Robotic Right Colectomy with Complete Mesocolic Excision and Central Vascular Ligation. Extended Right Colectomy

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7.1 Introduction

Disease recurrence after right colectomy for stage II–III cancer is estimated to be up to 10% of cases. This is potentially related to the understaging of nodal status [1]. Hohenberger thus proposed a translation of Heald's basic principles of total mesorectal excision for rectal cancer, into the management of right colon cancer. Hohenberger standardized the technique of complete mesocolic excision (CME) with central vascular ligation (CVL) and he demonstrated interesting oncological outcomes [2]. Originally described as an open procedure, the Hohenberger technique is today performed by minimally invasive approaches, although it is considered challenging and requires advanced laparoscopic skills [3]. Of note, however, is the recent uptake and diffusion of robotic systems in the field of colon cancer surgery, which offers interesting alternatives to conventional laparoscopy.

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7.2 Definition of Technique and Indications

The CME technique involves sharp dissection along the embryological planes of fusion (Gerota, Toldt and Fredet), whilst the CVL technique requires delicate sharp dissection along the anterior surfaces of the superior mesenteric vessels. The main aim of these techniques is the removal of the infrapancreatic and gastroepiploic arcade nodes, by transecting the accompanying vessels at their origin (ileocolic, right colic, Henle's trunk and middle colic vessels or the right branch of middle colic vessels) (Fig. 7.1a) [2, 3]. Tumor location is crucial to determine the exact extent of colon resection and the location of draining nodes that need to be removed (Fig. 7.1b). In the absence of strong evidence, indications for CME today remain a controversial issue. Major benefits have been reported for tumors located in the ascending colon, hepatic flexure and proximal transverse colon. Benefits of CME have also been demonstrated when there is preoperative computed tomography identification of positive nodes in young patients and those with poorly differentiated disease [4, 5].

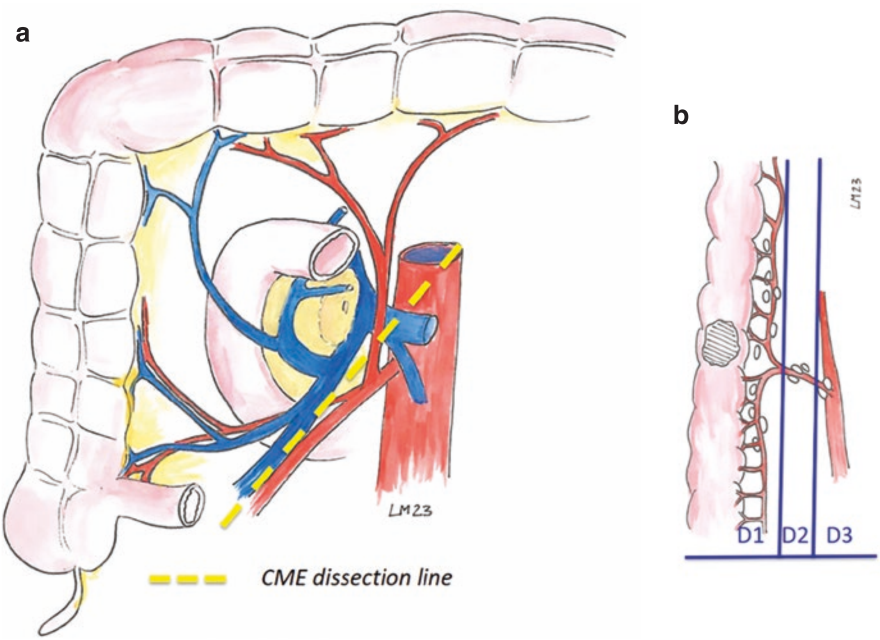

Fig. 7.1 The concept of complete mesocolic excision (*CME*): central vascular ligation at the root of superior mesenteric vessels (see text for details)

7.3 Variations in the Vascular Anatomy of the Right Colon

Surgeons must be well versed in the vascular anatomic variations of the right colon, to avoid causing catastrophic bleeding or iatrogenic injuries, especially for surgeons new to this technique. In 2015, the Japanese National Clinical Database reported a higher rate of surgical mortality for right colon resections compared to rectal resections (1.3% vs. 0.3%), mainly due to vascular injuries [6].

