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ORIGINAL ARTICLE

Does the degree of calcification of the celiac trunk and superior mesenteric artery on preoperative computerized tomography predict the risk of anastomotic leak after right colectomy? A single center retrospective study



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KEYWORDS

Right colectomy;
Anastomotic leak;
Anastomotic fistula;
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ASA

Summary Anastomotic leak is a serious complication of colonic surgery. The aim of our study is to evaluate the impact of vascular calcifications of the celiac axis and superior mesenteric artery in patients undergoing elective right colectomy, and particularly their relationship to the risk of anastomotic leak.

Materials and methods: We performed a retrospective analysis of preoperative abdominal computerized tomography (CT) scans of patients who underwent right colectomy at the Vendean Departmental Hospital (France) between January 2011 and December 2016. We established a calcification score, which was correlated to the incidence of anastomotic leak and to the patients' American Society of Anesthesiologists (ASA) score.

Results: The charts of 250 patients were reviewed. Twenty-three patients had a postoperative anastomotic leak. A stratified analysis revealed that the risk of developing an anastomotic leak was statistically significantly increased in patients whose calcification score was equal to or greater than 3 ($P < 0.05$). In these patients, the risk was increased by a factor of 3.48 [odds ratio: 3.48 (1.45–8.36)]. A second stratified analysis showed that a calcification score of 2 at the level of the celiac axis takeoff was correlated with a statistically significantly increased risk of anastomotic leak ($P < 0.01$). There was a correlation between a calcification score ≥ 3 and an ASA score ≥ 3 .

Conclusion: A calcification score ≥ 3 correlates to an increased risk of anastomotic leak. The analysis of CT findings is simple, easy and reproducible. This calcification score should be confirmed by a prospective study.

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Colorectal surgery constitutes an important portion of the activity of digestive surgery services. Despite progress in perioperative management, colectomy interventions are still associated with severe morbidity and mortality [1,2]. Anastomotic leak represents the major complication of these interventions. Its prevalence ranges from 1 to 19% [3]. Numerous risk factors have been identified, in particular preoperative malnutrition, an American Society of Anesthesiologists (ASA) score greater ≥ 3 , smoking, and diabetes [4].

Ruggiero et al. [5] showed that the risk of anastomotic fistula varied with the localization of the anastomosis. In their multicenter retrospective study, fistula was found to be 5.6% for ileocolic anastomosis, 7.6% for colo-colonic anastomosis and 16.6% for colorectal anastomosis. A possible explanation of these differences may be explained by variations of the territories of vascularization between the superior and inferior mesenteric artery.

Recently, Eveno et al. [6] have shown that there is a correlation between the degree of aortic calcification and the risk of anastomotic leak in colorectal surgery. This study evaluated the territory of the inferior mesenteric artery.

The objective of our study was to evaluate the impact of calcification of the celiac trunk and superior mesenteric artery in patients undergoing elective right colectomy, and in particular, on the risk of anastomotic leak.

Material and methods

From January 1, 2011 to December 31, 2016, all patients who had undergone elective colectomy, by laparoscopy or by laparotomy, were included retrospectively in our study. For this, we extracted the charts of patients from the French Medical Information Systems Program (MISP) [programme de médicalisation des systèmes d'information (PMSI)] database patients coded with French coding system for procedures "Classification Commune des Actes Médicaux" (CCAM – Common Classification of Medical Procedures) codes HHFA008 (right colectomy with restoration of continuity, laparoscopic preparation plus laparotomy) and HHFA009 (right colectomy with restoration of continuity, by laparotomy).

The preoperative CT scan of all patients was reinterpreted by a senior surgeon who analyzed arterial calcifications at key hemodynamic locations:

- at the takeoff of the celiac trunk;
- at the takeoff of the superior mesenteric artery;
- in the first segment of the superior mesenteric artery (from the takeoff to the first jejunal artery);
- distal segment of the superior mesenteric artery (segment after the first jejunal artery).

This analysis allowed us to establish a calcification score based on the following criteria:

- each segment was assigned a score from 0 to 2;
- a score of 0 corresponded to a total absence of calcification;
- a score of 1 was given to minimal or moderate calcified atheroma involving less than 50% of vessel circumference;
- a score of 2 was given to calcifications involving > 50% of the vessel circumference.

This classification uses the calcium distribution established by Eveno et al. [6]. Summation of the scores according to the locations made it possible to obtain a total score. The maximum score was 8.

Table 1 Calcification score.

	0	1	2
Celiac axis ostium			
Superior mesenteric artery ostium			
1st segment of the superior mesenteric artery			
Distal segment of the superior mesenteric artery			

This score and the localization of calcifications were analyzed and correlated with postoperative anastomotic leak (Table 1).

In the retrospective analysis of the files, an anastomotic leak was diagnosed when there was a disruption of the anastomosis with digestive fluid issuing via a drainage system (intraoperative drain placement or postoperative radiological drain placement) or when disunity was observed during a surgical revision. The postoperative follow-up period for the occurrence of an anastomotic leak was 90 days.

