



# Vascular Anatomy and Variants: Knowledge during Laparoscopic Right Colectomy

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## Abstract

From the review of the literature and clinical data, it is clear that the anatomy of the vessels of the right colon is remarkably variable, especially those of Henle branch. This justifies why the laparoscopic colectomy (LRC) plus complete mesocolon excision (CME) is often difficult to perform with the conversion rate due to the lesion of the vessels. The objective of this study was to retrospectively review the videos and literature of the right laparoscopic colectomy plus CME to highlight the greatest number of vascular variations of the right colon, to record them, and to highlight the methods by which cope with these variations during surgery.

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## Introduction

A long -term follow-up of the literature studies showed that long-term survival outcomes for laparoscopic surgery for colon cancer were comparable to open surgery. Laparoscopic right colectomy based on complete mesocolic excision (CME) introduced by Hoenberg in 2008 seems to increase the number of dissected lymph nodes, to give improvement of the prognosis, and to reduce local recurrence. CME technique application seems to produce better oncological and functional outcomes for patients when compared to traditional approaches as similar concept of total mesorectal excision (TME) becomes a gold standard. However, nowadays not evidence from randomized controlled trials were found and concerns have been raised regarding CME-related morbidity [1], [2]. However, since vascular anatomical variations are also found in the right colon, which are often complex, an incorrect knowledge of the variants can lead to improper management of the vessels during laparoscopic surgery with consequent serious vascular complications. A detailed knowledge of the right colon is, therefore, considered that essential vascular variations is to be able to improve the technique and carry out interventions with greater safety, reducing

the risk of vascular complications during minimally invasive surgery. The objective of this study was to retrospectively review the videos and literature of the right laparoscopic colectomy plus CME to highlight the greatest number of vascular variations of the right colon, to record them, and to highlight the methods by which cope with these variations during surgery.

## Materials and Methods

We have retrospectively evaluated PubMed databases, EMBASE, and the Cochrane Library by applying various combinations of the subject-related terms. The search terms identified with the medical subject heading (MeSH) were “right colectomy, right hemicolectomy, laparoscopic right colectomy, minimally invasive right colectomy, CME, vascular anatomy, variants.” The databases were used to collect the literature published up to 2010. Inclusion criteria were reports that included the following: “Right colectomy, right hemicolectomy, laparoscopic right colectomy, minimally invasive right colectomy, CME, vascular anatomy, variants.” Exclusion criteria were as follows:

Case reports, letters, comments, and abstracts. Duplicate reports and studies that contained non-cancer patients were also excluded from the study. No language restriction was applied in the search strategy. Two independent researchers performed the review. The PRISMA guidelines were followed during all stages of this systematic review. Recommendations were protocol, research question, search strategy, study eligibility, data extraction, study designs, risk of bias, publication bias, heterogeneity, and statistical analysis.

## Results

The systematic literature search found 39 articles, nine of which were duplicates and excluded from analysis. The titles and abstracts from the remaining 30 articles were assessed. After careful evaluation, 19 articles were determined to be unrelated to our study and subsequently excluded. The full text of the remaining 11 articles was thoroughly assessed. Case reports, editorials, letters to the editor, and general reviews were then excluded from the study. A total of 11 articles were ultimately included for this review, describing laparoscopic right colectomy plus CME with vascular anatomy variants. After excluding repetitive reports, four manuscripts comprised the relevant literature for this review article. All procedures were in accordance with ethical standards of the relevant committee on human experimentation and Helsinki Declaration. Informed consent was waived because the study was retrospective. After excluding repetitive reports, four manuscripts comprised the relevant literature for this review article.

Ke-Kang Sun *et al.* [3] performed a review from 2011 to 2018 on laparoscopic right colectomy (LRC) variants and demonstrated that the ICA and MCA are evident in the majority of patients. They noted that the right colic artery (RCA) was present from 12% to 45% and it passed anterior to the superior mesenteric vein (SMV) in the majority of patients. The ileocolic artery (ICA) passed in the anterior or posterior field respect to the SMV. While the ileocolic vein (ICV) was present in all patients, the right colic vein (RCV) can be absent in 80% of patients. The gastrocolic trunk of Henle (GTH) was present in nearly 80% of patients with three main types such as gastrocolic trunk (GCT) and gastropancreaticocolic trunk (GPCT) more common types while the gastropancreatic trunk (GPT) was relatively rare. Haywood *et al.* [4] made a systematic review on 1073 patients showing incidence of the different origins of the RCA. The study showed that RCA arises for 36.8% from the superior mesenteric artery, 31.9% from the ileocolic artery, 27.7% from the middle colic artery, and 2.5% from the right branch of the middle colic artery, 1.1% of it arises from a trunk

