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ORIGINAL ARTICLE

Complete mesocolic excision does not increase short-term complications in laparoscopic left-sided colectomies: a comparative retrospective single-center study

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Abstract

Background Since the implementation of total mesorectal excision (TME) in rectal cancer surgery, oncological outcomes improved dramatically. With the technique of complete mesocolic excision (CME) with central vascular ligation (CVL), the same surgical principles were introduced to the field of colon cancer surgery. Until now, current literature fails to invariably demonstrate its oncological superiority when compared to conventional surgery, and there are some concerns on increased morbidity. The aim of this study is to compare short-term outcomes after left-sided laparoscopic CME versus conventional surgery.

Methods In this retrospective analysis, data on all laparoscopic sigmoidal resections performed during a 3-year period (October 2015 to October 2018) at our institution were collected. A comparative analysis between the CME group—for sigmoid colon cancer—and the non-CME group—for benign disease—was performed.

Results One hundred sixty-three patients met the inclusion criteria and were included for analysis. Data on 66 CME resections were compared with 97 controls. Median age and operative risk were higher in the CME group. One leak was observed in the CME group (1/66) and 3 in the non-CME group (3/97), representing no significant difference. Regarding hospital stay, postoperative complications, surgical site infections, and intra-abdominal collections, no differences were observed. There was a slightly lower reoperation (1.5% versus 6.2%, $p = 0.243$) and readmission rate (4.5% versus 6.2%, $p = 0.740$) in the CME group during the first 30 postoperative days. Operation times were significantly longer in the CME group (210 versus 184 min, $p < 0.001$), and a trend towards longer pathological specimens in the CME group was noted (21 vs 19 cm, $p = 0.059$).

Conclusions CME does not increase short-term complications in laparoscopic left-sided colectomies. Significantly longer operation times were observed in the CME group.

Keywords Colonic neoplasm · Sigmoid neoplasm · Complete mesocolic excision · Central vascular ligation · Laparoscopic surgery

Introduction

Background The introduction of the total mesorectal excision (TME) technique for the surgical treatment of rectal cancer in 1979 dramatically improved oncological outcomes [1]. By adhering to the principles of a sharp dissection along embryological anatomical planes, thereby removing all draining lymphatic tissue with an intact coverage, both local recurrence rates and survival rates were ameliorated significantly [1, 2].

With the technique of complete mesocolic excision (CME) and central vascular ligation (CVL), the same surgical principles were introduced to the field of colon cancer surgery. Generally, the Erlangen group is considered as the first to

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describe this technique [3]. Some advocate that these principles have been part of a "good surgical practice" for decades, and authors reported on similar surgical principles before 2009 [4, 5].

In their initial paper on 1329 patients, Hohenberger et al. reported on excellent oncological outcomes with the adoption of the CME technique. Local 5-year recurrence rates dropped from 6.5 to 3.6%, and the 5-year survival rates increased from 82.1 to 89.1% [3]. Similarly, Bokey et al. reported in 2003 on superior oncological results with a more radical surgical technique, demonstrating an improvement in 5-year overall survival from 48 to 63% [4]. More recently, a retrospective patient series from Storli et al., comparing CME with conventional surgery, showed a higher 3-year overall survival (88.1% vs 79.0%) and disease-free survival (82.1 vs 74.3%) in the CME group [6]. A Danish retrospective study, published in 2015, reported an improved 4-year disease-free survival (DFS) in early stage disease with CME surgery, but could not demonstrate a difference in overall survival [7]. Besides simple removal of a possible lymphatic metastatic process and stage migration due to increased lymph node harvest, proponents of the CME technique use a standardization of surgical technique, resection of possible micrometastases and the possibility of nodal "skip metastases" as their main arguments [8–10].

