

## ORIGINAL ARTICLE



# The retrocolic fascial system revisited for right hemicolectomy with complete mesocolic excision based on anatomical terminology: do we need the eponyms Toldt, Gerota, Fredet and Treitz?

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## Abstract

**Aim:** Right hemicolectomy with complete mesocolic excision (CME) requires the removal of an intact mesocolic envelope. The study aimed to determine, on the basis of macroscopic and microscopic anatomical studies, the optimal surgical dissection planes for CME to preserve fascial integrity. Unequivocal anatomical nomenclature was applied to describe the retrocolic fascial system and compared to frequently used eponyms (Toldt, Gerota, Fredet, Treitz).

**Method:** Stepwise macroscopic dissections, cross-section studies and histological analysis were performed on body donors to identify the components of the retrocolic fascial system. Based on these anatomical findings, the optimal surgical dissection planes for CME were validated in laparoscopic training courses on body donors and in robot-assisted surgical procedures in patients.

**Results:** The mesocolic tissue and lymphovascular pedicles were enveloped by the ventral and dorsal mesocolic leaf (mesocolic fascia). The mesocolic fascia was attached to the parietal peritoneal fascia ('fascia of Toldt') along the parieto-mesocolic interface, and further cranially to the pre-duodenopancreatic fascia along the mesocolic-duodenopancreatic interface ('space of Fredet'). Dorsally, the parietal peritoneal fascia was separated from the anterior renal fascia ('fascia of Gerota') by the parieto-renal interface. Dissection along this interface in front of the anterior renal fascia followed by incision of the parietal peritoneal fascia at the duodenal border and opening the mesocolic-duodenopancreatic interface yielded the best macroscopic appearance of specimens and was considered optimal for CME.

**Conclusion:** The retrocolic fascial system as well as the surgical dissection planes for CME can be described by clearly defined anatomical terms rather than potentially confusing eponyms.

## KEYWORDS

complete mesocolic excision, Fredet, Gerota, right hemicolectomy, Toldt, Treitz

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## INTRODUCTION

Since its introduction by Hohenberger, the concept of complete mesocolic excision (CME) for right hemicolectomy has been widely adopted by the surgical community for the treatment of colon cancer [1] and has yielded convincing oncological benefits [2, 3]. As pointed out in the original technical description, one essential prerequisite for harvesting an intact specimen is the 'separation of the mesocolic from the parietal plane' following embryologically defined interfaces [1]. The ability to surgically dissect the entire mesocolic envelope from the underlying retroperitoneum is based on the crucial observation that the ascending mesocolon neither 'disappears' nor 'dissolves' but persists throughout embryological development and postnatal life [4].

Surgical mobilization of the mesocolon can be achieved by either open, laparoscopic or robotic techniques using different surgical approaches (e.g., lateral, uncinat process first, superior mesenteric vein first, subileal, supracolic) [1, 5–7]. However, descriptions of the exact surgical dissection planes are not uniform and are still a matter of debate for the following reasons. (a) The retrocolic fascial system is multi-layered. Thus, more than one surgical dissection plane can be chosen for mesocolic separation [8]. (b) The anatomical nomenclature applied in colonic surgery, especially with reference to CME, is very heterogeneous, often imprecise and lacks standardization [8, 9]. (c) Eponyms such as Toldt, Gerota, Fredet, Treitz [10–13] are frequently used to describe the retrocolic fascial system and may cause misunderstanding due to differing perceptions. Despite attempts to define the eponym-based terminology in the past [14, 15], no general consensus has been achieved with regard to anatomical nomenclature in CME surgery [9, 16–18].

The aims of the study were to provide a comprehensive visualization of the retrocolic fascial system at the macroscopic and microscopic level using a uniform and appropriate anatomical terminology. Optimal dissection planes for CME were defined on the basis of these anatomical considerations and were also demonstrated in body donors (surgical training courses) and patients.

## METHODS

### Nomenclature of the retrocolic fascial system and retrocolic interfaces

We used anatomical terms instead of eponyms to describe the retrocolic fascial system. Table 1 shows all fascial components that can be dissected in adults (postnatal anatomy) and provides the corresponding anatomical terms applied during foetal development (embryological anatomy) as well as their links to the attributed eponyms. Table 2 describes the dissection planes related to the retrocolic fascial system, which became evident in both macroscopic and microscopic studies. These planes were defined as interfaces

### What does this paper add to the literature?

Awareness of the retrocolic fascial system is an essential prerequisite for right hemicolectomy with complete mesocolic excision. As eponyms attributed to fascial structures are often misleading, the paper provides anatomical studies of the retrocolic fascial system described by an unambiguous nomenclature to facilitate optimal surgical release of the mesocolic package.

between adjacent fascial structures which could be opened by surgical dissection.

### Macroscopic studies

After written consent, eight body donors (two female, six male, 65–82 years, mean age 77 years) were obtained from the body donation programme at the Institute of Anatomy, Kiel University. Previous diseases of the abdominal and retroperitoneal organs were excluded. After formalin (3%) perfusion via femoral arteries and preservation in ethanol (70%), the ventral abdominal wall was removed to expose the abdominal viscera. In order to illustrate each component of the retrocolic fascial system, fascial separation was carried out in a stepwise dissection. First, the ascending and transverse mesocolon were carefully mobilized and detached from the underlying parietal peritoneal fascia and, further cranially, from the ventral aspect of the duodenum/pancreas. The parietal peritoneal fascia was then released from the anterior renal fascia and followed behind the duodenum/pancreas ('Kocher manoeuvre'). Finally, the anterior renal fascia was lifted to expose the renal adipose capsule and the embedded kidney, ureter and gonadal vessels. Dissections were carried out by various approaches to obtain a comprehensive view of the retrocolic fascial system from different perspectives. Moreover, cross-sections were taken from the ascending colon/mesocolon and underlying fascial structures to display the retrocolic fascial system in a single tissue block. Photographs were taken at all dissection steps (Sony Alpha 7.III, Sony FE 90mm F2.8, Japan), and structures of interest were highlighted in semi-transparent colours.

