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ORIGINAL ARTICLE

Proposal of a new classification system for complete mesocolic excison in right-sided colon cancer

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Abstract

Background Although complete mesocolic excision has been performed for 10 years there remains no published prospective data. The lack of a classification which includes completeness of mesocolic tissue removal as well as plane of surgery contributes to the problem of comparing studies. The aim of the present study was to develop such a classification for right hemicolectomy.

Methods In a prospective, non-randomized trial we collected specimens of right hemicolectomies from 38 German hospitals between February 2012 and October 2016. The degree of radicality of resection was reported. Photographs were taken of the specimens. After screening the images it became apparent that the specimens could be divided into four main groups according to the degree of missing mesocolic tissue, and three subgroups reflecting the plane of surgery.

Results Of 1373 patients 1097 images were available. Grading was possible in 1077 (98.2%). Distribution was Type 0 (best) 38.6%, Type I 43.3%, Type II 8.5%, Type III (poorest) 7.8%. Surgery was considered to be in a suboptimal plane of surgery in 15.2% overall, highest in Type III (37%) and lowest in Type 0 (7.8%, $p < 0.001$).

Conclusions The proposed classification may be a relevant tool for the further investigation of CME for right colon cancer because it allows us to differentiate the aspects of lymphadenectomy and the preservation of the integrity of the mesocolon.

Keywords Complete mesocolic excison · CME · Right hemicolectomy · Colon cancer · Colorectal cancer

Introduction

Ten years after the concept of complete mesocolic excision (CME) was published by Hohenberger [1] many uncertainties remain, and there is little prospective data to help resolve these uncertainties One reason for the lack of data is related to problems of study design, especially the lack of a standard definition for hemicolectomy without CME, which could serve as a control group in a randomized trial [2]. Another problem is the lack of classification for the specimen that includes the two main principles of CME: first, removal of the entire mesocolic tissue that contains the regional lymphatic drainage, second, the preservation of the embryological fascial envelope. Essentially, the current classification only takes the latter into account [3]. Another important issue is that CME for right and left-sided tumors have been analyzed together despite significant differences in technical complexity for the procedures [3–5]. This biases the analysis of differences in surgical morbidity. It also impairs the analysis of whether a true CME is achieved in right versus left colonic resections. Therefore, we have developed a new classification exclusively for right-sided colon cancer that includes both aspects: completeness of tissue removal and the plane of surgery. We believe that by applying this classification in clinical trials the current controversy of how much each aspect contributes to the effect of CME can be elucidated. In this report, the applicability of the classification is evaluated using data from our current prospective multicenter non-randomized trial for the evaluation of CME in right-sided colon cancer (RESCTAT-trial) [6].

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Methods

In a prospective open, registry-based, quasi-experimental trial we collected 1373 specimens of right hemicolectomies from 53 German hospitals between February 2012 and October 2016 [6]. Standardized photodocumentation of the fresh specimen of the anterior surface of the outstretched and specimen with suture markings of the vessels was carried out. The degree of radicality (location of the division of ileocolic and middle colic vessels, dissection of superior mesenteric vein (SMV)) had to be reported. It was anticipated that approximately half of the surgeons would intend to perform CME. The primary end-point of the trail was 5-year disease-free survival after CME versus non-CME. According to the original protocol, the question of whether CME was performed was judged using the operative note, planimetric evaluation of the mesocolon using photographs of the anterior aspect of the fresh specimen and additionally, evaluation of the mesocolon by pathologic examination of the fixed specimen (original West-classification). The latter was performed by a single institution to which all specimens (formalin fixed) were shipped. However, after a first screening of the photographs of the specimens it became apparent that non-CME specimens show a marked variation and therefore may better be grouped according to morphologic patterns that reflect the lack of distinct anatomical regions of the mesocolon instead of just measuring the surface area of the mesocolon. We, therefore, developed a classification which defined four main categories (Type 0–III) for the anatomical completeness of the mesocolon and three subcategories (a–c) for integrity of the mesocolon. Both, main categories and subcategories were assessed using the photographs of the fresh specimens. In addition, a second assessment of the mesocolic plane of excision was performed by the pathologists on the fixed specimen as described by West [3] et al. This is referred to as "original West classification" in this manuscript.

