The right colic artery: An anatomical demonstration and its relevance in the laparoscopic era

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ABSTRACT

INTRODUCTION Hemicolectomies are not tailored in right-sided colon cancer resections, despite significant variation in the incidence and origin of the right colic artery (RCA). Early evidence suggests that removal of the relevant lymphovascular package and associated cancer as part of complete mesocolic excision (CME), rather than the entire right colon, may produce better outcomes. Advancing laparoscopic techniques are making this possible, and so it is increasingly important to more precisely define the anatomy of the RCA.

METHODS To demonstrate the incidence and variation of the RCA, 25 formalin embalmed cadavers were dissected. Consent to dissection and photography was obtained under Human Tissue Act regulations.

RESULTS Eleven female and 14 male cadavers (mean age 79.7 years, range 41–95 years) were included. The RCA originated from the right branch of the middle colic artery in nine cadavers (36%), while it arose from the superior mesenteric artery in eight cases (32%) and from the ileocolic or root of the middle colic artery in a smaller number of specimens. The RCA was absent in two individuals.

CONCLUSIONS The RCA arises from the right branch of the middle colic artery in a considerable number of cases. The literature to date does not reflect the precision of anatomical understanding required for CME; hence, a new definition for the right colic vessel is proposed.

KEYWORDS

Ascending colon – Colectomy – Colic – Cadaver – Superior mesenteric artery

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Colonic resection and anastomosis for malignancy has existed for almost 200 years, with a clear understanding of the underlying vascular anatomy one of the most important aspects of good oncological surgery. Surgical texts of the 19th century such as *The Anatomy of the Arteries of the Human Body* made no note of the vast variation seen in the colonic vasculature.¹ Although we have begun to develop a better understanding of this critical area in the last few decades, the procedure undertaken for benign and malignant diseases of the right colon (ie right hemicolectomy) has remained essentially unchanged for the last 100 years.² Moreover, the extent of resection has remained the same, despite the surgical approach having changed from an open to minimally invasive procedure.³ Only very recently has there been an increasing emphasis on precision surgery, involving sound oncological principles and improved functional outcomes after colonic surgery.^{4–6}

Complete mesocolic excision (CME) is a term that was coined by Hohenberger et al in 2009,⁷ and is founded upon

the principles of the established procedure of total mesorectal excision for rectal cancer.⁸ CME involves undertaking precision surgery to attain good oncological outcomes and involves three important components: mesocolic excision, a high vascular tie and removal of the relevant lymphovascular package draining the tumour.^{9,10} Some prospective data suggests there may be a cancer-related survival benefit and reduction in local recurrence with the approach, although randomised trials are needed to confirm these preliminary findings.⁵ While the traditional resection approaches involving the right colon are the right hemicolectomy and extended right hemicolectomy, it is our belief that precision surgery based on the principles of CME would not only be oncologically sound but also functionally better in terms of risk of diarrhoea and malabsorption.

Oncosurgery of this nature therefore demands a tailored patient-by-patient approach, together with a meticulous understanding of the underlying anatomy, and is arguably most pertinent in right-sided resections. The right colonic

vasculature demonstrates significant variation and there is a lack of consensus with regard to the incidence and origin of the right colic artery (RCA), as shown in several review articles.^{11–15} Furthermore, the definition of this vessel varies considerably between different authors. In 1933, Steward and Rankin considered the act of defining the RCA with respect to its origin as an ‘academic’ issue.¹⁴ They proceeded to regard it as any anastomosed vessel arising from the superior mesenteric, middle colic or ileocolic artery and supplying the hepatic flexure region. Similarly, Sonneland et al in 1958 analysed 600 dissections and suggested that the RCA should be considered the major feeding vessel, independent of its origin, ‘directed to the ascending colon between the ileocaecal junction and the hepatic flexure.’¹⁵ While these viewpoints are reflected in other studies,^{11,15,16,17} some authors reserve ‘right colic artery’ for a vessel arising from an independent origin on the superior mesenteric artery, preferring to use ‘right colic branch’ in all other cases.^{12,18}

With regards to an origin other than the superior mesenteric artery, some articles consider the right colic vessel to share a common trunk with another artery;^{15,15} however, other groups regard the right colic vessel as being a smaller branch of a larger artery.^{12,14} When it shares a common trunk with the middle colic artery, not only is there significant disagreement regarding its incidence between two of the largest studies (23.8% versus 49.2%),^{15,15} but they also fail to specify whether the trunk bifurcates in close proximity to the middle colic root or more distally along the course of the left or right branch of the middle colic artery. This lack of clarity is further perpetuated if one chooses to acknowledge the presence of superior, middle and inferior right colic arteries,¹⁹ or accessory RCAs.¹⁵ The current authors also encountered papers wherein no definition for the RCA was given.^{20,21}

The current body of literature regarding the incidence and origin of the RCA is inconsistent, contradictory in parts and not representative of what is important in a modern, minimally invasive approach to the right colon. We sought to perform cadaveric dissection in light of these findings with the aim of defining the incidence and the origin of the RCA in our small cohort. We have also made an attempt to clarify the definition for the RCA in the age of precision oncosurgery.

Methods

A prospective study was undertaken in the Queen Mary University of London anatomical cadaveric laboratory between March 2015 and February 2016. Twenty-five cadavers were studied under the supervision of the Director of Anatomical Studies. A mix of traditional formalin-fixed and soft-fixed specimens was used. In all cases, consent to dissection and photography was obtained in line with the Human Tissue Act regulations.

