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SHORT COMMUNICATION

Level of inferior mesenteric artery ligation in low rectal cancer surgery: high tie preferred over low tie

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Abstract

Background There is no demonstrated benefit of high-tie versus low-tie vascular transections in low rectal cancer surgery. The aim of this study was to compare the effects of high tie and low tie of the inferior mesenteric artery on colonic length.

Methods This study was conducted in a surgical anatomy research laboratory. Anatomical dissections were performed on 11 human cadavers. We performed full left colonic mobilization, section of the descending-sigmoid junction, and high and low ligation of the inferior mesenteric artery. Distance from the proximal colon limb to the lower edge of the pubis symphysis was recorded after each step of vascular division. Three measurements were successively performed: before vascular section, after inferior mesenteric artery ligation, and after inferior mesenteric artery and vein section.

Results Before vascular section, the mean distance between colonic end and lower edge of the symphysis pubis was -1.9 ± 3.5 cm. After combined artery and vein section, the mean distance was $+10.7 \pm 4.6$ cm for high tie and $+1.5 \pm 3$ cm for low tie. A limitation of this study is the use of embalmed anatomical specimens, rather than live patients, and the small number of specimens. This study also does not evaluate colon limb vascularization or the impact of proximal lymph node dissection on survival rates.

Conclusions High tie of the inferior mesenteric artery at its aortic origin allows a gain of extra length of about 9 cm over low tie.

Keywords Rectal cancer · Inferior mesenteric artery · Vascular anatomy · High tie

Introduction

Total mesorectal excision following chemoradiotherapy is standard treatment for advanced middle and low rectal cancer. However, it is unclear whether the inferior mesenteric artery (IMA) should be ligated as high as possible, at its origin from the aorta (high tie), or low, below the origin of the left colic artery (low tie) [1, 2]. A recent review of the literature including 11 non-randomized studies did not lead to definitive conclusions about high tie versus low tie [3]. Neither the high-tie nor low-tie strategy has had evidence-based advantage in terms of anastomotic leakage rate, overall postoperative morbidity and mortality, and long-term overall or disease-free survival [3]. One of the causes of low rectal or anal anastomotic leakage is excessive tension on the anastomosis due to a short proximal colon limb leading to decreased perfusion [4]. Furthermore, many surgeons perform high-tie ligation of the IMA to achieve more lymphatic clearance and improve survival, although there is no conclusive evidence to support this view [5]. For these two reasons, high tie is theoretically the best strategy in patients with low rectal cancer. The aim of this study was to compare the effects of high tie and low tie of the IMA on colonic length after total mesorectal excision, using an unpublished anatomical procedure, and to provide a docent paper.

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Materials and methods

Anatomical specimens

Formalin-fixed human specimens were obtained from the French Alps Anatomy Laboratory (LADAF) for dissection. Any specimen with previous abdominal disease, vascular disease, pelvic radiotherapy, or abdominal scars was excluded. This study was consistent with the current French regulations on post-mortem experimentation and was approved by the scientific council of LADAF.

Operative procedure

The abdomen was opened using an atypical U-laparotomy. Left colon dissection began at the lateral peritoneal fold and continued in the mesofascial interface with a lateral-to-medial approach. The splenic flexure, descending colon, and sigmoid were then fully mobilized. The peritoneum was incised beside the aorta to identify the IMA origin. All vessels branching off the IMA were identified with fine anatomical dissection to the point of the smallest visible branches. The descending-sigmoid junction was stapled and cut with a GIA clamp ahead of the first sigmoid artery branch. At this stage, only vascular elements limited the descent of the distal end of the colon (Fig. 1).

Original methods of measurement

The lower edge of the symphysis pubis, representing the reference point for measurements, was marked with a needle. The distal end of the colon was unfolded toward the symphysis pubis on the skin surface, for each experimental step. The distance from the lower part of the colon to the reference point was measured. Distance was negative if the distal end of the colon did not reach the symphysis pubis landmark and positive if it did reach the symphysis.

Comparison between two types of arterial ligation was performed in each case. First, high-tie transection measurement was performed (Fig. 1a). Then, after vascular anastomosis using interrupted 6/0 polypropylene stitches, low-tie transection measurement was performed (Fig. 1b). For each group, three measurements were successively performed: before vascular section, after IMA ligation, and after IMA and inferior mesenteric vein (IMV) section at the lower edge of the pancreas (Fig. 2).

Statistical analysis

Data were analyzed using R statistical software (Portable-Apps.com). Quantitative variables were reported as mean and standard deviations, or median with interquartile range (IQR). Quantitative and qualitative variables were compared with analysis of variance or Fisher's exact test, respectively. A p value < 0.05 was considered significant.