The main categories with an increasing lack of anatomical structures (Fig. 1) of the mesocolon are as follows:

Type 0 (true CME specimen): The stalks of the ileocolic vessels and middle colic vessels are connected by tissue of the surgical trunk (lymphatic tissue package covering the SMV). The mesocolic window has a complete medial frame of mesocolic tissue (Fig. 2a, b).

Type I

The stalks of ileocolic and middle colic vessels are present but are not connected by tissue. The frame of the mesocolic window is not complete on its medial aspect (Fig. 3a, b).

Type II

The stalks of the ileocolic vessels are present with more than 50% of their anticipated length according to the geometric configuration of the specimen but the middle colic vessels are not detectable. The frame of the window has a medial and cranial defect Fig. 4a, b.

Type III

Ileocoloic vessels have an amputated appearance (less than 50% of the anticipated length according to the

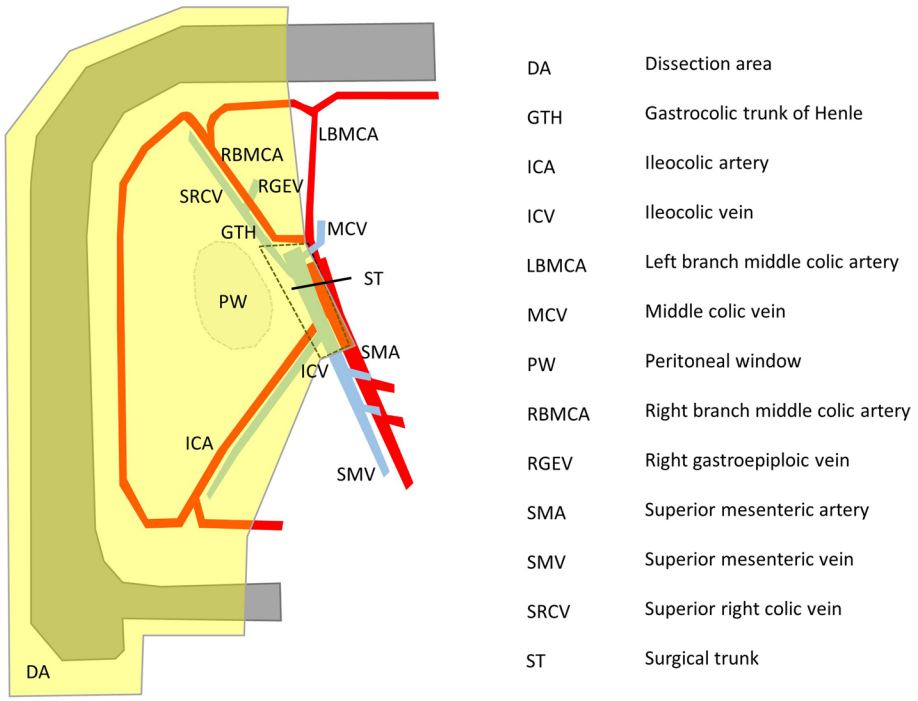

Fig. 1 Schematic depiction of the anatomy of right hemicolectomy. *DA* Dissection area, *GTH* Gastrocolic trunk of Henle, *ICA* Ileocolic artery, *ICV* Ileocolic vein, *PW* Peritoneal window, *RBMCA* Right branch middle colic artery, *SRCV* Superior right colic vein, *ST* Surgical trunk