Despite these promising initial results, the quality of evidence supporting the oncological superiority of CME remains limited. To date, all available patient series have a retrospective design. Of the 4 studies reporting oncological superior results with CME surgery [6, 7, 11–13], 2 of them used historical controls [11–13]. One could assume that besides adjuvant treatment, both peroperative and postoperative care have evolved, making interpretation of these data difficult. Other studies have used patient data from other hospitals as their control group, again complicating interpretation [6, 7, 13]. The remaining studies showed no significant differences in oncological outcomes after CME, compared to conventional surgery [13].

As current literature fails to demonstrate an oncological benefit with the CME technique, concerns are often raised on intra- and postoperative morbidity. One study reported higher intraoperative complications during CME surgery [14]. Most studies show comparable results regarding anastomotic leak and postoperative morbidity between both techniques.

Objectives The purpose of this study is to investigate short-term outcomes after laparoscopic left-sided colectomies using the CME technique. By comparing these data with patients who underwent conventional surgery, we aim to add information on a possible increase in morbidity when using the CME technique for laparoscopic sigmoid resections.

Materials and methods

Setting This retrospective single center study was conducted at the surgical department of Maria Middelares Hospital (Ghent, Belgium). Included patients were treated between October 2015 and October 2018. Surgery was performed by three consulting colorectal surgeons. All three of them had adequate proficiency in colorectal surgery and laparoscopic CME procedures before the start of the study. Data were retrospectively collected from the electronic patient file and entered in an anonymized database. Before closure of the database on December 1st 2018, data and missing values were double checked. The study protocol was approved by the local ethics committee before the start of data collection.

Patients All patients scheduled to undergo elective laparoscopic sigmoid resection during the period October 1st 2015–October 1st 2018 were eligible for inclusion. Exclusion criteria were conversion to laparotomy, combined procedures, robot-assisted procedures, defunctioning stoma, obstructive disease, and transanal extraction of the specimen. Thirteen cases operated by non-participating surgeons (that are not familiar with the laparoscopic CME technique) and 12 rectal resections (mid-rectal anastomosis or lower) were excluded. Eventually, 163 patients met the inclusion criteria and were included for further analysis. Of the included patients, 66 were operated with a CME technique for malignancy, and 97 patients underwent conventional colectomy for benign disease. A flowchart of patient numbers is depicted in Fig. 1.

Surgical technique In the absence of contraindications, mechanical bowel preparation was administered. No oral antibiotics were given preoperatively. At induction of anesthesia, a single prophylactic dose of 2 g cefazoline (Cefacidal, Bristol-Myers Squibb, Braine-l'Alleud, Belgium) and 500 mg of metronidazole (Metronidazol, B. Braun, Diegem, Belgium) was administered. Surgery for malignancy was performed strictly adhering to the principles of CME. After a medial-to-lateral dissection along the mesocolic plane, the inferior mesenteric vein (IMV) was ligated at the lower border of the pancreas. The splenic flexure was systematically mobilized, including

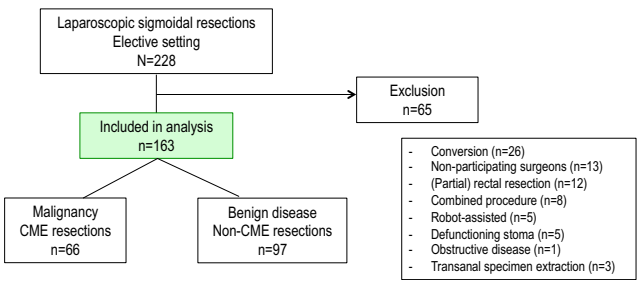

Fig. 1 Flowchart for patients included in the analysis

dissection of the pancreas from the mesocolon and dissection of the omentum from the transverse colon. A ligation of the inferior mesenteric artery (IMA) was performed at its origin. When possible, a double-stapled technique was used, with an end-to-end circular mechanic anastomosis. Conventional sigmoid resection for benign disease was performed using a lateral-to-medial dissection. A mobilization of the splenic flexure was only performed when necessary to avoid traction, and the sigmoidal vessels were ligated at 2–3 cm from the origin of the IMA. Details on bowel preparation and intraoperative characteristics are listed in Table 1. An intraoperative leak test was performed in all cases, except for one anastomosis with a side-to-side (STS) configuration.

