surg Endosc* 2019; **33**: 2975-2981 [PMID: 30456502 DOI: 10.1007/s00464-018-6563-8]

47 **Hohenberger W**, Weber K, Matzel K, Papadopoulos T, Merkel S. Standardized surgery for colonic cancer: complete mesocolic excision and central ligation--technical notes and outcome. *Colorectal Dis* 2009; **11**: 354-64; discussion 364-5 [PMID: 19016817 DOI: 10.1111/j.1463-1318.2008.01735.x]

48 **Ferri V**, Vicente E, Quijano Y, Duran H, Diaz E, Fabra I, Malave L, Agresott R, Isernia R, Cardinal-Fernandez P, Ruiz P, Nola V, de Nobili G, Ielpo B, Caruso R. Right-side colectomy with complete mesocolic excision *vs* conventional right-side colectomy in the treatment of colon cancer: a systematic review and meta-analysis. *Int J Colorectal Dis* 2021; **36**: 1885-1904 [PMID: 33983451 DOI: 10.1007/s00384-021-03951-5]

49 **Cuk P**, Jawhara M, Al-Najami I, Helligsø P, Pedersen AK, Ellebæk MB. Robot-assisted versus laparoscopic short- and long-term outcomes in complete mesocolic excision for right-sided colonic cancer: a systematic review and meta-analysis. *Tech Coloproctol* 2023; **27**: 171-181 [PMID: 36001164 DOI: 10.1007/s10151-022-02686-x]

**Footnotes**

**Conflict-of-interest statement:** All the authors report no relevant conflicts of interest for this article.

**Open-Access:** This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: https://creativecommons.org/Licenses/by-nc/4.0/

**Provenance and peer review:** Invited article; Externally peer reviewed.

**Peer-review model:** Single blind

**Peer-review started:** December 27, 2022

**First decision:** January 30, 2023

**Article in press:**

**Specialty type:** Gastroenterology and hepatology

**Country/Territory of origin:** Singapore

**Peer-review report’s scientific quality classification**

Grade A (Excellent): 0

Grade B (Very good): 0

Grade C (Good): C, C

Grade D (Fair): 0

Grade E (Poor): 0

**P-Reviewer:** Pandey NM, India; Shukla A, India **S-Editor:** Wang JJ **L-Editor:** A **P-Editor:**

**Table 1 Robotic *versus* laparoscopic colorectal surgery in elderly studies**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Ref.** | **Study type** | **Age cut-off** | **Number patients** | **Complication (%)** | **Conversion (%)** | **Operative time (min)** | **LOS (d)** | **Adequacy of resection and oncological outcomes** |
| **RACS** | **LACS** | **RACS** | **LACS** | ***P* value** | **RACS** | **LACS** | ***P* value** | **RACS** | **LACS** | ***P* value** | **RACS** | **LACS** | ***P* value** |
| Palomba *et al*[37], 2022 | Retrospective, comparative | 65 | 32 | 51 | 25 | 29.4 | 0.66 | 3.1 | 13.7 | 0.35 | RC = 238.5 | RC = 183.5 | 0.004a | RC = 6.6 | RC = 6.3 | 0.26 | No difference in LN yield and length of specimen |
| LC = 249.6 | LC = 211.7 | 0.003a | LC = 4.2 | LC = 5.8 | 0.004a |
| RS = 276 | RS == 270 | 0.87 | RS = 3.7 | RS = 6.2 | 0.003a |
| RR = 302.8 | RR = 291.7 | 0.12 | RR = 5 | RR = 7.1 | 0.003a |
| de’Angelis *et al*[38], 2018 | Retrospective, PSM comparative | 65 | 43 | 43 | 37.2 | 44.2 | 0.66 | 0 | 0 | NA | 300.6 | 214.5 | 0.034 | 11.7 | 14.8 | 0.079 | No difference in LN yield. No difference in R0 resection. No difference in OS, DFS at 1,2 and 3 yr |

a*P* values < 0.05 were considered statistically significant.

LOS: Length of stay; LN: Lymph node; OS: Overall survival; DFS: Disease free survival; PSM: Propensity score matched; RACS: Robotic assisted colorectal surgery; LACS: Laparoscopic assisted colorectal surgery; RC: Right colectomy; LC: Left colectomy; RS: Rectosigmoid colectomy; RR: Rectal resection; NA: Not available.

**Table 2 Robotic colorectal surgery in elderly *versus* non-elderly**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Ref.** | **Study type** | **Age cut-off** | **Number patients** | **Operative time (min)** | **Complication (%)** | **LOS (d)** | **Oncological outcomes** |
| **ELD** | **NELD** | **ELD** | **NELD** | ***P* value** | **ELD** | **NELD** | ***P* value** | **ELD** | **NELD** | ***P* value** |
| Hannan *et al*[39], 2022 | Retrospective, comparative | 65 | 89 | 73 | 228 | 254 | 0.09 | 30.3 | 26 | 0.2 | 7 | 6 | 0.007a | No difference in LN yield. No difference in R0 resection |
| Su *et al*[40], 2021 | Retrospective, comparative | 70 | 30 | 126 | 320 | 280 | 0.187 | 16.7 | 20.6 | 0.002a | 7 | 6 | 0.084 | No difference in LN yield. No difference in R0 resection. No difference in OS and DFS |
| Oldani *et al*[41], 2017 | Retrospective, comparative | 70 | RC = 9 | RC = 6 | NI | NI | NI | 0 | 0 | NI | 5.22 | 5.66 | NI | No difference in LN yield |
| LC = 5 | LC = 15 | 0 | 6.7 | 6.75 | 6.4 |
| RR = 8 | RR = 7 | 0 | 14.3 | 5.75 | 9.0 |
| Cuellar-Gomez *et al*[42], 2022 | Retrospective, comparative | YO: 75-80; MO: 81-85; OO: ≥ 86 | YO: 48; MO: 19; OO: 9 | YO: 280; MO: 290; OO: 253 | 0.538 | YO: 27.2; MO: 52.6; OO: 44.4 | 0.144 | YO: 13.77; MO: 13.58; OO: 18.22 | 0.579 | No difference in LN yield |

a*P* values < 0.05 were considered statistically significant.

ELD: Elderly; NELD: Non-elderly; LOS: Length of stay; LN: Lymph node; OS: Overall survival; DFS: Disease free survival; RC: Right hemicolectomy; LC: Left hemicolectomy: RR: Rectal resection; NI: No information; YO: Youngest-old; MO: Middle-old; OO: Oldest-old.