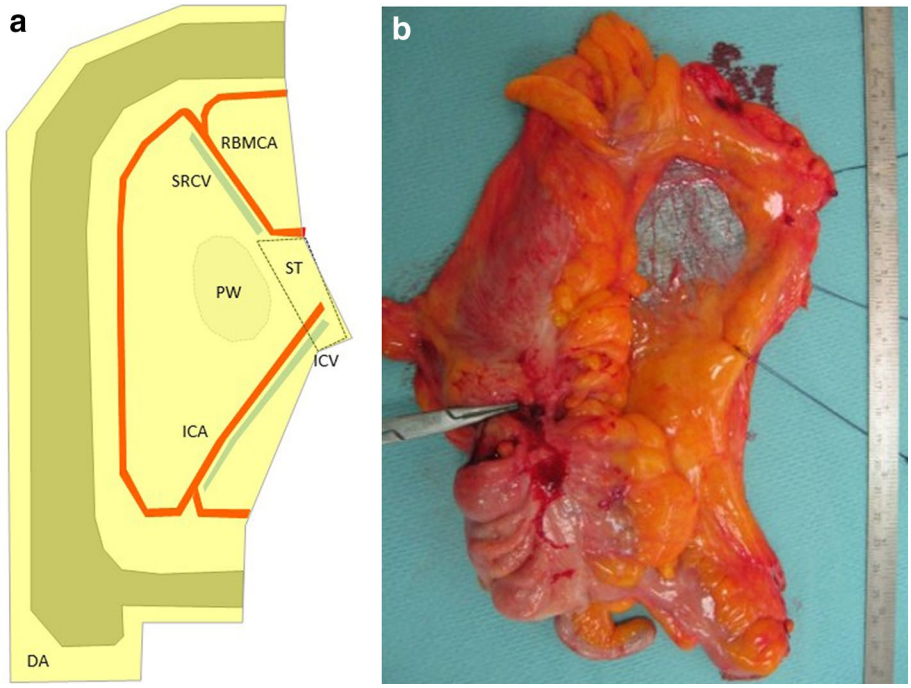

Fig. 2 Schematic view (**a**) and typical example (**b**) of Type 0 specimen. *DA* Dissection area, *GTH* Gastrocolic trunk of Henle, *ICA* Ileocolic artery, *ICV* Ileocolic vein, *PW* Peritoneal window, *RBMCA* Right branch middle colic artery, *SRCV* Superior right colic vein, *ST* Surgical trunk

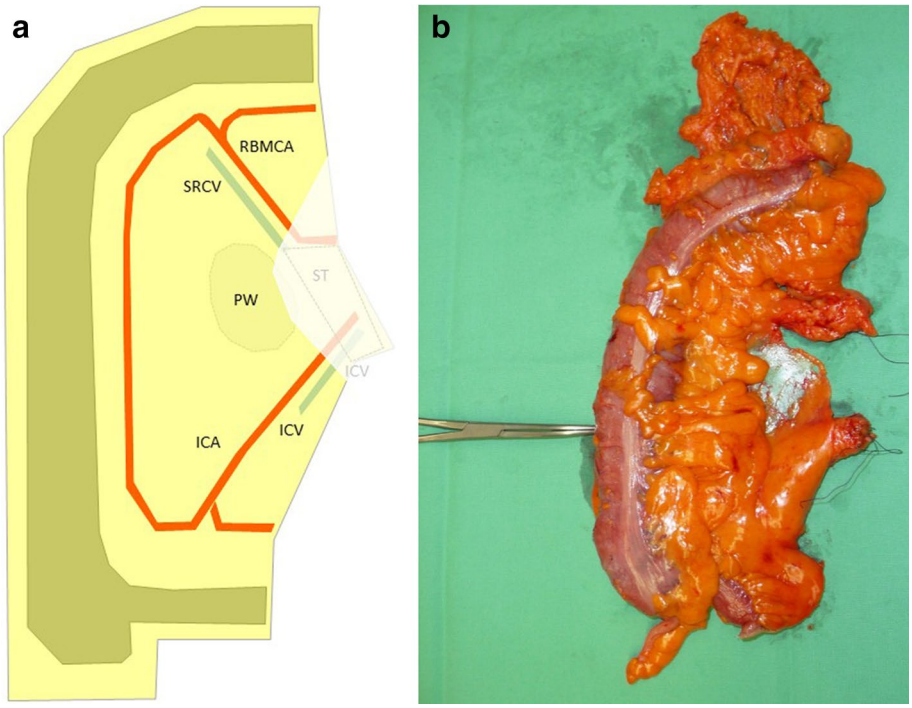

Fig. 3 Schematic view (**a**) and typical example (**b**) of Type I specimen. *DA* Dissection area, *GTH* Gastrocolic trunk of Henle, *ICA* Ileocolic artery, *ICV* Ileocolic vein, *PW* Peritoneal window, *RBMCA* Right branch middle colic artery, *SRCV* Superior right colic vein, *ST* Surgical trunk

geometric configuration of the specimen). The window is not detectable (Fig. 5a, b).

For the subcategory (a–c) The macroscopic integrity of the mesocolon was graded using the photographs of the fresh specimens in the following way:

a. intact mesocolon: mesocolic plane
b. laceration in the mesocolon: intramesocolic plane
c. laceration in the mesocolon reaching the bowel in the vicinity of the tumor: muscularis plane.

These categories describe the same phenomena as in the original West classification (Grade I–III) but are assessed using photographs and not the fixed specimens.