The exclusion criteria were the absence of preoperative CT and patients who had been operated on for Crohn's disease.

Surgical technique

Laparoscopic approach

In this analysis, all the surgeons at our center used this same surgical technique. It is a laparoscopy-assisted right colectomy with transverse or peri-umbilical laparotomy.

With the patient in a double team position, the operator stands between the patient's legs and the assistant on his right. Two 10 mm trocars were placed in peri-umbilical and suprapubic positions, and two 5 mm trocars were placed in the left iliac fossa and in the right iliac fossa. After exploration of the peritoneal cavity, the superior mesenteric axis was identified, and division of the peritoneal leaf of the mesocolon proceeded from bottom to top. Then, mobilization of the right colon was performed passing beneath the right mesocolon up to the hepatic flexure and along to the anterior face of the 2nd portion of the duodenum taking care to avoid elevation or mobilization of the duodenum and pancreas. The blood vessels serving the area to be resected were divided and then the omental attachments of the right side of the transverse colon were freed. Finally, the parietal attachments of the right colon in the gutter and the secondary root of the right mesocolon were freed.

With the right colon completely mobilized, a mini-laparotomy was made either in the midline as an extension of the peri-umbilical trocar incision or as a right transverse incision allowing the mobilized colon to be extracted. The colon was then divided proximally and distally and a hand-sewn side-to-side ileocolic anastomosis was performed. The colon was returned to the peritoneal cavity and the mesenteric gap was closed under laparoscopic control. Drainage was not routinely placed.

Laparotomy approach

The incision was either a transverse laparotomy or a midline laparotomy centered on the umbilicus. Dissection began with release of the right colon from its parietal attachments in the right gutter followed by mobilization of the hepatic flexure and lysis of the omental attachments of the

Table 2 Calcification score and risk of anastomotic leak.

Calcification score	No leak <i>n</i> = 230	Anastomotic leak <i>n</i> = 23	<i>P</i>	Odds ratio [95% CI]
≥ 1	139	18	0.01	2.36 [0.85; 6.57]
≥ 2	104	14	0.157	1.88 [0.78; 4.53]
≥ 3	48	11	0.005	3.48 [1.45; 8.36]
≥ 4	29	5	0.228	1.93 [0.66; 5.58]
≥ 5	17	3	0.345	1.88 [0.51; 6.97]

Table 3 Localization of calcifications: score of 0 vs. scores of 1 and 2.

Localization	Calcification score	No anastomotic leak <i>n</i> = 230	Anastomotic leak <i>n</i> = 23	<i>P</i>
Celiac axis	0	113	7	0.09
	≥ 1	117	16	
Superior mesenteric artery	0	123	8	0.09
	≥ 1	107	15	
Segment I	0	195	19	0.76
	≥ 1	35	4	
Segment II	0	201	17	0.11
	≥ 1	29	6	

right side of the transverse colon. After ligation and division of the mesenteric vessels at their root, the colon was divided proximally and distally followed by a side-to-side hand-sewn anastomosis. The mesenteric defect was then closed. Drainage was not routinely placed.

Statistical analysis

SAS version 9.4 software was used for the statistical analysis. Quantitative data were expressed as means with ranges. Variables were compared using logistic regressions. Depending on the number of the samples, a Chi² or Fisher test was performed. McNemar's test was used as the correlation test between the ASA and the total calcification scores. A *P*-value of < 0.05 was considered statistically significant.

Results

Three hundred and six patients underwent right colectomy from 2011 to 2016. The mean age was 72 years old (19–94) with an average body mass index (BMI) of 25.9 kg/m² (14–45). Sixty patients were ASA 1 (19.6%), 157 ASA 2 (51.3%), 78 ASA 3 (25.5%) and 11 ASA 4 (3.6%). Twelve of the operated patients had Crohn's disease, while 229 had right colic malignancy, 62 had benign right colic adenoma, two had right colon diverticular pathology and one had intestinal duplication.

One hundred forty-five patients had a laparoscopic procedure (47.4%).

Forty-one patients did not have a preoperative CT scan found in their record and were excluded. The twelve patients operated for Crohn's disease were also excluded.

Of the remaining 253 patients, 23 (9.1%) developed an anastomotic leak within 90 days of surgery.

A stratified analysis was performed. It showed that, for a calcification score ≥ 3, the risk of anastomotic leak increased significantly (*P* < 0.05). Indeed, in the group without anastomotic leak, 48 patients had a calcification score ≥ 3 (20.9%), while in the group with anastomotic leak,

11 patients had a score greater than or equal to 3 (47.8%). The risk of developing anastomotic leak was 3.48 times greater in the group with a calcification score of 3 [odds ratio: 3.48 (1.45–8.36)] (Table 2).

A second stratified analysis was made according to the location of the calcifications (Table 3). This analysis revealed that a calcification score of 2 in the celiac trunk was correlated with an increased risk of anastomotic leak (*P* < 0.01) (Table 4). In fact, 30.4% (*n* = 7) of patients with anastomotic leak had a calcification score of 2 at the celiac trunk compared to only 8.3% (*n* = 19) in the non-leak group [odds ratio: 4.86 (1.78–13.3)].