In 24 cases, we attempted to identify a vessel representing the RCA by first reflecting the transverse mesocolon and dissecting down to the origin of the superior mesenteric artery (SMA) in situ. All branches of the SMA were then followed

laterally until it was possible to determine the supply to the ascending colon. In one cadaver prepared using novel embalming techniques, it was possible to visualise the colonic vasculature without peritoneal dissection. Sketches and photographs were taken in each case (see Figs 1–4). Six cadavers were excluded from the present study due to difficulties in dissection: two females and three males had disseminated intra-abdominal malignancy and one male had megacolon precluding identification of the relevant anatomical structures.

Results

The basic demographics of the cohort of dissected cadavers are shown in Table 1.

One or more right colic vessels were identified in 24 out of 25 specimens (96%), with origins as shown in Table 2. In two of the cadavers with a right colic vessel arising from the ileocolic artery, a second smaller right colic vessel was found to arise from the SMA in one case and from the root of the middle colic artery in the other. In one individual, two right colic vessels arose adjacent to one another from the root of a middle colic artery. In one further specimen in which a right colic vessel arose from the right branch of the middle colic artery, a second smaller right colic vessel arose from the ileocolic artery (Figs 1, 2, 3, 4).

Discussion

The surgical and anatomical communities have largely failed to dispel the classical but incorrect textbook paradigm in which the ileocolic, right colic and middle colic arteries

ILC = ileocolic artery; MC = middle colic artery; RC = right colic vessel; RBMC = right branch of middle colic artery; SMA = superior mesenteric artery.

Figure 1 Right colic originating from the right branch of the middle colic artery

Figure 2 Right colic artery originating directly from the superior mesenteric artery

Figure 3 Right colic artery originating from the root of the middle colic artery

all arise independently from the superior mesenteric artery.^{22,25} As can be seen from our review of the literature and the results of the present study, the RCA is highly variable in its origin and its definition is not universally agreed upon.

Our documented incidence of the right colic vessel originating directly from the SMA in 32% of cases is similar to the findings of two of the larger studies in this domain by Sonneland et al and Michels et al, at 27% and 32%, respectively (combined n=780).^{15,15} Sonneland et al reported an ileocolic

Figure 4 Absent right colic vessel

Table 1 Demographics of dissected cadavers		
Gender	Frequency	Mean age (range), years
Female	11	77.7 (41–95)
Male	14	81.2 (58–93)
Total	25	79.7 (41–95)

point of origin in 26% of cases while Michels et al gave a figure of 8%; however, our documented incidence of 12% more closely aligns with the findings of Igiri et al (13%, n=75) and Steward (12%, n=50).^{14,24} Regarding a middle colic point of origin, most authors describe either a common trunk of the two arteries,^{13,15,18,25} or the right colic vessel arising as a branch of the middle colic artery.^{2,11,12,14} We choose to differentiate between cases where the right colic vessel arose either from the root of the middle colic artery (Figure 3; ie before it bifurcates to supply the transverse colon) or from the right branch of the middle colic artery (Fig 1). In doing this, we may have shown, for the first time, that the right colic vessel arises from the right branch of the middle colic artery in a considerable number of cases. Considered together, the incidence of the right colic vessel arising from some part of the middle colic artery is 48% in our cohort of cadavers, with Michels et al and Nelson et al reporting similar figures, at 49% and 50%, respectively.^{11,15} A finding of an absent right colic vessel displays wide variation in the literature, from 2% to 18%.^{13,14}

As a result of this variation, it is more difficult for the surgeon to perform a true high tie of the RCA as part of a CME procedure when compared to a left-sided colectomy, where

Table 2 Origins of right colic vessels in dissected cadavers	
Origin	N (%)
Right branch of middle colic artery	9 (36)
Superior mesenteric artery	8 (32)
Ileocolic artery	3 (12)
Root of middle colic artery	3 (12)
Absent	2 (8)

the inferior mesenteric artery is more anatomically consistent and thus more easily taken flush at its origin on the aorta. The risk therefore is of only taking intermediate lymph nodes, thus potentially leaving tumour cells behind that have spread to nodes closer to the arterial root. A clear understanding of the true arrangement of the right colic vessel is therefore of paramount importance to the success of precision surgery in the region of the hepatic flexure and ascending colon, and it is proposed that pre-operative imaging of the vascular supply to this area should be routine as part of the work-up for a CME procedure. We propose that the term ‘right colic artery’ be reserved for a vessel supplying the region of the hepatic flexure which originates directly from the SMA. All other vessels that supply the area described but which arise from a more distal vessel than a main branch of the aorta should be termed a ‘right colonic branch.’

Finally, if more than one right colic vessel is found, these should be numbered by the proximity of their origin to the tumour. The term ‘accessory’ should be abandoned, as it is less specific.

Conclusions

The right colic vessel is highly variable in its origin and provides unique challenges for CME in the region of the ascending colon and hepatic flexure. The literature to date does not reflect the precision of anatomical understanding that is required for CME to be performed effectively. By providing simplified definitions for right colic vasculature and proposing that the right colic vessel arises in a considerable number of cases from the right branch of the middle colic artery, we hope to make some small but important contributions towards future randomised trials comparing CME to current resection techniques. In this small cohort, we have demonstrated the huge variation that exists in the origin of the RCA and right colonic branch in the absence of the true RCA. A simplified and contemporary classification of the right colon blood supply has also been provided.

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