### Microscopic studies

The mesocolon and underlying fascial structures, including the duodenum, were harvested en bloc, embedded in paraffin wax, cut into sections (12 µm) and processed for haematoxylin-eosin (general orientation) and Azan (connective tissue) staining. Special attention was given to the texture and trajectories of the fascial components. The findings were documented with a BZ-X810 microscope (Keyence) using the stitching module BZ-H4XD.

**TABLE 1** Postnatal and embryological anatomy related to the retrocolic fascial system

Postnatal anatomy	Embryological anatomy	Topographic relations	Alternative terms	Eponym
Mesocolic peritoneum	Ventral mesocolic leaf	Visceral peritoneum of the mesocolon exposed to the abdominal cavity		
Mesocolic fascia	Dorsal mesocolic leaf	Visceral peritoneum of the mesocolon attached to the parietal peritoneum		
Parietal peritoneal fascia	Parietal peritoneum	Parietal peritoneum attached to the ascending/descending mesocolon	Visceral fascia <sup>a</sup> Visceral plane <sup>b</sup>	Fascia of Toldt
Anterior renal fascia	Anterior renal fascia	Anterior part of the fascial envelope surrounding the adipose renal capsule	Deep subperitoneal fascia <sup>c</sup> Parietal fascia <sup>a</sup> Parietal plane <sup>b</sup>	Fascia of Gerota
Paracolic peritoneal fusion line	Paracolic recess	Visceral peritoneum of the ascending/descending colon fused with parietal peritoneum		White line of Toldt
Pre-duodenopancreatic fascia	Anterior mesoduodenum/pancreas	Mesoduodenum/pancreas attached to the mesocolon	Anterior pancreatic fascia <sup>c</sup>	Fascia of Fredet
Retro-duodenopancreatic fascia	Posterior mesoduodenum/pancreas	Mesoduodenum/pancreas attached to the parietal peritoneum	Posterior pancreatic fascia <sup>c</sup>	Fascia of Treitz

<sup>a</sup>Gao et al. [17].<sup>b</sup>Hohenberger et al. [1].<sup>c</sup>Mike and Kano [13].

Anatomical terminology	Anatomical description	Synonym
Parieto-mesocolic interface	Plane between the parietal peritoneal fascia and the mesocolic fascia	Meso-fascial <sup>a</sup> interface
Parieto-renal interface	Plane between the parietal peritoneal fascia and the anterior renal fascia	Retro-fascial <sup>a</sup> interface
Mesocolic-duodenopancreatic interface	Plane between the mesocolic fascia and the pre-duodenopancreatic fascia	Space of Fredet

<sup>a</sup>Culligan et al. [8].**TABLE 2** Anatomical terminology and description of retrocolic interfaces

## Evaluation of surgical specimens retrieved from body donors and patients

The surgical dissection planes for CME derived from the anatomical studies outlined above were applied in surgical training courses for right hemicolectomy with CME. The workshops were organized by the German Society of General and Visceral Surgery and conducted at the Institute of Anatomy, Kiel University. Body donors were preserved by soft-tissue fixation to allow laparoscopic surgery [19]. The retrocolic fascial system was addressed in anatomical lectures and demonstrated on predissected specimens. The tutor-guided surgical procedures were carried out in accordance with the 'critical view' concept to ensure standardization of each procedural step [20]. The harvested surgical specimens were evaluated with regard to the completeness and integrity of the mesocolon [21] and with respect to the retrocolic fascial components. Photographs were taken from the retrieved specimens to document the quality of the resection, especially in the dorsal aspect. Similar evaluation and photo documentation of the aforementioned aspects were carried out in

surgical specimens obtained from patients undergoing laparoscopic and robot-assisted right hemicolectomy performed by the authors (DM, SB).

## Illustration of the retrocolic fascial system

In order to visualize the retrocolic fascial system comprehensively, the findings were schematically illustrated and transferred to a 3D model for educational purposes. An arterial phase CT scan with 1-mm slice thickness was segmented in ITKSNAP (version 3.8, open source) [22] to extract the 3D geometry of core anatomical structures (bones, muscles, organs, blood vessels). The resulting 3D mesh files were imported into ZBrush (V2022.1, Pixologic). Standard 3D modelling techniques were employed to optimize the appearance of each structure and add the fascial structures and mesenteries. The model was textured in Adobe Substance 3D Painter (V2, Adobe) and displayed for end users on the web-based 3D model visualization platform Sketchfab.