The ileocolic artery and the middle colic artery have been found in almost 100% of cases, while a right colic artery (as a direct branch from the superior mesenteric artery) was detected in about 30% of cases [7]. The gastrocolic (Henle's) trunk represents one of the most variable and crucial anatomic structures. It is composed of various veins from the colon, stomach, omentum and pancreas, merging together prior to draining into the superior mesenteric vein (SMV). These contributing veins have also been found to drain independently and directly into the SMV. Henle's trunk represents an important landmark and, together with the middle colic vessels, it is the cranial border of the CME surgery. Hohenberger called this region the "bleeding point" [2]. Major bleeding during laparoscopic surgery has been shown to occur in 3–9.2% of cases, with conversion to open surgery in 1–2% of cases [8].

7.4 Surgical Techniques of Robotic Right Colectomy with Complete Mesocolic Excision and Central Vascular Ligation

Descriptions of open, laparoscopic and robotic approaches have been reported in many papers, with many variations in robotic techniques [2, 9–11].

7.4.1 Medial-to-Lateral/Superior Mesenteric Vein-First Approach

The medial-to-lateral/SMV-first approach represents the most common technique. The port placement and robot set-up are shown in the Video 7.1 and in Chap. 5. In this approach, the mesocolon is first pulled upward and countertraction is applied downward to the ileocolic region. This exposes the anatomical fold created by the ileocolic vessels and the superior mesenteric axis. The peritoneal layer covering the superior mesenteric vein and artery is incised. Next, the lymphatic tissue and fat are removed en bloc, medially to laterally along the embryological planes between the Gerota's and Toldt's fascia and the pre-duodenopancreatic Fredet's fascia, using monopolar and bipolar energy. The ileocolic vessels are transected close to their origin. Following the path of the superior mesenteric vessels upward, Henle's venous trunk and the origin of the middle colic vessels are dissected and sectioned. The proximal transverse colon is subsequently transected with endoscopic staplers (10 cm of free margin is recommended).

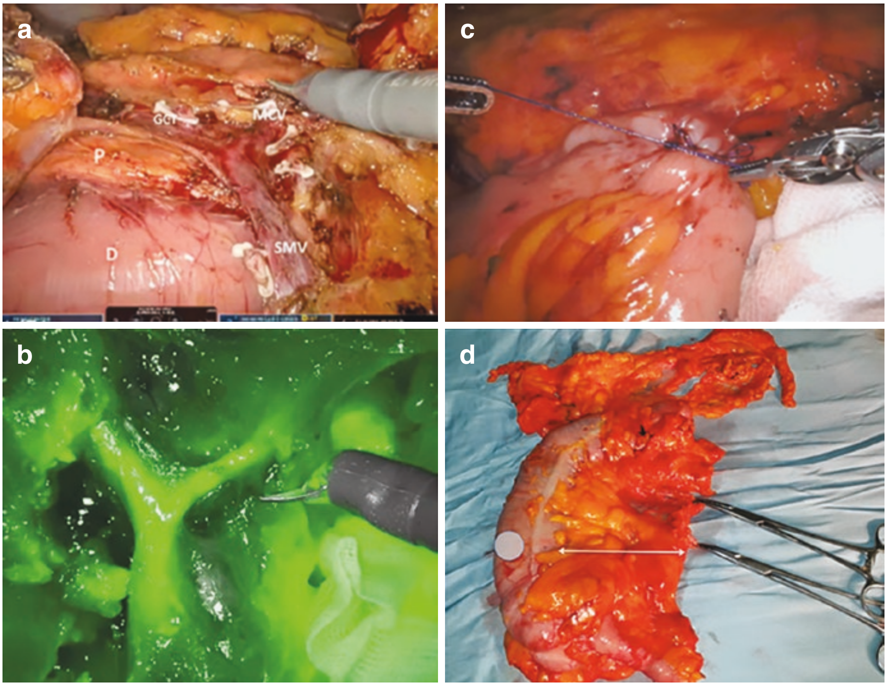

Fig. 7.2 (**a**) The surgical field at the end of the complete mesocolic excision (*D* duodenum; *P* pancreas; *SMV* superior mesenteric vessels; *GCT* gastrocolic trunk; *MCV* middle colic vessels). (**b**) The middle colic vessels with indocyanine green intraoperative identification. (**c**) Intracorporeal anastomosis. (**d**) Specimen showing the "mesocolic plane"