Endpoints and variables The rate of anastomotic leak within a follow-up period of 30 days was defined as the primary endpoint. The reference of Rahbari et al. on the definition and grading of anastomotic leaks after rectal surgery was used to define our primary endpoint [15]. Furthermore, overall complications (using the Clavien–Dindo classification), surgical site infections, intra-abdominal collections, and reoperation and readmission rates within 30 days were monitored as secondary endpoints. Data on skin-to-skin operation times, postoperative hospital stay and specimen length were added to our database. There were no specific enhanced recovery after surgery (ERAS) measures undertaken during the study period. Specimen length was measured by the pathology department between 2 and 5 days after formalin fixation.

Statistical analysis The tested null hypothesis was defined as a higher short-term complication rate in the group undergoing CME surgery. For descriptive data on patient demographics and outcomes, median values and interquartile ranges (IQR) or proportions (%N) were calculated. Data were checked for distribution and normality using the Kolmogorov–Smirnov and Shapiro–Wilk tests. p values were calculated using the Mann–Whitney U test for continuous variables and Fisher's exact test for categorical variables. p values ≤ 0.05 were considered indicating statistical significance. The Spearman's rank correlation coefficient was used to assess a possible correlation between operation times and postoperative hospital stay. The statistical analysis was performed in a blinded manner and was reviewed by an independent statistician. Data analysis was carried out using Microsoft Excel (Redmond, WE, USA), GraphPad (La Jolla, CA, USA), and SPSS Statistics (North Castle, NY, USA).

Results

Patient characteristics The main characteristics of included patients are listed in Table 1. Median age in the CME group was significantly higher than in the non-CME group (68.0 versus 58.7 years, $p < 0.001$), and significantly more patients who underwent surgery for malignancy had a high operative risk. For the other variables, no statistically significant difference between both groups was shown. TNM stage of 66 patients in the CME group is shown in Table 2. The majority of the tumors had a T3–T4 stage (56%); in 63.6% tumors were nodal negative (N0). Mean and median lymph node count was 17.

Endpoints Outcomes are shown in Table 2. Regarding the primary endpoint, only one grade A leak was observed in the CME group, for which no surgical or radiological intervention was undertaken. Of the 97 patients who underwent a conventional colectomy, 3 had an anastomotic leak requiring surgical intervention. In two cases, this resulted in a left-sided colostomy; in one case, a local suture repair was done with placement of a defunctioning ileostomy. One 87-year-old patient (ASA 3) who underwent conventional colectomy with a STS anastomosis for recurrent sigmoid volvulus died during his hospitalization due to anastomotic leak. No major differences were observed in overall postoperative complications, surgical site infections, and intra-abdominal collections. While not statistically significant, there was a trend towards lower reoperation (1.5% versus 6.2%, $p = 0.243$) and readmission rate (4.5% versus 6.2%, $p = 0.740$) in the CME group during the first 30 postoperative days. Skin-to-skin operation times were significantly longer in the CME group (210 versus 184 min, $p < 0.001$), and a trend towards longer pathological specimens in the CME group was noted (21 vs 19 cm, $p = 0.059$). Post hoc power analysis revealed insufficient power to show significant differences in specimen lengths. Figure 2 depicts a significant correlation between operative times and postoperative hospital stay (Spearman's rank correlation coefficient $\rho = 0.174$, $p = 0.027$).

Discussion

Main results In a pooled analysis, reported leak rates after both conventional and CME surgery for colonic cancer were around 6.0% [13]. In this analysis, data on left-sided, right-sided, and transverse colectomies were included. Only the Hohenberger group demonstrated a statistically significant difference between both groups, with a lower number of anastomotic leaks in their CME group [12]. Again, the historical controls (dating from the period 1978–1984) remain a major confounder in these numbers. Recently reported leak rates after laparoscopic sigmoidectomy for benign disease vary between 1.2 and 7% [16, 17]. Generally, there is consensus that preservation of the superior rectal artery (SRA) does not decrease leak rates in the surgical treatment of diverticulitis [16–18]. The outcomes of our study regarding anastomotic leak are similar. There was a higher proportion of anastomotic