## RESULTS

### Stepwise dissection of the retrocolic fascial system

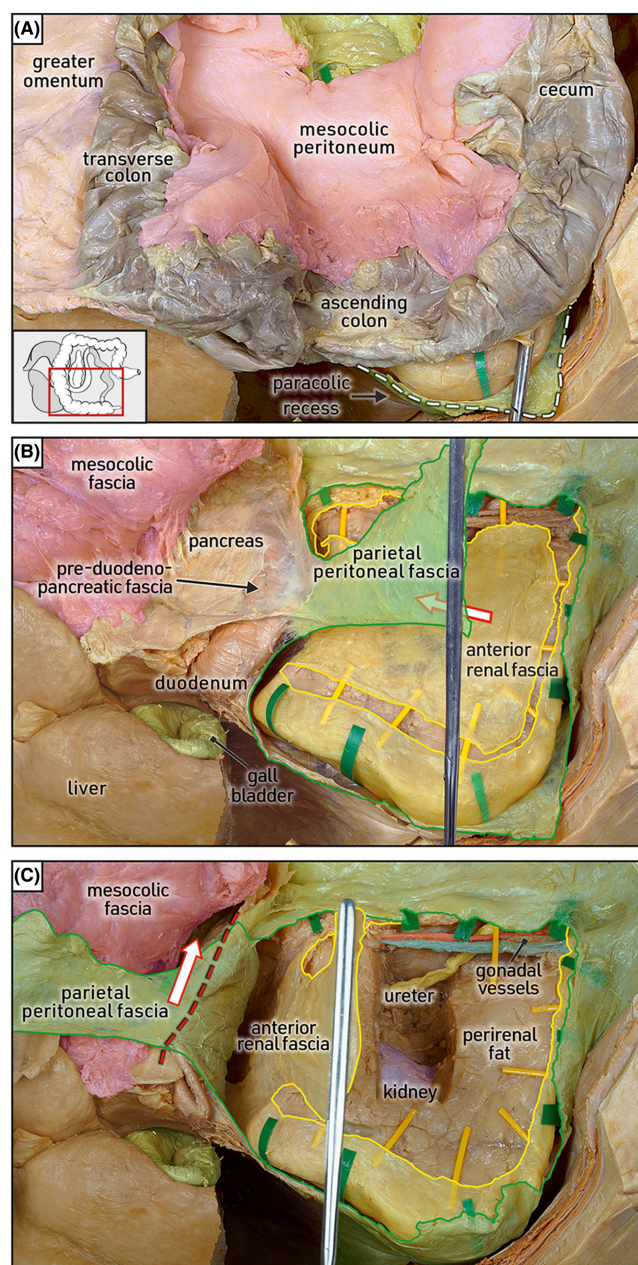
After incision of the parietal peritoneum along the right paracolic recess (Figure 1A), the caecum and ascending colon were separated from the underlying parietal peritoneal fascia. The ascending mesocolon was detached from the parietal peritoneal fascia by opening the parieto-mesocolic interface, allowing exposure of the delicate mesocolic fascia covering the dorsal aspect of the mesocolon (Figure 1B). The mesocolon was separated from the ventral aspect of the duodenum and pancreas along the mesocolic-duodenopancreatic interface, thus revealing the pre-duodenopancreatic fascia covering the duodenum and pancreas (Figure 1B). The parietal peritoneal fascia could be followed further cranially behind the dorsal aspect of the

duodenum and pancreas, bordering on the retro-duodenopancreatic fascia (Figure 1B,C). When the parietal peritoneal fascia was lifted by opening the parieto-renal interface, the anterior renal fascia became evident. Separation of both layers was easily achieved, as the parieto-renal interface corresponded to a 'self-opening' dissection plane with only minor interfering blood vessels. Incision and reflection of the anterior renal fascia allowed access to the kidney, ureter and gonadal vessels embedded in the renal adipose capsule (Figure 1C). Depending on the quantity of perirenal fat, the ureter and gonadal vessels were discernible beneath the anterior renal fascia.

To depict the retrocolic fascial system at a glance, the mesocolon was detached from the pancreatic head and the duodenum (segment II + III) and separated further caudally from the underlying parietal peritoneal fascia by medial-to-lateral dissection. This dissection demonstrated the pre-duodenopancreatic fascia covering the duodenum and pancreatic head, including the tributaries of the gastropancreaticocolic trunk, as well as the parietal peritoneal fascia extending behind the mesocolon and duodenum/pancreas (Figure 2).

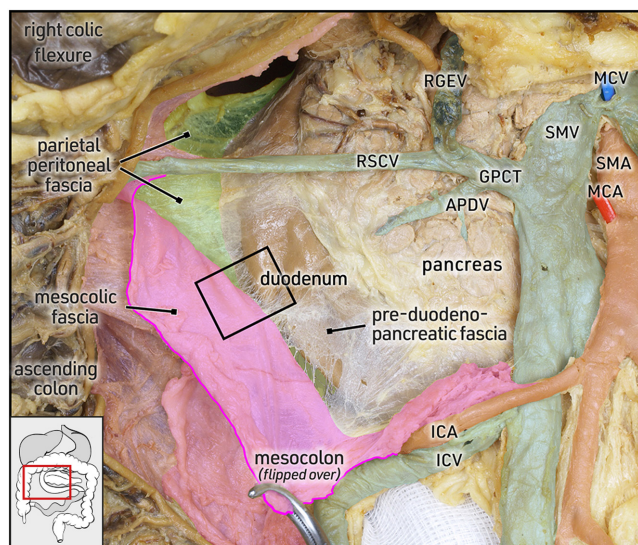
### Parieto-mesocolic interface and parieto-renal interface

The most important finding was the clear identification of two different retrocolic interfaces which could be used for surgical mobilization of the mesocolon: (a) the parieto-mesocolic interface between the parietal peritoneal fascia and the mesocolic fascia, and (b) the parieto-renal interface between the parietal peritoneal fascia and the anterior renal fascia. Both interfaces and the corresponding surgical dissection planes were opened