The decision as to whether or not to preserve the left branch of the middle colic vessel depends on the tumor location. The vascular supply of the remnant bowel is then evaluated using indocyanine green (ICG) fluorescence imaging. An intracorporeal side-to-side isoperistaltic anastomosis is then finally performed. For obese patients, the use of intraoperative ultrasound or ICG may be useful to help identify the main vessels [5] (Fig. 7.2) (see Video 7.1).

7.4.2 Top-Down/Cranial-to-Caudal Technique

The top-down/cranial-to-caudal technique, proposed especially for an extended right hemicolectomy [4, 12], consists of the early identification of the gastrocolic trunk and the middle colic vessels. This approach begins by first dissecting the gastrocolic ligament to identify the right gastroepiploic vein, which is the landmark for the gastrocolic trunk. Afterwards, the dissection proceeds downward along the SMV, toward the ileocolic vessels. This technique may prevent or reduce inadvertent vascular injuries to the mesenteric root of the transverse colon. A drawback of this technique is the need for double docking of the robot; with the first docking performed in a 30° reverse Trendelenburg position and the second docking in a 30° Trendelenburg position.

7.4.3 Bottom-to-Up Approach

The bottom-to-up approach, described by Petz et al. [13], requires preferably the last da Vinci Xi system (see Chap. 6). This technique involves a suprapubic positioning of the four ports, along a horizontal line 3–5 cm above the pubis, plus one 12-mm assistant trocar. A 25° Trendelenburg position with a slight left-sided tilt will provide an optimal view for retrocolic dissection and superior mesenteric vessel exposure for CME. The first step in this approach is to begin mobilization retrocecally, followed by further mobilization of the ascending and transverse mesocolon along the embryonic layers. The superior mesenteric vessels are thus identified during mobilization, keeping the "envelope" of the specimen intact prior to any vessel ligation. Excessive tension on the ileocolic vessels is also avoided to reduce the risk of iatrogenic vessel injuries, especially in obese patients. Specimen retrieval is performed via a horizontal minilaparotomy joining the two robotic ports. One of the main advantages of this technique is the retrieval of a higher number of lymph nodes (median of about 40 vs. 16 nodes ($p < 0.001$) compared to conventional medial-to-lateral techniques [14].

7.5 Complete Mesocolic Excision and Indocyanine Green Guidance

For better identification of the regional lymph nodes, an endoscopic submucosal injection of ICG around the tumor is preferably performed the day before surgery. During surgery, the site of the primary tumor and its corresponding lymphatic basin will then be clearly visible with the Firefly modality. Petz et al. demonstrated how effective this technique was, as it ensured high accuracy in the identification of lymph nodes during CME. It was demonstrated that in 17 out of 50 patients (34%), lymph nodes were identified that were out of the usual anatomical lymphatic routes. The main drawback of this approach is, however, the need for endoscopy the day before surgery and its corresponding bowel preparation [13, 15].

7.6 Quality of the Specimen in Complete Mesocolic Excision

The definition of completeness and quality of the CME specimen is not universal. On the basis of total mesorectal excision for rectal cancer, West et al. suggested a grading of the specimen based on the integrity of the mesocolon, and proposed that specimens be classified as either good, moderate or poor. The authors graded the quality of CME by reviewing specimen photographs, and described three grades [16]:

– *Grade A*: intact mesocolon
– *Grade B*: significant mesocolic disruptions
– *Grade C*: disruptions extending down to the muscularis.

Benz et al. also introduced a classification based on four grades of completeness and integrity of the mesocolon [17]. Another important aspect for grading the quality of surgery is the surgical field after specimen removal. It is essential to share all this information with the pathologist examining the specimen (Fig. 7.2d).