Table 1 Patient characteristics and intraoperative variables during laparoscopic left-sided colonic resections

	Malignancy ($N = 66$) CME resection Median (IQR) or % (n/N)	Benign disease ($N = 97$) Non-CME resection Median (IQR) or % (n/N)	p value[a]
Age (years)	68.0 (60.4–77.1)	58.7 (52.3–68.2)	< 0.001*
Gender			
Male	54.5% (36/66)	40.2% (39/97)	
Female	45.4% (30/66)	59.8% (58/97)	0.080
ASA classification			
Low risk (1–2)	75.8% (50/66)	89.7% (87/97)	0.028*
High risk (3–5)	24.2% (16/66)	10.3% (10/97)	
Body mass index (kg/m^2)	25.7 (23.8–28.7)	26.5 (24.2–29.7)	0.179
Diabetes mellitus			
Yes	10.6% (7/66)	7.2% (7/97)	0.057
No	89.4% (59/66)	92.8% (90/97)	
Smoking			
Current smoker	10.6% (7/66)	22.7% (22/97)	0.059
Non-smoker	89.4% (59/66)	76.3% (74/97)	
Missing	0.0% (0/66)	1.0% (1/97)	
Bowel preparation			
None	4.5% (3/66)	2.1% (2/97)	
Mechanical	93.9% (62/66)	89.7% (87/97)	
Missing	1.5% (1/66)	8.2% (8/97)	
Anastomosis configuration			
ETE	100% (66/66)	97.9% (95/97)	
ETS	0% (0/66)	1.0% (1/97)	
STS	0% (0/66)	1.0% (1/97)	
Anastomosis type			
Stapled	100% (66/66)	100% (97/97)	
Handsewn	0% (0/66)	0% (0/97)	
Stapling technique			
Circular	100% (66/66)	97.9% (95/97)	
Linear	0% (0/66)	2.1% (2/97)	
Leak test			
Yes	98.5% (65/66)	99.0% (96/97)	
No	0% (0/66)	1.0% (1/97)	
Missing	1.5% (1/66)	0% (0/97)	

CME complete mesocolic excision, *IQR* interquartile range, *ETE* end-to-end, *ETS* end-to-side, *STS* side-to-side

*Indicating statistical significance

[a] p values calculated by the Mann–Whitney U test for continuous variables and Fisher's exact test for categorical variables

dehiscence in the surgical treatment of benign disease (3.1%), and no clinically relevant leaks were observed after CME surgery.

Generally, all available comparative studies between CME and conventional colectomy include mainly patients operated on by open surgery. Only the data from the Danish Colorectal Cancer Group (DCCG) included significant numbers of laparoscopic procedures [7, 14]. Concerning operation times, two comparative studies showed significantly longer procedure times in CME surgery. However, both of them included only right hemicolectomies performed by laparotomy [9, 19]. Our data—indicating a significantly longer operation time for CME surgery—are in accordance with current literature.

During a consensus meeting in 2014, the three main elements of CME surgery were defined: first, a sharp dissection along the embryological plane between the mesorectal fascia and the retroperitoneum (thereby resecting an intact mesocolon with all draining lymph nodes and lymphatics); second, a central vascular tie

Table 2 Outcome variables and tumor characteristics after laparoscopic left-sided colonic resections