**FIGURE 1** Stepwise dissection of the retrocolic fascial system. (A) Ventral view onto the right colon and mesocolon. The greater omentum is reflected cranially. The parietal peritoneum is partly incised along the right paracolic recess (dotted white line). (B) The ascending colon and mesocolon are separated from the underlying parietal peritoneal fascia by opening the parieto-mesocolic interface and reflected cranially, so that the mesocolic fascia is exposed. The pre-duodenopancreatic fascia is seen after detachment of the mesocolon from the duodenum and pancreatic head. A flap (clamp) of the parietal peritoneal fascia (green strips) is lifted to expose the underlying anterior renal fascia (yellow strips). The surgical dissection plane (arrow) for mesocolic excision extends along the parieto-renal interface between the parietal peritoneal fascia and the anterior renal fascia. (C) A flap (clamp) of the anterior renal fascia is lifted to expose the perirenal fat capsule with the embedded kidney, ureter and gonadal vessels. The parietal peritoneal fascia is pulled further cranially to lift up and separate the duodenum and pancreas from the underlying anterior renal fascia ('Kocher manoeuvre'). Incision (dotted red line) of the parietal peritoneal fascia is required to reach the pre-duodenopancreatic fascia and extend the surgical dissection in front of the duodenum and pancreas along the mesocolic-duodenopancreatic interface (arrow). Formalin-fixed specimen



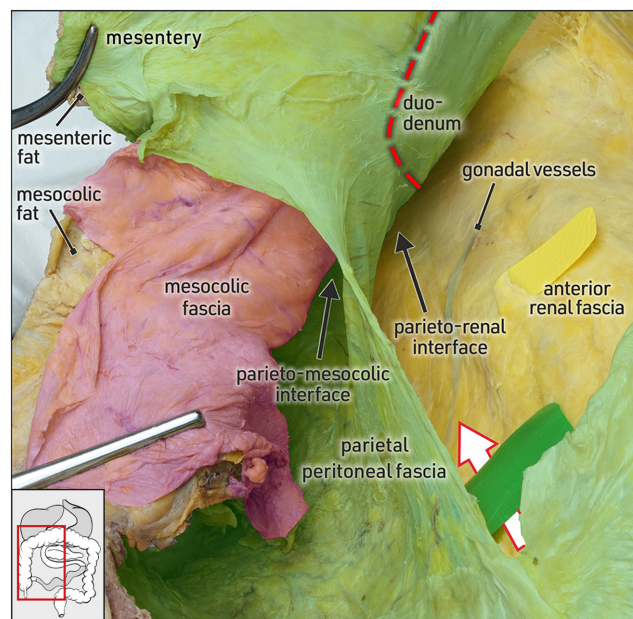


**FIGURE 2** Exposure of the retrocolic fascial system. Ventral view onto the ascending colon, mesocolon, pancreas and duodenum. The mesocolon is detached from the duodenum and pancreas and reflected caudo-laterally (clamp), revealing the pre-duodenopancreatic fascia. The ventral leaf of the ascending mesocolon is partly removed to expose its dorsal leaf (mesocolic fascia). The parietal peritoneal fascia extends behind the mesocolon and the duodenum/pancreas. The tributaries of the gastropancreaticocolic trunk (GPCT, 'trunk of Henle') are seen in front of the pancreatic head, comprising the right gastroepiploic vein (RGEV), the right superior colic vein (RSCV) and the anterior pancreaticoduodenal veins (APDV) draining into the superior mesenteric vein (SMV). Both the middle colic vein (MCV, blue marker) and the middle colic artery (MCA, red marker) are cut at their origin. The ileocolic artery (ICA) originates from the superior mesenteric artery (SMA), crosses the SMV ventrally and joins the ileocolic vein (ICV). The black rectangle indicates the region taken for histological studies (Figure 5). Formalin-fixed specimen

by a medial-to-lateral approach (Figure 3). As the parietal peritoneal fascia continued along the dorsal aspect of the duodenum, the surgical dissection plane following the parieto-renal interface also led to partial detachment of the duodenum from the underlying anterior renal fascia ('Kocher manoeuvre'). Thus, in order to achieve full mesocolic mobilization, the parietal peritoneal fascia had to be incised at the duodenal border to enter the mesocolic-duodenopancreatic interface and separate the mesocolic fascia from the pre-duodenopancreatic fascia.

### Cross-section of the retrocolic fascial system

The multi-layered architecture of the retrocolic fascial system was confirmed by separating its different components in cross-sectioned specimens (Figure 4). The fatty mesocolic tissue was surrounded by the mesocolic peritoneum ventrally and the mesocolic fascia dorsally. Behind the mesocolic fascia extended the parietal peritoneal fascia, which was firmly fused with the ascending colon along the paracolic peritoneal fusion line. The parietal peritoneal fascia was