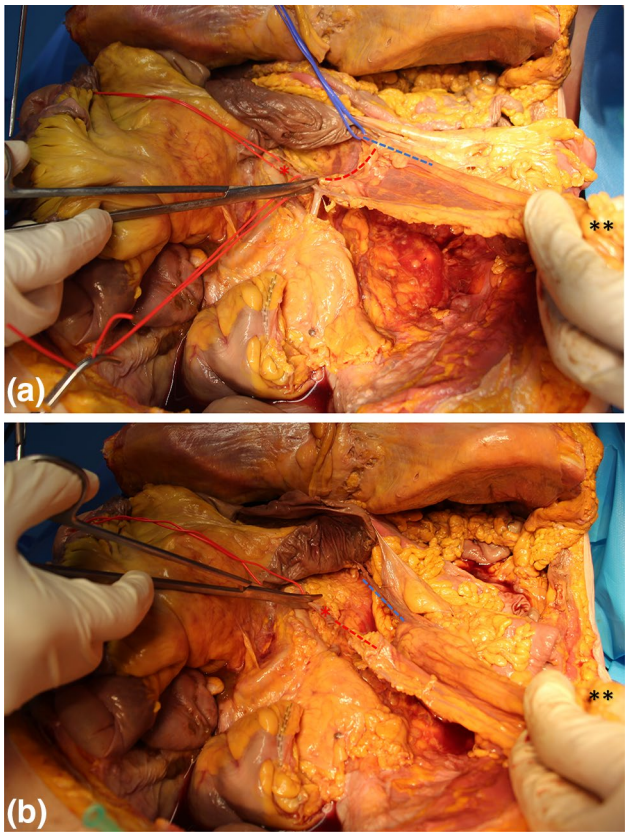

Fig. 1 Illustrations of the cadaveric dissection. Splenic flexure, descending colon, and sigmoid were fully mobilized. **a** Low-tie transection. **b** High-tie transection (with anastomosed IMV). Inferior mesenteric artery (IMA) (asterisk), stapled descending-sigmoid junction (double asterisk), inferior mesenteric vein (IMV) (dotted blue line), left colic artery (dotted red line)

Results

Anatomical specimens

Anatomical dissections were performed on 11 human cadavers including 5 male and 6 female specimens, aged 72–101 years [median age, 84 (3.5) years], with height between 150 and 180 cm [median height 165 (8.8) cm], and weight between 30 and 90 kg [median weight 70 (19) kg].

Anatomical measurements

Before vascular section, the mean distance between colonic end and lower edge of the symphysis pubis was

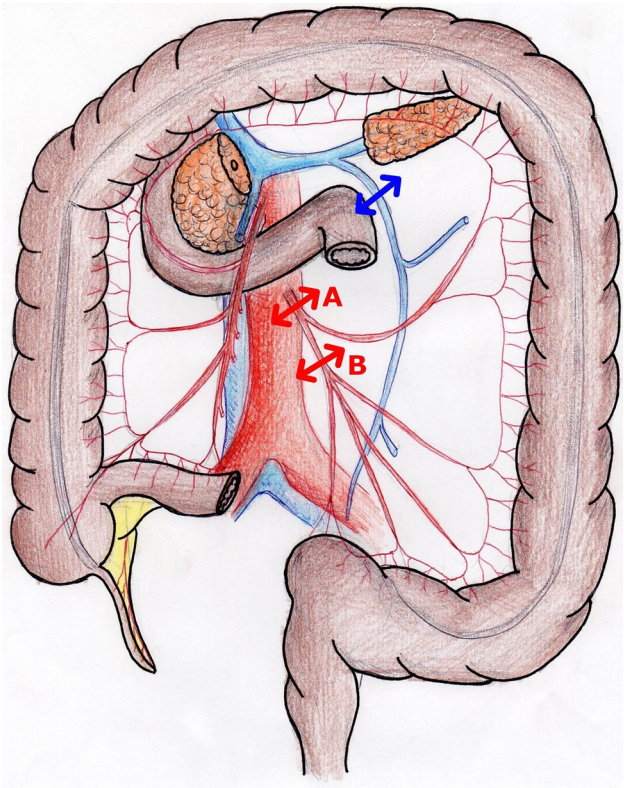

Fig. 2 Drawing of the vascular sections performed in the anatomical study. Inferior mesenteric artery (IMA) section (red arrows), high-tie transection (**a**) and low-tie transection (**b**), inferior mesenteric vein (IMV) section (blue arrow)

-1.9 ± 3.5 cm. In all cases, the distance was less than $+2$ cm. In eight cases (73%), the colonic end did not reach the symphysis pubis, and distance measurement was then negative. Average measurement without arterial section and after vascular repair was, respectively, -1.9 ± 3.5 cm and -1.8 ± 3.5 cm ($p = 0.9$).

The gain in length after high tie was still higher than after low tie (Table 1).

In 80% of cases, regardless of the level, arterial ligation did not allow length gain when not accompanied by IMV section.

For high tie, the mean distance after artery section alone was -1.1 ± 4 cm. After combined artery and vein section, the mean distance was $+10.7 \pm 4.6$ cm, with 91% more than $+6$ cm; in one case, the distance was $+5.7$ cm (Table 1).

For low tie, the mean distance after artery section alone was -1.7 ± 3.7 cm. After combined artery and vein section, the mean distance was $+1.5 \pm 3$ cm. The distance was negative in 2 cases (18%), less than 2 cm in 6 cases (55%), and never exceeded 6 cm (Table 1).