	Malignancy ($N = 66$) CME resection Median (IQR) or % (n/N)	Benign disease ($N = 97$) Non-CME resection Median (IQR) or % (n/N)	p value[e]
Skin-to-skin operation time (minutes)	210.0 (182.8–249.3)	184.0 (163.0–205.0)	< 0.001*
Hospital stay (days)	7.0 (6.0–8.8)	7.0 (6.0–8.0)	0.226
Postoperative complications[a]			
None	59.1% (39/66)	52.6% (51/97)	0.598
Grades I–IIIa	33.3% (22/66)	41.2% (40/97)	
Grades IIIb–IV	7.6% (5/66)	5.2% (5/97)	
Grade V	0.0% (0/66)	1.0% (1/97)	
Surgical site infection			
Yes	1.5% (1/66)	2.1% (2/97)	0.783
No	98.5% (65/66)	97.9% (95/97)	
Leak[b]			
None	98.5% (65/66)	96.9% (94/97)	0.108
Grade A	1.5% (1/66)	0.0% (0/97)	
Grade B	0.0% (0/66)	0.0% (0/97)	
Grade C	0.0% (0/66)	3.1% (3/97)	
Intra-abdominal collection			
Yes	4.5% (3/66)	2.1% (2/97)	0.395
No	95.5% (63/66)	97.9% (95/97)	
Reoperation[c]			
Yes	1.5% (1/66)	6.2% (6/97)	0.243
No	98.5% (65/66)	93.8% (91/97)	
Readmission[d]			
Yes	4.5% (3/66)	6.2% (6/97)	0.740
No	95.5% (63/66)	93.8% (91/97)	
Specimen length (cm)	21.0 (18.0–26.0)	19.0 (17.0–24.0)	0.059
T stage			
T1	27.3% (18/66)		
T2	15.2% (10/66)		
T3	51.5% (34/66)		
T4	4.5% (3/66)		
Missing	1.5% (1/66)		
N stage			
N0	63.6% (42/66)		
N1	13.6% (9/66)		
N2	21.2% (14/66)		
Missing	1.5% (1/66)		
M stage			
M0	90.9% (60/66)		
M1	7.6% (5/66)		
Missing	1.5% (1/66)		

CME complete mesocolic excision, *IQR* interquartile range

*Indicating statistical significance

[a] According to the Clavien–Dindo classification

[b] Grade A, no radiological or surgical intervention; grade B, radiological intervention (drain); grade C, surgical intervention

[c] Reoperation rates during the first 30 postoperative days

[d] Readmission rates during the first 30 postoperative days

[e] p values calculated by Mann–Whitney U test for continuous variables and Fisher's exact test for categorical variables

with removal of all central lymph nodes; and third, a resection of sufficient bowel length to remove pericolic lymph nodes [8, 20]. The Japanese practice of standard D3 lymphadenectomy in colon cancer surgery represents a similar technique to the Western CME concept. In comparison, both techniques result in pathological specimens with high mesocolic resection plane rates and equally long distance between the bowel wall and a high vascular tie. The CME technique however seems to result in longer specimen lengths and a higher nodal yield [8, 21, 22]. The pooled data on specimen length reported by West et al. generally showed longer specimen lengths than in our patient series [10, 23]. However, bowel length was measured after several days of formalin fixation, which reduces specimen length. In the paper of Storli et al., 10% was added to the specimen length to correct for previous fixation in formalin [6]. Specific studies on the topic report reduction in specimen length