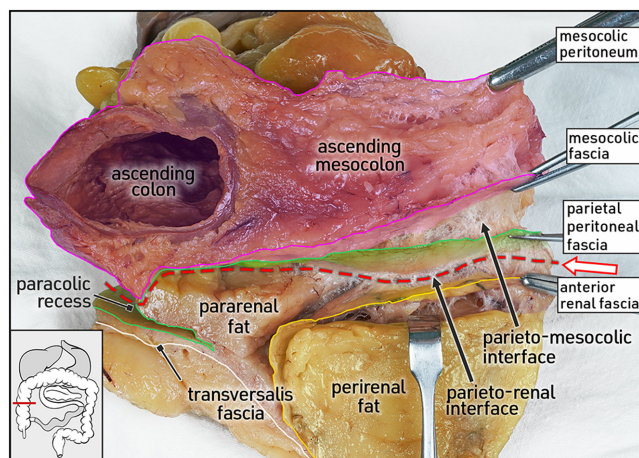


**FIGURE 3** Parieto-mesocolic and parieto-renal interface. Medial view onto the caecum and ascending colon. The mesocolon is detached from the underlying parietal peritoneal fascia by opening the parieto-mesocolic interface. The parieto-renal interface (green strip) extends between the parietal peritoneal fascia (incised) and the anterior renal fascia (inserted yellow strip) which covers the gonadal vessels. The surgical dissection plane (arrow) for mesocolic excision follows the parieto-renal interface until the posterior aspect of the duodenum is reached. At this level the parietal peritoneal fascia has to be incised (dotted red line) in order to reach the ventral aspect of the duodenum and pancreas. Formalin-fixed specimen

bordered dorsally by the anterior renal fascia. Again, two dissection planes could be exposed: one in front of the parietal peritoneal fascia (parieto-mesocolic interface) and one behind the parietal peritoneal fascia (parieto-renal interface). While opening the parieto-mesocolic interface required gentle dissection to avoid damage to the thin mesocolic fascia, the parieto-renal interface allowed for effortless detachment of the parietal peritoneal fascia from the anterior renal fascia.

### Microscopic study of the retrocolic fascial system

The components of the retrocolic fascial system observed in macroscopic dissections could be validated on microscopic investigation (Figure 5). The mesocolon contained adipose lobules separated by thin connective tissue septa, and was delineated by the mesocolic peritoneum ventrally and a delicate mesocolic fascia dorsally. Mesocolic blood vessels and lymphatics were found primarily at the dorsal aspect of the mesocolon, running in close proximity to the mesocolic fascia. The mesocolic fascia bordered the parietal peritoneal fascia and continued cranially in front of the duodenum and pancreas, where it was attached to the pre-duodenopancreatic fascia. The parietal peritoneal fascia corresponded to a condensed and



**FIGURE 4** Cross-section of the ascending colon/mesocolon and retrocolic fascial system. Caudal view onto a cross-section of the ascending colon, mesocolon and retrocolic fascial system. The ascending colon and mesocolic fatty tissue are enveloped by the mesocolic peritoneum ventrally and the mesocolic fascia dorsally. The attachment of the mesocolic fascia to the parietal peritoneal fascia is separated by opening the parieto-mesocolic interface. Dorsally, the parietal peritoneal fascia borders the anterior renal fascia, which ensheathes the perirenal fat capsule. The surgical dissection plane (arrow, red dotted line) for mesocolic excision extends along the parieto-renal interface between the parietal peritoneal fascia and the anterior renal fascia towards the paracolic recess. Formalin-fixed specimen

continuous fascial layer which adhered ventrally to the mesocolic and retro-duodenopancreatic fascia and was bordered dorsally to the anterior renal fascia.

### Evaluation of resected specimens after right hemicolectomy with CME

Surgical training courses for laparoscopic right hemicolectomy with CME were performed in body donors according to the standardized 'critical view' concept and 'open book' model described previously [20], adhering to the anatomical findings outlined above. Mobilization of the mesocolon was started by lifting the parietal peritoneal fascia from the underlying anterior renal fascia using the parieto-renal interface as the surgical dissection plane. The medial-to-lateral approach extended from the ileocolic region towards the duodenum and included mobilization of the inferior duodenal segment. The parietal peritoneal fascia was incised at the level of the duodenum, and mesocolic release was completed by detaching it from the ventral aspect of the duodenum and pancreatic head along the mesocolic-duodenopancreatic interface. As a result, the dorsal aspect of the resected specimen was covered by the shiny surface of the parietal peritoneal fascia which remained attached to the caudal part of the specimen (Figure 6A). Further cranially, the incision line of the parietal peritoneal fascia was clearly discernible. The macroscopic findings were confirmed on histological investigation

(Figure 6B). Application of this surgical procedure in patients undergoing laparoscopic and robot-assisted right hemicolectomy resulted in similarly shaped specimens (Figure 6C). The parietal peritoneal fascia was particularly evident as an additional protective sheath in patients with a low body mass index and little visceral fat.

### Schematic illustration and 3D model of the retrocolic fascial system

Based on the anatomical findings, the retrocolic fascial system was schematically illustrated (Figure 7) and transferred to a 3D model (Figure 8). This model allows interactive exposure of the fascial components and adjustment of the viewing angle to the preferred surgical approach: <https://skfb.ly/ozn8F>.