7.7 Robotic Complete Mesocolic Excision Outcomes from Literature

Operating time for CME is significantly longer compared to non-CME, for both open and minimally invasive approaches. For robotic surgery, there is the added time taken for the theatre set-up and docking. Spinoglio et al. reported longer mean operating room times for robotic surgery, as compared to laparoscopy (279 vs. 236 min; $p < 0.001$), with a significant difference between the earlier and the later robotic series, underlining the importance of the learning curve [18]. Operative time generally decreases significantly after a number of cases (30–40) [5].

A longer length of hospital stay in CME is sometimes associated with prolonged ileus, probably due to nerve injury along the superior mesenteric artery axis. Intracorporeal anastomosis may help reduce postoperative ileus by less mobilization of the transverse colon [5]. Ozben et al. reported a significantly higher rate of intracorporeal anastomosis using the robotic approach (86.8% vs. 20.0%) [19]. No difference in the postoperative length of stay was generally observed when comparing robotic and laparoscopic CME [18, 19]. Spinoglio et al., however, observed a difference in the conversion rates between the two groups (robotic 0% vs. laparoscopic 6.9%; $p = 0.01$), in favor of the robotic series [18].

Compared with conventional techniques, CME was not associated with higher risk of postoperative complications, including anastomotic leakage. Major vascular injury or chylous ascites were rarely described and can be prevented by not removing the neurolymphatic tissue surrounding the superior mesenteric artery. The use of intraoperative ultrasound in obese patients was reported to reduce vascular complications [20]. Spinoglio et al. reported no intraoperative complications in the robotic series. No incisional hernias were reported after 1 year using the Pfannenstiel incision for specimen extractions [18].

7.8 Lymph Node Yield in Complete Mesocolic Excision

Current guidelines consider the harvesting of 12 lymph nodes as the minimum target for accurate disease staging [21]. The incidence of central mesocolic lymph node metastases is estimated to be between 1% and 22%. This affects the local recurrence rates and represents an independent prognostic factor for survival. CME is associated with a higher number of lymph nodes retrieved [20, 22, 23]. Wong et al. demonstrated that when more than 28 lymph nodes were harvested during CME, this was associated with a better prognosis [24]. One of the reasons for the improved prognosis is the "stage migration effect" and consequent increased use of adjuvant therapy. A mean number of 46.1 ± 22.2 vs. 39.1 ± 17.8 lymph nodes were respectively reported in the comparative study between robotic and standard laparoscopic CME for transverse colon cancer [19].

CME has been shown to have better oncologic outcomes, as compared to standard techniques in selected cases. CME has been shown to reduce local recurrence rates, especially for stage III tumors with proximal lymph node metastases, with improved disease-free survival (DFS) and disease-specific survival (DSS) rates [22, 25]. A positive survival trend in terms of DFS in the CME group was observed in the meta-analysis of De Simoni et al. [20]. Spinoglio et al. also reported a 5-year overall survival rate of 77% for the robotic series versus 73% for the laparoscopic group ($p = 0.64$), with a DFS rate of 85% versus 83% for the robotic versus laparoscopic group ($p = 0.58$) [18].

7.9 Extended Right Colectomy for Right Transverse Colon Cancer

Colon cancer located in the hepatic flexure or transverse colon represents 3% and 5% of cases, respectively. Cancers in these locations are more likely to metastasize to the middle colic and gastrocolic lymph nodes. Adopting minimally invasive approaches in these cases may be challenging, and therefore the robotic system may represent an interesting tool. In these cases, extended lymph node dissections have to include the infrapyloric lymph nodes (No. 206 according to the Japanese classification), and those of the greater curvature of the stomach (No. 204) which are located 10–15 cm from the tumor. The No. 206 station is defined as the area surrounding the root of the right gastroepiploic artery, up to its first branch and down to the junction of the right gastroepiploic vein and the superior anterior pancreaticoduodenal vein. No. 204 includes nodes along the greater curvature of the stomach, distal to the first branch of the right gastroepiploic artery [26]. Toyota et al. reported a study where 2% of colonic hepatic flexure cancers had infrapyloric lymph node metastases, suggesting that when infrapyloric nodal metastases are suspected, they should be removed [27]. One of the typical complications reported after such an extended surgery is a higher incidence of gastroparesis.