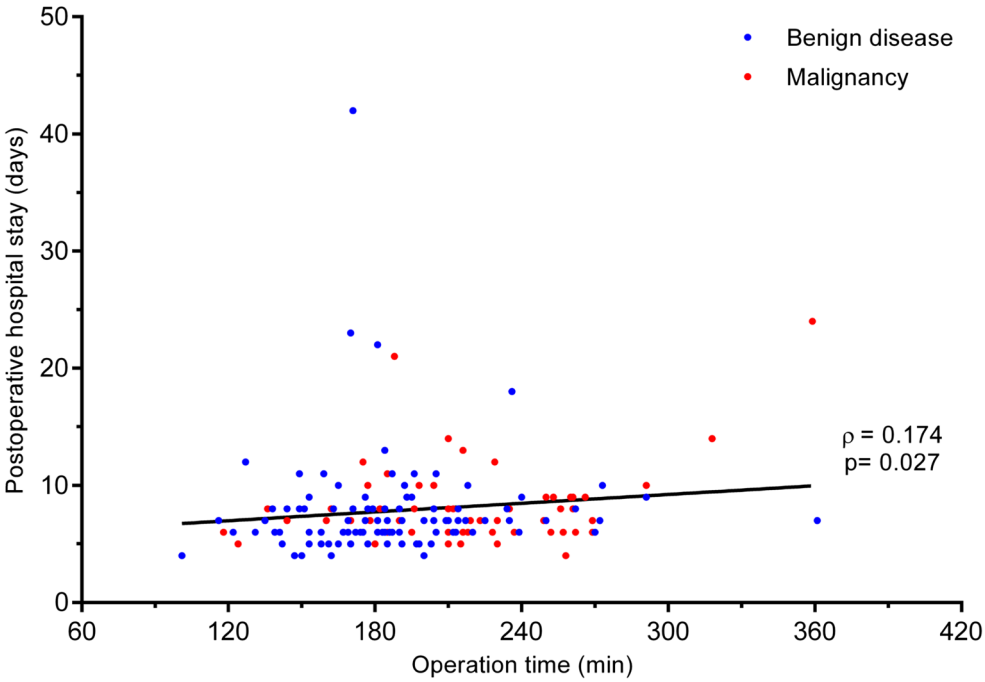

Fig. 2 Correlation between operation time and postoperative hospital stay in 163 laparoscopic sigmoidal resections. Spearman's rank correlation coefficient indicating statistical significance ($\rho = 0.174$, $p = 0.027$)

of about 30% when comparing unfixed with fixed (yet a few minutes old) specimens [24]. Most studies on the topic include left-sided, right-sided, and transverse colectomies. The only study including only left-sided colectomies was published by Feng et al. [22]. They reported significantly longer specimen lengths with the CME technique than in our results. However, their data were gathered from fresh specimens, which could partially explain the differences. On the other hand, median lymph node count was higher in our study.

Limitations Besides the retrospective design, this study is subject to several limitations. First, comparing colon cancer surgery with the surgical treatment of benign disease does complicate the interpretation of results. However, by using conventional colectomies for benign disease as a control group, this allowed for a control group within the same time frame, treated by the same surgeons. As mentioned above, several available patient series use historical controls [11–13] or patients from different surgical centers as their control group [6, 7, 13]. By using a control group from our own surgical center, variability in peroperative and postoperative care was reduced to a minimum. This implies a rather limited number of patients included, as only patients of our own center were included and the inclusion period was limited to 3 years.

Second, one could assume that the conversion threshold is lower in case of malignancy. Indeed, in our numbers, most conversion occurred during CME resections for malignancy. However, our patient cohort does include a quite large proportion of large tumors (with 56% T3–T4 tumors) that were not converted. Whether the reason for conversion was the local (malignant) circumstances or the technical challenges during CME surgery remains undetermined. Some surgeons remain hesitant to perform CME surgery, especially for right-sided colectomies, where it implicates dissection near the root of the superior mesenteric vessels. Remaining grossly underreported, only one study from 2016 (Bertelsen et al.) reported on higher intraoperative complications (9.1% CME group vs 3.6% non-CME group, $p < 0.001$) during CME surgery [14].

Unlike the length of resected bowel and lymph node yield, adherence to the mesocolic plane remains underreported in most patient series. This involves a dedicated pathological service, as it requires immediate evaluation of the fresh specimen. Mesocolic resection plane rates are not reported on in our study. As an important element in CME surgery, it should be included in future prospective study protocols on the topic.

Conclusion

With this retrospective patient series, we aim to add information on outcomes after laparoscopic left-sided CME colectomies. These results confirm that CME does not increase short-term complications in this patient group.

Authors' contributions Maxime Dewulf: study conception and design, acquisition of data, analysis and interpretation of data, and drafting of manuscript. Alain Kalmar: analysis and interpretation of data and critical

revision of manuscript. Bert Vandenberk: analysis and interpretation of data and critical revision of manuscript. Filip Muysoms: critical revision of manuscript. Barbara Defoort: acquisition of data. Donald Claeys: acquisition of data. Pieter Pletinckx: study conception and design, acquisition of data, analysis and interpretation of data, and critical revision of manuscript.