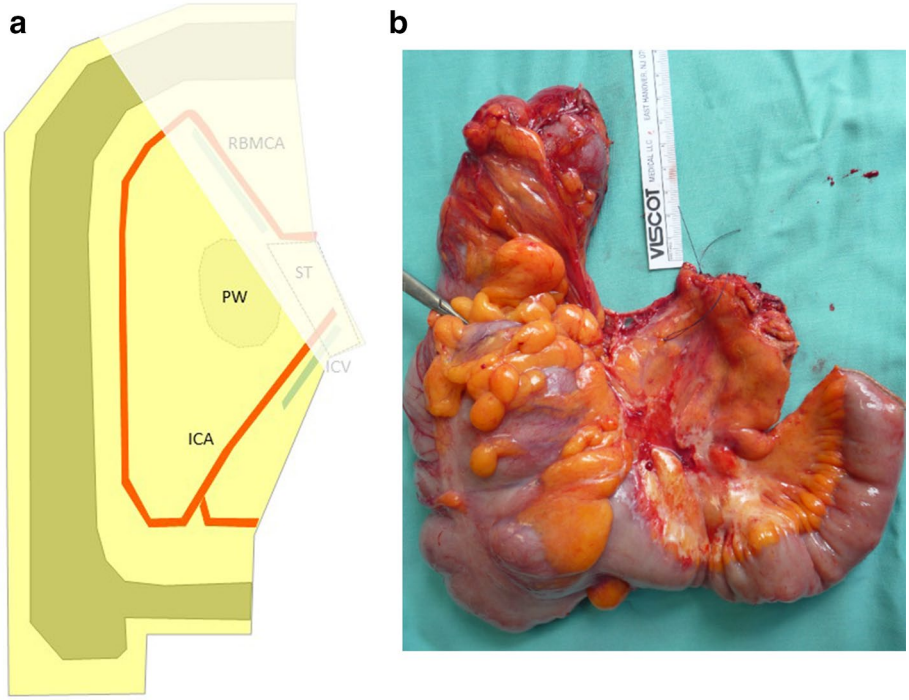

Fig. 4 Schematic view (**a**) and typical example (**b**) of Type II specimen. *DA* Dissection area, *GTH* Gastrocolic trunk of Henle, *ICA* Ileocolic artery, *ICV* Ileocolic vein, *PW* Peritoneal window, *RBMCA* Right branch middle colic artery, *SRCV* Superior right colic vein, *ST* Surgical trunk