Robotic extended right hemicolectomy may be performed using the medial-to-lateral approach, with a port placement slightly different with respect to the standard right colectomy with CME.

Some studies addressed specifically the robotic approach for transverse colon cancers [28, 29], but only a few were focused on the CME technique [30, 31]. In a comparative study of robotic and laparoscopic CME, de Angelis et al. reported fewer conversions, anastomotic leaks, ileus, and reoperation rates, as well as more intracorporeal bowel anastomosis and greater numbers of harvested lymph nodes, in the robotic series, whilst operative time and blood loss were in favor of laparoscopy [30].

7.10 Conclusions

Long-term oncological benefits of CME with CVL over standard techniques have yet to be definitively demonstrated. There is also no shared consensus on the definition of CME itself, nor on CME's indications, technical details and complications. The minimally invasive approach appears possible but challenging, and generally requires a long learning curve. The robotic technique, conversely, offers more precise dissection and a shorter learning curve as compared to conventional laparoscopy. The robotic approach is also particularly helpful when applied to obese patients. Prospective randomized studies with long-term follow-up and large series are required before recommending the CME technique and the robotic approach in routine practice.

References

1. Sjovall A, Granath F, Cedermark B, et al. Locoregional recurrence from colon cancer: a population-based study. Ann Surg Oncol. 2007;14:432–40.
2. Hohenberger W, Weber K, Matzel K, et al. Standardized surgery for colonic cancer: complete mesocolic excision and central ligation – technical notes and outcome. Color Dis. 2009;11:354–64; discussion 364–5.
3. Søndenaa K, Quirke P, Sugihara K, et al. The rationale behind complete mesocolic excision (CME) and a central vascular ligation for colon cancer in open and laparoscopic surgery: proceedings of a consensus conference. Int J Color Dis. 2014;29:419–28.
4. West NP, Kobayashi H, Takahashi K, et al. Understanding optimal colonic cancer surgery: comparison of Japanese D3 resection and European complete mesocolic excision with central vascular ligation. J Clin Oncol. 2012;30(15):1763–9.
5. Siddiqi N, Stefan S, Jootun R, et al. Robotic complete mesocolic excision (CME) is a safe and feasible option for right colonic cancers: short and midterm results from a single-centre experience. Surg Endosc. 2021;35(12):6873–81.
6. Kakeji Y, Udagawa H, Unno M, et al. Annual report of national clinical database in gastroenterological surgery 2015. Jpn J Gastroenterol Surg. 2017;50(2):166–76.
7. Alsabilah J, Kim WR, Kim NK. Vascular structures of the right colon: incidence and variations with their clinical implications. Scand J Surg. 2017;106(2):107–15.
8. Marcello PW, Roberts PL, Rusin LC, et al. Vascular pedicle ligation techniques during laparoscopic colectomy: a prospective randomized trial. Surg Endosc. 2006;20(2):263–9.