Compliance with ethical standards

Conflict of interest Drs. Maxime Dewulf, Bert Vandenberk, Barbara Defoort, Donald Claeys, and Pieter Pletinckx have no conflicts of interest or financial ties to disclose. Dr. Alain Kalmar reports having patents on steerable laparoscopic instruments. Dr. Filip Muysoms reports having received research grants from Medtronic and Dynamesh; received speakers honorarium from Medtronic, Bard-Davol, Dynamesh, and Intuitive Surgical; and received consultancy fees from Medtronic, Intuitive Surgical, and CMR Surgical.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study protocol was approved by the local ethics committee (ethics committee Maria Middelares, Ghent, Belgium—Reference Number MMS.2018.063) before the start of data collection.

Informed consent In this retrospective analysis, all data were gathered and processed in an anonymized manner. In accordance with national regulations and after consultation of the ethics committee, a specific written informed consent for this study was not obtained.

References

1. Heald R, Ryall R (1986) Recurrence and survival after total mesorectal excision for rectal cancer. Lancet 1(8496):1479–1482
2. Wibe A, Møller B, Norstein J, Carlsen E, Wiig J, Heald R, Langmark F, Myrvold H, Søreide O, Norwegian Rectal Cancer Group (2002) A national strategic change in treatment policy for rectal cancer—implementation of total mesorectal excision as routine treatment in Norway. A national audit. Dis Colon Rectum 45(7):857–866
3. Hohenberger W, Weber K, Matzel K, Papadopoulos T, Merkel S (2009) Standardized surgery for colonic cancer: complete mesocolic excision and central ligation—technical notes and outcome. Color Dis 11(4):354–364
4. Bokey E, Chapuis P, Dent O, Mander B, Bissett I, Newland R (2003) Surgical technique and survival in patients having a curative resection for colon cancer. Dis Colon Rectum 46(7):860–866
5. Liang J, Fazio V, Lavery I, Remzi F, Hull T, Strong S, Church J (2015) Primacy of surgery for colorectal cancer. Br J Surg 102(7): 847–852
6. Storli K, Søndenaa K, Furnes B, Nesvik I, Gudlaugsson E, Bukholm I, Eide G (2014) Short term results of complete (D3) vs. standard (D2) mesenteric excision in colon cancer shows improved outcome of complete mesenteric excision in patients with TNM stages I-II. Tech Coloproctol 18(6):557–564
7. Bertelsen C, Neuenschwander A, Jansen J, Wilhelmsen M, Kirkegaard-Klitbo A, Tenma J, Bols B, Ingeholm P, Rasmussen L, Jepsen L, Iversen E, Kristensen B, Gögenur I, Danish Colorectal Cancer Group (2015) Disease-free survival after complete mesocolic excision compared with conventional colon cancer surgery: a retrospective, population-based study. Lancet Oncol 16(2):161–168
8. Emmanuel A, Haji A (2016) Complete mesocolic excision and extended (D3) lymphadenectomy for colonic cancer: is it worth that extra effort? A review of the literature. Int J Color Dis 31(4):797–804
9. Liang J, Lai H, Huang J, Sun C (2015) Long-term oncologic results of laparoscopic D3 lymphadenectomy with complete mesocolic excision for right-sided colon cancer with clinically positive lymph nodes. Surg Endosc 29(8):2394–2401
10. Faerden A, Sjo O, Bukholm I, Andersen S, Svindland A, Nesbakken A, Bakka A (2011) Lymph node micrometastases and isolated tumor cells influence survival in stage I and II colon cancer. Dis Colon Rectum 54(2):200–206
11. Galizia G, Lieto E, De Vita F, Ferraraccio F, Zamboli A, Mabilia A, Auricchio A, Castellano P, Napolitano V, Orditura M (2014) Is complete mesocolic excision with central vascular ligation safe and effective in the surgical treatment of right-sided colon cancers? A prospective study. Int J Color Dis 29(1):89–97