with the middle colic and ileocolic arteries. About 8% of patients had not RCA while in 7% of cases, they found double RCA. Alsabilah *et al.* [5] performed a review where they confirmed that ileocolic artery and middle colic artery arise from the superior mesenteric artery, ileocolic artery passes posterior and anterior in some case to the superior mesenteric vein, the right colic artery is inconsistently present ranging from 63% to 10%. Ileocolic vein and middle colic vein are always present, while the right colic vein is absent in 50% of patients, and finally, that the gastrocolic trunk of Henle was present in 46–100% of patients with different variants confluence of two or three or four veins. Wu *et al.* [6] analyzed right colonic vascular variability in 60 patients. They noted that the superior mesenteric artery and vein were always present during pre-operative imaging and during LRC, in 95.0% of cases, they found the superior mesenteric artery on the left side of the superior mesenteric vein such as the classical anatomy. The ileocolic artery was present in 96% of the patients while ICV was always present. In 50.0% of patients, the ileocolic artery passed anterior to the superior mesenteric vein. RCA was present in 55.0% of cases while in 3%, it was double. RCV was present in 93% of cases and passed anterior to the superior mesenteric artery in 90.9%. It was found with a right colic artery in 12% of case. RCV drained into GTH in 66%, in 23% into SMV or double RCV that drained into SMV and GTH, respectively. A gastrocolic trunk of Henle was found in 88% such as gastrocolic trunk in 35.8%, a gastropancreatic trunk in 9.4%, and a gastropancreaticocolic trunk in 54.7%. Middle colic artery was always found while MCV was present for 93% of the patients. Tajima *et al.* [7] found ICA in 100%, RCA 32%, ICA anterior to SMV in 61%, and RCA anterior to SMV in 78% of cases, respectively. Posterior ICA and RCA were found in 38% and 21%, respectively. Other studies evaluated ICA founding it in 100% of cases [8], [9], [10], [11], while one study conducted by Wu chuying *et al.* [12] found it in 96% of case. In some review, RCA was found between 12% and 55% [8], [9], [10], [11] while MCA was always present in 100% of cases [8], [9], [10], [11]. Studies noted that ICA passed anterior or posterior respect to SMV almost 50% of cases [10], [11], [12]. RCA passed anterior to SMV between 80% and 90% of cases [10], [11], [12]. Studies highlighted a presence of ICV in 100% of patients while RCV was found between 19 and 21%, MCV 74%–93% and finally GTH from 74% to 88% [9], [11], [12], [13].

## Discussion

From the review of the literature and clinical data, it is clear that the anatomy of the vessels of the right colon is remarkably variable, especially those of Henle branch. This justifies why the LRC plus CME is

often difficult to perform with the conversion rate due to the lesion of the vessels. The results of the anatomical variants of the right colon increase our knowledge and allow us to highlight the uncommon characteristics that could be met by surgeons during laparoscopy right colectomy. The results of the literature take into account the variations in the right branches blood vessels of the colon and the relationships between these branches. In particular, a study performed by Wu *et al.*, highlighted two very rare variants: A superior mesenteric artery positioned to the right of the superior mesenteric vein and variation in middle colic artery length. Wu *et al.* [12] observed 3/60 patients who had superior mesenteric artery (SMA) to the right of the superior mesenteric vein (SMV). Usually, SMA is located to the left of SMV. Menten *et al.* [14] used identified one case of a superior mesenteric artery to the right of the superior mesenteric vein among 80 children with a normal duodenum position and two cases in three children with an abnormal duodenum position. Sodhi *et al.* [15] reported a counterclockwise rotation of the superior mesenteric vein around the superior mesenteric artery. The use of pre-operative 3D CT has shown a high sensitivity, specificity, accuracy, and reliability in highlighting and drawing the right colon anatomy, however, is not routinely used preoperatively. However, we believe that the routine use of 3D CT associated with the constant recording of videos of the right colon allows surgeons to be able to study and catalog well the anatomical variations of the blood vessels of the right colon with greater precision. The ileocolic artery and middle colic artery were both present in 100%. The right colonic artery originates independently from the superior mesenteric artery in 19–45%. The right colic artery was present from 19% to 55.0% [12] and was anterior to the superior mesenteric vein in 62.5–84.2% [12] and found it anterior to SMV in 90.9% of cases. Studies indicate that the right colic vein originates independently from the superior mesenteric vein in 25% of cases. Wu *et al.* [12] described seven cases of double right colic vein drained in SMV and Henle trunk. As the right colic artery and vein drain directly into the superior mesenteric artery and superior mesenteric vein, respectively, their lesion could lead to uncontrollable bleeding. The ileocolic artery, right colic artery, and middle colic artery originate individually from the superior mesenteric artery in 10.7–45.0% of cases. The ileocolic artery was present in 96.7%. The ileocolic artery was anterior to the superior mesenteric vein in 33.0–36.7%, 50.0% in the studies by Wu *et al.* The gastrocolic trunk of Henle currently includes the right gastro-omental vein plus a colic vein (right colic vein or middle colic vein) and the pancreaticoduodenal vein. The gastrocolic trunk of Henle type was gastrocolic trunk in 35.8%, gastropancreatic trunk in 9.4%, and gastropancreaticocolic trunk in 54.7%. Gastrocolic trunk of Henle and tributaries lesions can lead to massive hemorrhage. It can be achieved for lesion or overtraction. Studies revealed middle colic

artery absence in 30%, double middle colic arteries in 32.5%, and triploid middle colic arteries in 6% of patients. The middle colic artery originates from the superior mesenteric artery but can originate from the hepatic or splenic artery or the coeliac trunk or dorsal pancreatic artery [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14].

## Conclusions

The superior mesenteric vein is a key landmark during dissection of the right vascular colic anatomy in LRC plus CME. SMV is identifiable as a vertical purple-blue line from ileum mesentery to inferior margin of the pancreas. It is recommended to take the intersection between IC vessels with the superior mesenteric vein to start CME. We believe that the knowledge of vascular variants of the right colon described may help surgeons reduce the risk of vascular complications during minimally invasive surgery, thereby improving the safety of the surgery, reducing the conversion rate to open, and potentially reducing hospitalization times and the costs of the treatment.

## Authors' Contributions

Danilo coco and Silvana Leanza conceived and coordinated the study; designed, performed and wrote the paper, carried out the data collection, data analysis, and revised the paper. All authors reviewed the results and approved the final version of the manuscript.

## Ethics Approval and Consent to Participate

All procedures were in accordance with ethical standards of the relevant committee on Helsinki Declaration. Informed consent was waived because the study was retrospective.

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