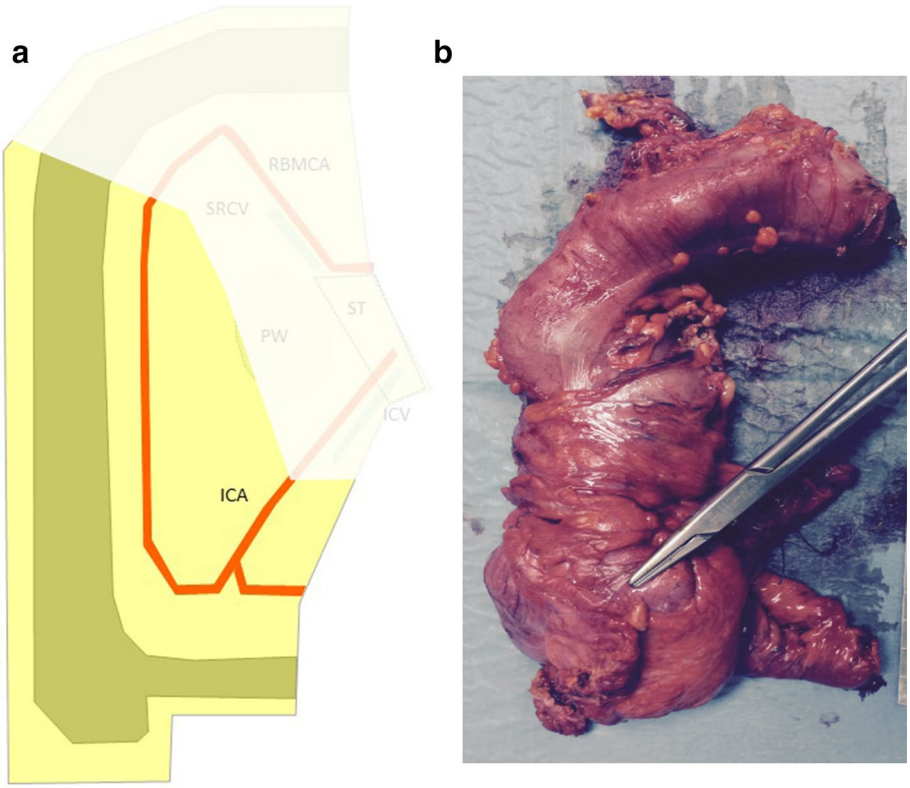

Fig. 5 Schematic view (**a**) and typical example (**b**) of Type III specimen. *DA* Dissection area, *GTH* Gastrocolic trunk of Henle, *ICA* Ileocolic artery, *ICV* Ileocolic vein, *PW* Peritoneal window, *RBMCA* Right branch middle colic artery, *SRCV* Superior right colic vein, *ST* Surgical trunk

Thus, the final grade consists of Type 0–III for the anatomical completeness of the mesocolon and a subgrade a-c for the integrity of the (excised) mescolon. For the current analysis, all specimens were used irrespective of the final histology.

After recruitment was stopped, three pathologists and one surgeon allocated each of the specimens to one of the four

groups. This was done in first a blinded and then an open round. Specimens in which no consensus could be found were classified as "classification not applicable". Statistical differences between the groups were assessed using the Chi-Square test (GraphPadPrism).

The trail is registered in the Deutsches klinisches Studienregister (DRKS-ID: DRKS0001240). It was approved by the ethics board of the Landesaerztekammer Baden Wuerttemberg (Medical Association of Baden Wuertenberg)(Aktenzeichen 2009-118-f#A1).

Results

For 1098 of 1373 (80%) specimens photographs were available. Demographics and results are shown in Tables 1 and 2. For 1348 (98.2%) a consensus for classification could be reached. The rate of laceration of the mesocolon (subgrade b/c) was lowest in type 0 (7.8%) and highest in type III specimens (38.2%, $p < 0.001$) (Fig. 5. Types I and II were in between. Reasons why the classification could not be applied are shown in Table 3. Nineteen specimens (1.8%) could not be graded. In 8 of them, this was due to an inadequate photograph, exposition or non-compliance with the trial procedures. In 11 specimens it seems that even with a perfect photograph and adequate procedures grading would not have been possible due to unfavorable anatomical features. However, we think that grading might have been possible if there had been inspection of the fresh specimen and perfect compliance with trial procedures. Intention to treat data were available for 953 specimens (69.4%). In 512 of the 953 operations, a CME was intended. The classification system using the photographs was also compared to the original West-classification of the pathologists in the fixed specimen: Out of 166 specimens that were graded "b" (lacerations in the visible mesocolon) only 9 (5.4%) were graded as suboptimal in the original West classification (grade II, intramesocolic plane). The only specimen which was graded "c" in photo documentation was also graded muscularis plane (grade III) in the fixed specimen using

Table 2 Distribution of specimen classification

Type	Subtype	*n*	%	Suboptimal Meso (%)
0	All	423	38.6	7.80
0	a	390	35.6	
0	b	33	3.0	
0	c	0	0.0	
I	all	475	43.3	18.11
I	a	389	35.5	
I	b	85	7.7	
I	c	1	0.1	
II	All	93	8.5	17.20
II	a	77	7.0	
II	b	16	1.5	
II	c		0.0	
III	All	86	7.8	37.21
III	a	54	4.9	
III	b	32	2.9	
III	c		0.0	
Total classified		1077	98.2	15.51
Not applicable		20	1.8	
All specimens		1097	100.0	15.22

Table 1 Demographics and distribution of CME type in relation to sex, age and tumor localization

	Type 0		Type I–III		All	*p* value
	(*n*)	(%)	(*n*)	(%)		
Sex						
M	207	41.9	287	58.1	494	0.14
W	216	37.0	368	63.0	584	
Age (years)						
– 49	13	31.7	28	68.3	41	0.46
50–59	39	46.4	45	53.6	84	
60–69	92	38.7	146	61.3	238	
70–79	165	37.8	272	62.2	437	
80–	114	41.0	164	59.0	278	
Tu-localisation						
Coecum	179	41.5	252	58.5	431	0.27
Ascending C	213	38.3	343	61.7	556	
Hep. Flexure	27	32.1	57	67.9	84	
Unclear	4	57.1	3	42.9	7	

CME complete mesocolic excision

Table 3 Number and reasons why specimens could not be graded as well as assumption if grading had been possible under better external conditions