## DISCUSSION

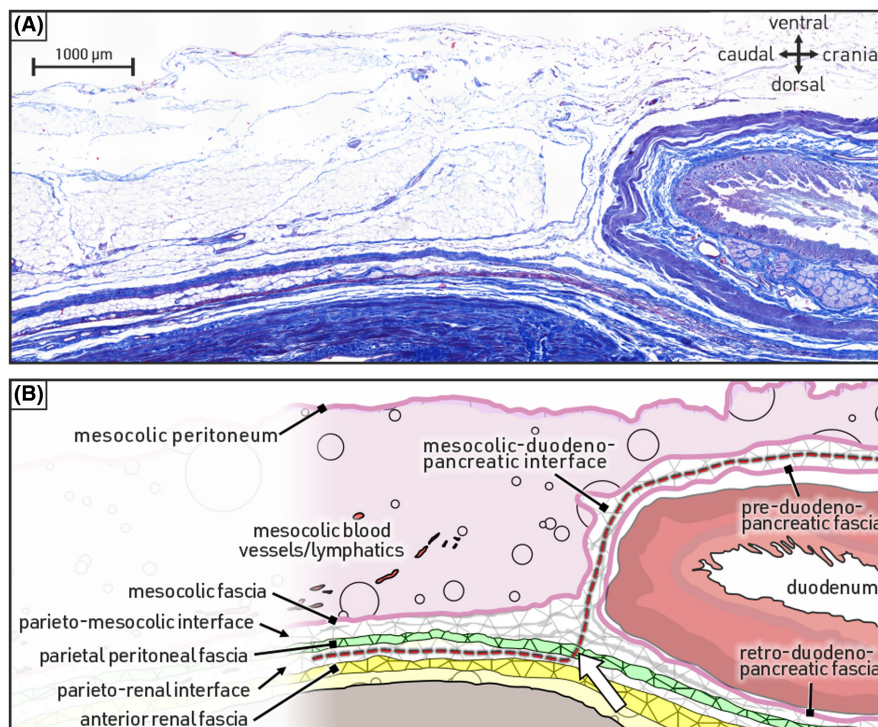
### Use of eponyms

Although eponyms are still widely used in medicine, both educators and researchers suggest abandoning this tradition because eponyms lack accuracy, lead to confusion and complicate scientific discussion [23–25]. Examples in colorectal surgery include the eponym 'Riolan's arch' which was deemed 'confusing, misnomer, and obsolete' [26] or the term 'Waldeyer's fascia' which was considered 'vague and best avoided' [27]. The essential contribution of Carl Toldt was his insight into the persistence of the embryological mesocolon during postnatal life. However, neither a distinct retrocolic fascia nor a 'white line' was explicitly described by him [10]. The 'fascia of Toldt' was properly interpreted by Adstrum as a 'fascia that binds the posterior parietal lamina of the peritoneum and the right lamina of the right mesocolon together' [28]. Likewise, Mike and Kano correctly pointed out that the so-called 'fascia of Treitz' [13] corresponds to the retro-duodenopancreatic fascia (or posterior pancreatic fascia) while the 'fascia of Fredet' [12], first mentioned by Rouvière [29], correlates with the pre-duodenopancreatic fascia or anterior pancreatic fascia [14]. Accordingly, the interface between the duodenum/pancreas and the mesocolon was interpreted as the 'space of Fredet' [14]. After decades of confusion, it was finally clarified that the term 'fascia of Gerota' should be assigned to the anterior renal fascia [30] (Table 1). Given the many misinterpretations caused by eponyms, their use appears to be of limited value.

### Embryological considerations

According to most standard textbooks, the ascending and descending colon, as well as the duodenum and pancreas, are considered to be 'secondary retroperitoneal organs' due to their allegedly vanished mesenteries. This traditional concept was refuted initially by Toldt





**FIGURE 5** Histology of the mesocolon and retrocolic fascial system in the duodenal region. The mesocolon, duodenum and underlying fascial components are excised en bloc as indicated in Figure 2 (black rectangle) and studied histologically. (A) The mesocolic tissue is delimited by the mesocolic peritoneum ventrally and a delicate mesocolic fascia dorsally. Mesocolic fat is lobulated by connective tissue septa and contains blood vessels and lymphatics extending predominantly in the dorsal aspect. The mesocolic fascia is attached to the parietal peritoneal fascia and pre-duodenopancreatic fascia, while the retro-duodenopancreatic fascia is attached to the parietal peritoneal fascia. Histology illustrates the condensed fascial nature of the parietal peritoneal fascia underlying the mesocolic fascia and confirms both the parieto-mesocolic and the parieto-renal interface. Azan staining. (B) Schematic illustration and explanatory legends for histological structures shown in (A). The dotted red line indicates the surgical dissection plane along the parieto-renal interface between the anterior renal fascia and the parietal peritoneal fascia for mesocolic excision. The parietal peritoneal fascia has to be incised at the inferior duodenal border (arrow) to continue surgical release of the mesocolon along the mesocolic-duodenopancreatic interface in front of the pre-duodenopancreatic fascia

[10] and later by the seminal work of Coffey and colleagues, who emphasized that the concept of both CME and TME (total mesorectal excision) relies on the 'mesenteric contiguity from ileocaecal to mesorectal levels' [31].

During embryological development, the right mesocolon attaches to the parietal peritoneum and further cranially to the duodenum and pancreas [18]. Although the dorsal aspect of the mesocolon merges with the parietal peritoneum, these layers remain in place and can be clearly discerned at the macroscopic and microscopic level. During the adhesion process, the serosal mesothelial lining disappears and is replaced by fibro-connective tissue [18, 32], so that the dorsal mesocolic leaf becomes the mesocolic fascia and the retrocolic parietal peritoneum turns into the parietal peritoneal fascia, also termed the 'fascia of Toldt' (Table 1). Several histological studies on human foetuses have confirmed the presence of fascial remnants of the primitive parietal peritoneum and a well-defined anterior renal fascia in later stages of gestation [32–34]. The retrocolic fascial components were intimately fused in some instances, allowing no clear distinction especially at those sites where the mesocolon was devoid of blood vessels and lymphatics [32]. However, it was postulated that mechanical stress due to intestinal growth,