12. Merkel S, Weber K, Matzel K, Agaimy A, Gohl J, Hohenberger W (2016) Prognosis of patients with colonic carcinoma before, during and after implementation of complete mesocolic excision. Br J Surg 103:1220–1229
13. Alhassan N, Yang M, Wong-Chong N, Liberman A, Charlebois P, Stein B, Fried G, Lee L (2018) Comparison between conventional colectomy and complete mesocolic excision for colon cancer: a systematic review and pooled analysis. A review of CME versus conventional colectomies. Surg Endosc 33:8–18. https://doi.org/10.1007/s00464-018-6419-2
14. Bertelsen C, Neuenschwander A, Jansen J, Kirkegaard-Klitbo A, Tenma J, Wilhelmsen M, Rasmussen L, Jepsen L, Kristensen B, Gögenur I, Copenhagen Complete Mesocolic Excision Study (COMES), Danish Colorectal Cancer Group (DCCG) (2016) Short-term outcomes after complete mesocolic excision compared with 'conventional' colonic cancer surgery. Br J Surg 103:581–589
15. Rahbari N, Weitz J, Hohenberger W, Heald R, Moran B, Ulrich A, Holm T, Wong W, Tiret E, Moriya Y, Laurberg S, den Dulk M, van de Velde C, Büchler M (2010) Definition and grading of anastomotic leakage following anterior resection of the rectum: a proposal by the International Study Group of Rectal Cancer. Surgery 147(3): 339–351
16. Posabella A, Rotigliano N, Tampakis A, von Fluë M, Füglistaler I (2018) Peripheral vs pedicle division in laparoscopic resection of sigmoid diverticulitis: a 10-year experience. Int J Color Dis 33:887–894
17. Sohn M, Schlitt H, Hornung M, Zülke C, Hochrein A, Moser C, Agha A (2017) Preservation of the superior rectal artery: influence of surgical technique on anastomotic healing and postoperative morbidity in laparoscopic sigmoidectomy for diverticular disease. Int J Color Dis 32:955–960
18. Cirocchi R, Trastulli S, Farinella E, Desiderio J, Listorti C, Parisi A, Noya G, Boselli C (2012) Is superior mesenteric artery ligation during sigmoid colectomy for diverticular disease associated with increased anastomotic leakage? A meta-analysis of randomized and non-randomized clinical trials. Color Dis 14:521–529
19. Tagliacozzo S, Tocchi A (1997) Extended mesenteric excision in right hemicolectomy for carcinoma of the colon. Int J Color Dis 12: 272–275
20. Søndenaa K, Quirke P, Hohenberger W, Sugihara K, Kobayashi H, Kessler H, Brown G, Tudyka V, D'Hoore A, Kennedy R, West N, Kim S, Heald R, Storli K, Nesbakken A, Moran B (2014) 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 29(4):419–428

21. West N, Kobayashi H, Takahashi K, Perrakis A, Weber K, Hohenberger W, Sugihara K, Quirke P (2012) Understanding optimal colonic cancer surgery: comparison of Japanese D3 resection and European complete mesocolic excision with central vascular ligation. J Clin Oncol 30(15):1763–1769
22. Feng H, Zhao X, Zhang Z, Han D, Mao Z, Lu A, Thasler W (2016) Laparoscopic complete mesocolic excision for stage II/III left-sided colon cancers: a prospective study and comparison with D3 lymph node dissection. J Laparoendosc Adv Surg Tech 26(8):606–613
23. West N, Kennedy R, magro T, Luglio G, Sala S, Jenkins J, Quirke P (2014) Morphometric analysis and lymph node yield in laparoscopic complete mesocolic excision performed by supervised trainees. Br J Surg 101:1460–1467
24. Goldstein N, Soman A, Sacksner J (1999) Disparate surgical margin lengths of colorectal resection specimens between in vivo and in vitro measurements. The effects of surgical resection and formalin fixation on organ shrinkage. Am J Clin Pathol 111(3):349–351