Reason for non-grading	Number (*n*)	Grading likely possible with better photograph	Grading likely possible by inspection of the native specimen	Error/non-compliance with trail procedures
Adhesions or omentum covering the mesocolon	11	No	Yes	No
Mesocolon not outstreched for adequate exposition	2	Yes	Yes	Yes
Photgraphs taken at inadequate angle or with low resolution	3	Yes	Yes	Yes
Probable duplicate photograph	3	Yes	Yes	Yes

the West classification. None of the specimens that were graded "a" in photo documentation were graded II or III in the West classification. No significant association of age, sex and tumor localization was found (Table1).

Discussion

It has been recognized for more than two decades that oncological results for right hemicolectomy vary considerably between hospitals and surgeons [7, 8]. The extent of lymphadenectomy and the preservation of the integrity of the mesocolon are considered to be major contributing factors to this phenomenon. Taking into account these two principles, Hohenberger developed the concept of CME, defining the extent of mesocolic excision and the preservation of the serosal and facial (retroperitoneal) coverage of the mesocolon [1]. However, although it is likely that complying with these principles leads to an improvement of oncological outcome evidence to support this asumption is limited. There is probably less doubt regarding the preservation of the integrity of the mesocolon. The work from the group in Leeds, UK [3, 9] and others [10] has established a good correlation between the plane of surgery of the mesocolon and the oncological outcome which has also led to the current classification of CME.

In contrast, it is more questionable to what extent the complete removal of the central lymphatic tissue contributes to the beneficial effect of CME observed so far. One major problem has been that a reliable system for quantification of lymphadenectomy is lacking. In order to achieve this, assessment of the area of the mesocolon and the length of the vascular stalks has been proposed [11]. However, this is highly variable even for right hemicolectomies. In a small series [12] we have shown a range in the area of the mesocolic plane for CME specimens of 95–250 cm^2 and in the distance of bowel to high-tie a range of 7.8–13.4 cm. Thus the suitability of these parameters to measure quality of CME has to be questioned. To overcome this problem, we propose a new classification that uses anatomical landmarks in the specimen in order to determine the completeness of mesocolic excision without inspection of the surgical site. In addition, the grading system includes the current classification of the integrity of the mesocolon [3] so that both aspects of CME (preservation of mesocolon, extent of lymphadenctomy) are considered. The presented data show that the sensitivity of reporting suboptimal mesocolic integrity using photodocumentation probably might even be higher compared to the original West-classification in the fixed specimen.

Using our classification system for the first time in a large series of patients, we have demonstrated that more than 98% of the specimens could be classified. If this was not the case or difficulties were encountered this was mainly due to adhesions of the omentum covering the mesocolon, so that the vascular structures could not be identified. From our experience of using the classification, we believe that it is easier if the fresh specimen is evaluated instead of photographs. If photo documentation is used we would recommend taking pictures of the ventral and dorsal aspect of the specimen (not done in our study) so that dorsal mesocolic fascia can also be evaluated for lacerations. In addition, adhesion of the omentum will not disturb the evaluation from the dorsal aspect.

The strength of our study is that the classification system uses anatomical landmarks in the specimens that make it possible to judge the extent of the lymphadenectomy without inspecting the surgical site. The applicability was tested in a large series of patients from numerous centers. In addition, the current classification of CME can be readily integrated into the proposed classification system.

A weakness of our study is that the proof of prognostic relevance is still awaited; our trial stopped recruiting in 2016 and therefore oncological results are not anticipated until 2020. Also, the grading of specimens was not entirely blinded because the evaluation of the specimens and the development of the classification were parallel processes. Therefore, the inter- and intra-individual observer variation has yet to be determined, although it has recently been done for the West classification [9]. Another restriction is that only the lack of mesocolic tissue can be graded. The lack of mesogastric (gastro-omental) tissue that might be relevant for tumors of the hepatic flexure was not taken into consideration.

Conclusions

Our new classification may well be an important tool for the further standardized investigation of CME for right colon cancer because it allows us to differentiate the aspects of lymphadenectomy on the one hand and the preservation of the integrity of the mesocolon on the other. Furthermore, the classification seems suitable for quality management in daily practice if CME is the intended procedure. Future studies have to determine the variations in allocation to the different categories and their prognostic relevance.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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.

Informed consent Patients were included only after written informed consent and in compliance with ethical standards.

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