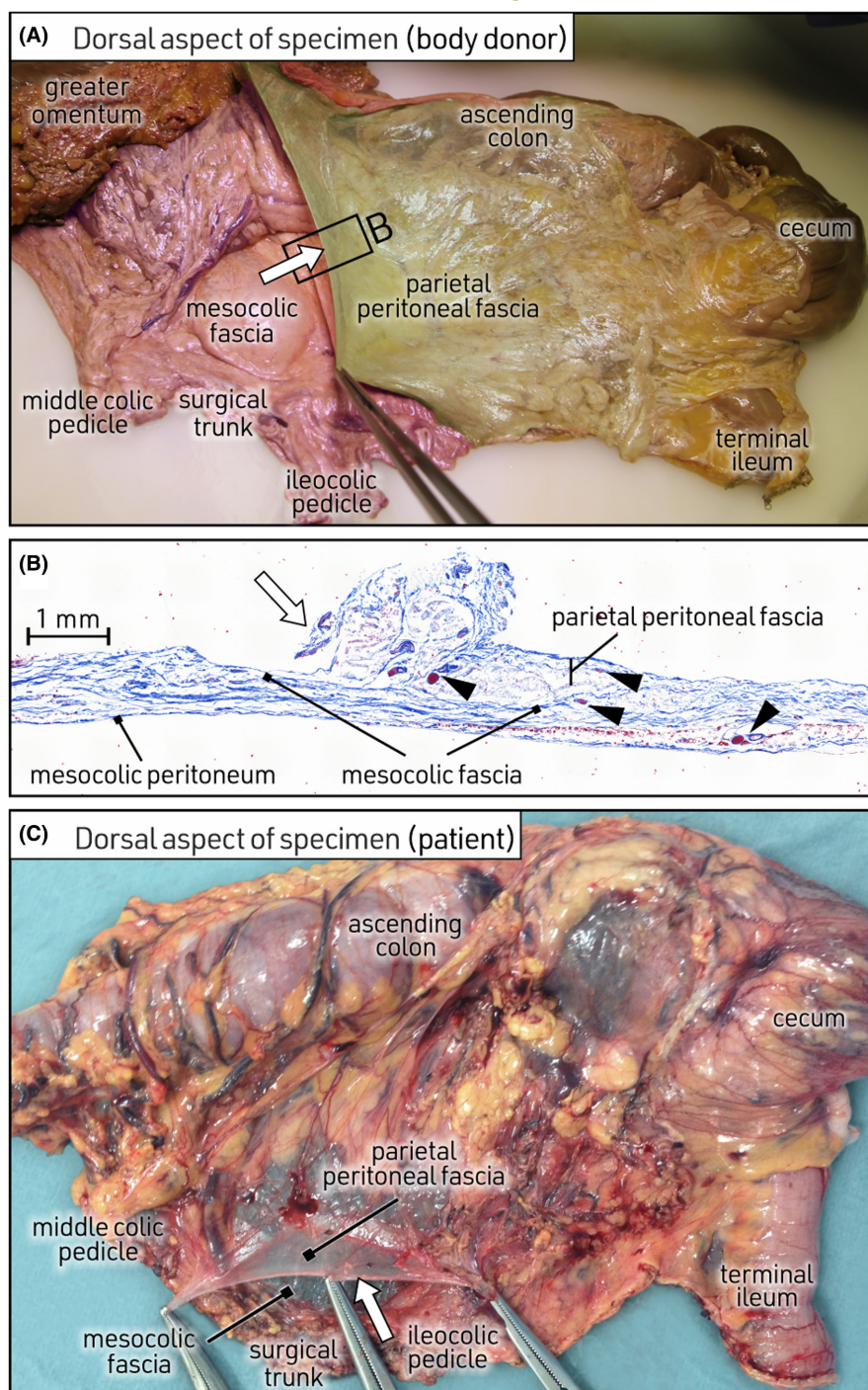
rotation and peristalsis induces reinforcement of these initially indistinct peritoneal remnants, turning them into the fascial layers seen in postnatal life [33].

Based on these embryological developmental processes, it has been concluded that 'the key to the dissection of either right or left colon is to separate the mesocolon from the anterior renal fascia' and that 'dissection should be processed under the Toldt fascia' [18]. This proposed surgical dissection plane corresponds exactly to the parieto-renal interface described in this study. Likewise, the mesoduodenum/pancreas becomes the pre- and retro-duodenopancreatic fascia. Consequently, further separation of the mesocolon is performed along the mesocolic-duodenopancreatic interface.

### Optimal surgical dissection planes for CME

The retrocolic fascial system comprises two distinct layers extending behind the proper mesocolon, namely the parietal peritoneal fascia and the anterior renal fascia, which is in line with the most detailed descriptions of the retrocolic system provided so far [4, 14,

**FIGURE 6** Evaluation of the dorsal aspect of CME specimens. (A) View onto the dorsal surface of a resected specimen retrieved by laparoscopic right hemicolectomy in a body donor during a surgical training workshop. Mesocolic excision was performed by opening the parieto-renal interface so that the parietal peritoneal fascia remained attached to the mesocolic fascia of the ascending mesocolon. The shiny and intact surface of the parietal peritoneal fascia is clearly seen. The parietal peritoneal fascia was transected at the duodenal border, and further mesocolic excision was carried out by releasing the mesocolic fascia from the ventral aspect of the duodenum and pancreas. Note the cutting edge (arrow) of the parietal peritoneal fascia stretched out between two forceps. Ethanol-glycerol-lysoformin-fixed specimen. (B) Histological evaluation of the region indicated by the black rectangle in (A) confirms the attachment of the parietal peritoneal fascia to the mesocolon caudally and its absence cranially at the transection line (arrow). Mesocolic blood vessels and accompanying lymphatics are highlighted (arrowheads). (C) View onto the dorsal surface of a resected specimen retrieved by robot-assisted right hemicolectomy performed in a patient, showing similar findings as in (A). Note the thin mesocolic tissue with no intervening fat ('mesocolic window') and the protective parietal peritoneal fascia transected along the duodenal border. The cutting line is lifted with three forceps