The total mean gain of distance was significantly different between the two groups, with $+12.6 \pm 5.8$ cm in the high-tie group versus $+3.3 \pm 2.2$ cm in the low-tie group ($p < 0.001$).

Discussion

Our study showed that with high ligation of IMV, high tie of the IMA at its aortic origin allows a gain of extra length of about 9 cm over low tie and could be necessary for creation of a low colorectal or coloanal anastomosis without tension. High ligation of IMV was still necessary to obtain a length gain. Buunen et al. analyzed the role of high IMA ligation in an anatomical study, and reported an anastomotic success rate of 80% when preserving the left colic artery and mobilizing the splenic flexure, versus a 100% success rate when performing high ligation [6]. High section of the IMA associated with accurate mobilization of the splenic flexure seemed to significantly reduce

Table 1 Anatomical measurements in 11 specimens

	High tie ($n = 11$) Mean ± SD	Low tie ($n = 11$) Mean ± SD	p
Before vascular ligation	-1.9 ± 3.5	-1.8 ± 3.5	0.93
After arterial ligation	-1.1 ± 4	-1.7 ± 3.7	0.74
After arterial + venous ligation	10.7 ± 4.6	1.5 ± 3	< 0.001
Total mean gain	12.6 ± 5.8	3.3 ± 2.2	< 0.001
Distances for total mean gain	n	n	
< 0	0	2	
$0 < x < 2$	0	4	
$2 < x < 4$	0	2	
$4 < x < 6$	1	3	
> 6	10	0	

Distances in cm

anastomotic tension. Based on a differently designed anatomical study, Bonnet et al. also demonstrated a significantly higher mean cumulative gain in colonic length in high-tie versus low-tie vascular transections in colorectal cancer surgery [7]. Thum-umnuaysuk et al. demonstrate that the only statistically significant lengthening technique is high ligation of IMA plus splenic flexure mobilization plus high ligation of IMV [8].

Our study showed that the level of IMA transection can determine the reach of proximal colon to be anastomosed, and that high-tie, by enabling anastomotic tension to be released, is superior to low-tie ligation, as also demonstrated by Alici et al. [9].

However, if division of the IMA at the aortic origin allows a tension-free anastomosis in distal colorectal resections, it might also diminish the blood supply, because the sacrifice of the left colic artery makes the supply to the anastomosis completely dependent on an intact marginal artery [10]. Hall et al. suggested that the marginal artery provides a more than adequate vascular supply to the descending colon and that the sigmoid colon is not suitable for anastomosis [11]. They concluded that the sigmoid colon can be sacrificed and there should be no hesitation in performing a high tie to avoid tension in low pelvic anastomosis [11].

If routine mobilization of the splenic flexure is not performed during anterior resection for rectal cancer as advocated by some authors, the sigmoid must be preserved to allow tension-free anastomosis; in that case, ligation of the IMA must preserve the left colic artery to secure blood flow in the marginal artery-dependent sigmoid colon [12–14]. However, performing a partial rather than a complete sigmoid resection could be a problem in case of a narrow, thick-walled sigmoid due to diverticulosis [6]. On the other hand, it has been proven that high ligation of the IMA does not represent a source of increased anastomotic leak in rectal cancer surgery [2, 3].

Few studies have reported data concerning the 5-year survival rate for patients with rectal cancer and have no revealed statistically significant differences between the high-tie and low-tie groups [5, 15].

Theoretically, high tie is more likely to damage the nerve plexus around the origin of the IMA, resulting in urinary or sexual dysfunction. However, most surgeons who perform a high-tie propose IMA ligation 2 cm from the aortic origin, and no complications due to autonomic nerve damage at this level have been reported [3, 16, 17].

A limitation of this study is the use of embalmed anatomical specimens, rather than live patients. Formalin fixation causes soft-tissue contraction, which results in shortening of the colorectal tract. However, as body length was not influenced, the relative endpoints are still appropriate. In vivo, the gastrointestinal tract is more flexible and more likely to increase in length. This anatomical study also does not evaluate colon limb vascularization, nor the impact of proximal lymph node dissection on survival rates.

Conclusions

High tie of the IMA at its aortic origin associated with high ligation of IMV allows a gain of extra length of about 9 cm over low tie and could be necessary for creation of a low colorectal or coloanal anastomosis without tension. However, high tie may also diminish the blood supply to the colorectal or anal anastomosis. Therefore, high-powered and well-designed randomized clinical trials are needed to draw definitive conclusion about this dilemma.

Compliance with ethical standards

Conflict of interest Pr. Faucheron received honoraria for punctual interventions, punctual consultancies, and had some reimbursed travels, and pre-paid subscriptions for meetings from AMI, Covidien, Medtronic, Ethicon, MSD, Legrand, Takeda, and Johnson & Johnson Beauté Santé France. Drs. Girard, Trilling, Rabattu, Sage, Taton, Robert, and Chaffanjon have no conflicts of interest or financial ties to disclose.

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 Informed consent was obtained from all individual participants included in the study.

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