9. Matsuda T, Iwasaki T, Sumi Y, et al. Laparoscopic complete mesocolic excision for right-sided colon cancer using a cranial approach: anatomical and embryological consideration. Int J Color Dis. 2017;32(1):139–41.
10. Aghayeva A, Baca B, Atasoy D, et al. Robotic complete mesocolic excision for splenic flexure of colon cancer. Dis Colon Rectum. 2016;59(11):1098.
11. Otero-Piñeiro A, Bravo R, Besa A, et al. Robotic right hemicolectomy with D3 lymphadenectomy, complete mesocolon excision and intracorporeal anastomosis – a video vignette. Color Dis. 2020;22(11):1809–10.
12. Hamzaoglu I, Ozben V, Sapci I, et al. "Top down no-touch" technique in robotic complete mesocolic excision for extended right hemicolectomy with intracorporeal anastomosis. Tech Coloproctol. 2018;22(8):607–11.
13. Petz W, Ribero D, Bertani E, et al. Robotic right colectomy with complete mesocolic excision: bottom-to-up suprapubic approach – a video vignette. Color Dis. 2017;19(8):788–9.
14. Schulte Am Esch J, Iosivan SI, Steinfurth F, et al. A standardized suprapubic bottom-to-up approach in robotic right colectomy: technical and oncological advances for complete mesocolic excision (CME). BMC Surg. 2019;19(1):72.
15. Spinoglio G, Marano A, Bianchi PP, et al. Robotic right colectomy with modified complete mesocolic excision: long-term oncologic outcomes. Ann Surg Oncol. 2016;23(Suppl 5):684–91.
16. West NP, Hohenberger W, Weber K, et al. Complete mesocolic excision with central vascular ligation produces an oncologically superior specimen compared with standard surgery for carcinoma of the colon. J Clin Oncol. 2010;28(2):272–8.
17. Benz S, Tannapfel A, Tam Y, et al. Proposal of a new classification system for complete mesocolic excison in right-sided colon cancer. Tech Coloproctol. 2019;23(3):251–7.
18. Spinoglio G, Petz W, Borin S, et al. Robotic right colectomy with complete mesocolic excision and indocyanine green guidance. Minerva Chir. 2019;74(2):165–9.
19. Ozben V, de Muijnck C, Esen E, et al. Is robotic complete mesocolic excision feasible for transverse colon cancer? J Laparoendosc Adv Surg Tech A. 2018;28(12):1443–50.
20. De Simoni O, Barina A, Sommariva A, et al. Complete mesocolic excision versus conventional hemicolectomy in patients with right colon cancer: a systematic review and meta-analysis. Int J Color Dis. 2021;36(5):881–92.
21. Vogel JD, Eskicioglu C, Weiser MR, et al. The American Society of Colon and Rectal Surgeons Clinical Practice Guidelines for the treatment of colon cancer. Dis Colon Rectum. 2017;60(10):999–1017.
22. Bertelsen CA, Neuenschwander AU, Jansen JE, et al. 5-year outcome after complete mesocolic excision for right-sided colon cancer: a population-based cohort study. Lancet Oncol. 2019;20(11):1556–65.
23. West NP. Complete mesocolic excision for colon cancer: is now the time for a change in practice. Lancet Oncol. 2019;20(11):1474–6.
24. Wong SL. Lymph node counts and survival rates after resection for colon and rectal cancer. Gastrointest Cancer Res. 2009;3(2 Suppl):S33–5.
25. Merkel S, Weber K, Matzel KE, et al. Prognosis of patients with colonic carcinoma before, during and after implementation of complete mesocolic excision. Br J Surg. 2016;103(9):1220–9.
26. Bertelsen CA, Neuenschwander AU, Jansen JE, et al. Disease-free survival after complete mesocolic excision compared with conventional colon cancer surgery: a retrospective, population-based study. Lancet Oncol. 2015;16(2):161–8.
27. Toyota S, Ohta H, Anazawa S. Rationale for extent of lymph node dissection for right colon cancer. Dis Colon Rectum. 1995;38(7):705–11.
28. Ceccarelli G, Biancafarina A, Patriti A, et al. Laparoscopic resection with intracorporeal anastomosis for colon carcinoma located in the splenic flexure. Surg Endosc. 2010;24(7):1784–8.
29. Jung KU, Park Y, Lee KY, Sohn SK. Robotic transverse colectomy for mid-transverse colon cancer: surgical techniques and oncologic outcomes. J Robot Surg. 2015;9(2):131–6.

30. de'Angelis N, Alghamdi S, Renda A, et al. Initial experience of robotic versus laparoscopic colectomy for transverse colon cancer: a matched case-control study. World J Surg Oncol. 2015;13:295.
31. Ozben V, de Muijnck C, Sengun B, et al. Robotic complete mesocolic excision for transverse colon cancer can be performed with a morbidity profile similar to that of conventional laparoscopic colectomy. Tech Coloproctol. 2020;24(10):1035–42.