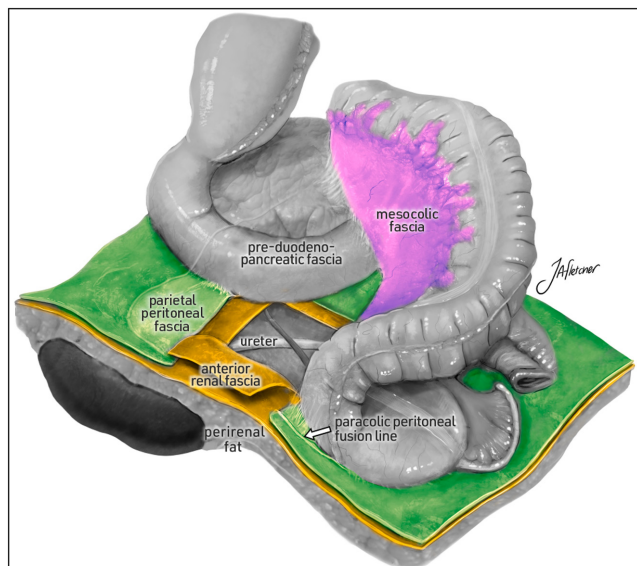
15]. Based on our anatomical studies and surgical experience, the preferred surgical dissection planes for complete release of the mesocolic package consist of two essential steps.

1. Mobilization of the ascending colon/mesocolon starting along the parieto-renal interface by strictly staying in front of the anterior renal fascia. This dissection plane will lift the duodenum and pancreatic head from the anterior renal fascia ('Kocher manoeuvre'), as initially reported by Hohenberger et al. [1].

The surgical dissection plane extending behind the so-called 'fascia of Toldt' along the anterior renal fascia has also been advocated as the preferred plane by several other groups [14–17] and is referred to as the 'retro-fascial interface' [8] (Table 2).

2. To mobilize the mesocolon fully, the parietal peritoneal fascia has to be transected at the inferior duodenal border to reach the anterior aspect of the duodenum and pancreas. In this area, the mesocolic fascia needs to be detached from the pre-duodenopancreatic





**FIGURE 7** Schematic illustration of the retrocolic fascial system. The mesocolic fascia is partly detached from the parietal peritoneal fascia and pre-duodeno-pancreatic fascia. The anterior renal fascia is fenestrated and partly lifted to demonstrate the ureter and gonadal vessels. For didactic purposes, the fascial components are displayed with exaggerated thickness and in semi-transparent colours like those used in Figures 1–5



**FIGURE 8** Interactive 3D model of the retrocolic fascial system. The 3D model shows all relevant organs and fascial structures including annotations, and allows for interactive exploration. Link/QR code: <https://skfb.ly/ozn8F>

fascia by opening the mesocolic–duodenopancreatic interface, also termed the ‘space of Fredet’ (Table 2).

The proposed surgical dissection planes result in a surgical specimen with the parietal peritoneal fascia remaining attached at

its dorsal aspect. Strikingly, this configuration resembles exactly the type of resected specimen retrieved after CME reported by Gao et al. [17]. Furthermore, as the histological studies showed that the mesocolic lymphovascular drainage routes extend in close proximity to the mesocolic fascia, the attached parietal peritoneal fascia may provide an additional ‘protective layer or barrier’ against tumour cell spillage. In contrast, if surgical dissection is carried out along the parieto–mesocolic interface directly adjacent to the mesocolic fascia, the risk of damaging this delicate fascial layer is higher. This holds true especially in patients with a small quantity of visceral fat and a thinned mesocolon, bearing the risk of mesocolic tears [9].

## CONCLUSION

Beside the principles of central vascular ligation and complete lymphadenectomy, the concept of CME demands resection of an intact and complete mesocolic package. In turn, surgical mobilization of the mesocolon relies on detailed knowledge of the retrocolic fascial system and its description in unequivocal anatomical terminology, as proposed in this study. Although eponyms reflect historical achievements and may still be useful in some instances, they do not add substantial value to the understanding of the retrocolic fascial system and the surgical procedures related to right hemicolectomy with CME.

## AUTHOR CONTRIBUTIONS

Conceptualization: TW, SB, DM. Macroscopic dissections: TW, TH, MH, JF, SS. Microscopic studies: TH, MH, TW. Data acquisition: TH, MH, SB, DM, TW. Drafting of the manuscript: TW, TH, MH. Visualization: TH, JF, TW. Critical revision of the manuscript: TW, DM, SB, SS.

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## CONFLICT OF INTEREST

The authors certify that they have no affiliations with, or involvement in, any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership or other equity interest; and expert testimony or patent-licensing arrangements) or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this paper.

## DATA AVAILABILITY STATEMENT

Data available on request from the authors.

## ETHICAL APPROVAL

The study was approved by the body donation programme of the Institute of Anatomy, Medical Faculty, Kiel University.

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