Finally, we compared the analysis of the ASA score and the analysis of our calcification score. A McNemar test was performed and no difference was found between the two scores as prognostic indicators for anastomotic leak (*P* = 0.71). Therefore, the calcification score could be a reflection of the patients' general condition as is the ASA score. In the anastomotic leak group, 12 patients (52%) had an ASA ≥ 3 (*P* = 0.02).

Discussion

Our study found that there was a correlation between the degree of arterial calcification and the risk of anastomotic leak. A calcification score of 3 seems to be a predictor of anastomotic fistula. The analysis of these results is consistent with the study done by Eveno et al. [6] who found the same correlation between the degree of aortic calcification and the risk of fistula on colorectal anastomosis. Calcifications of the vascular axes are a marker of the vascular state of the patient but also of his general condition. This correlation explains the link between calcifications and anastomotic leak. The surgeon's analysis of the preoperative CT scan could allow the surgeon to assess the general condition of the patient but also the postoperative risk of anastomotic leak. An ASA score ≥ 3 is a risk factor for anastomotic leak [4]. In our study, a calcification score of 4 or > 5 is not statistically significant. This result is probably explained

Table 4 Localization of calcifications – score of 0 and 1 vs. score of 2.

Localization	Calcification score	No anastomotic leak <i>n</i> = 230	Anastomotic leak <i>n</i> = 23	<i>P</i>
Celiac axis	≤ 1	211	16	< 0.01
	2	19	7	
Superior mesenteric artery	≤ 1	204	18	0.15
	2	26	5	
Segment I	≤ 1	225	21	0.13
	2	5	2	
Segment II	≤ 1	223	21	0.19
	2	7	2	

by the lack of power of our study and its retrospective nature.

It seemed interesting to us to analyze the superior mesenteric axis and the celiac trunk because they govern the distribution of vascularization of the right colon. Our analysis of the localization of calcifications shows a correlation between the risk of anastomotic leak and the degree of calcification of the vascular axes of the celiac trunk ostia (> 50% of the circumference to the ostium). These results underscore the importance of the main vascular axes in the vascularization of the right colon. This correlation was not found during the analysis of the superior mesenteric axis, but a trend was found ($P=0.15$). The lack of power of our study on this location can explain these results. In 2017, Hoffmann et al. [7] analyzed intraoperative colonic perfusion. In this study, six patients developed an anastomotic leak, five of whom had abnormal perfusion at the beginning of the procedure. Therefore, ostial involvement of major vascular axes may be responsible for abnormal preoperative ileocecal perfusion.

One of the biases of this analysis of calcifications of the vascular axes on CT scan is the absence of evaluation of the arterial flows of the various axes since it is a static examination. It would be interesting to evaluate vascular flow with a dynamic examination since some calcifications can be minimally or asymptomatic. A decrease in arterial flow may lead to hypoperfusion of the anastomotic region and explain anastomotic leaks. This correlation between hypoperfusion and anastomotic leak was demonstrated by Vignali et al. [8] for colorectal anastomosis. At present, intraoperative assessment of intestinal perfusion is a rapidly developing field. It appears that intraoperative use of indocyanine green fluorescence reduces the risk of postoperative anastomotic leak [9]. However, there are not yet any prospective randomized trials of this intraoperative technique.

Due to arterial compromise, patients with a total calcification score ≥ 3 could be considered to have arterial disease. For patients with chronic gastrointestinal ischemia, the use of medical treatment, especially an anti-aggregant agent, is recommended [10]. It would be interesting to evaluate the use of an anti-aggregant agent in this type of patient and to evaluate the risk/benefit of this type of treatment for patients undergoing right colectomy. An endovascular revascularization procedure seems excessive, on the other hand, because of the morbidity related to this type of intervention. Oderich et al. [11] reported a 9% rate of complications in 156 patients undergoing angioplasty on the superior mesenteric artery with or without stent placement (6 distal emboli, 3 branch perforations, 2 arterial dissections, 2 stent migrations and 1 stent thrombosis). In this patient group, there was excess mortality since 18% of

patients died compared to 1.5% in the uncomplicated group. There are few studies on the endovascular treatment of the celiac trunk since revascularization of the superior mesenteric artery is most often the favored procedure. Ahanchi et al. [12] showed that celiac trunk involvement was a poor localization for endovascular angioplasty and stenting.

Obviously, it seems difficult to conclude on the basis of our study that arterial calcification is, by itself, responsible for anastomotic leaks, since the causation of this complication is multifactorial. Acknowledged predictive factors for anastomotic leak after right colectomy include malnutrition, diabetes, smoking, and stapled anastomosis [13,14].

In practice, the analysis of this calcification score can help in the management of our patients. Particularly, for patients with a high score or severely calcified celiac trunk ostium, it might seem reasonable to drain the anastomosis in view of the greater risk of anastomotic leak. These patients should be informed preoperatively of the increased risk of anastomotic leak and therefore the risk of surgical revision.

This study focuses exclusively on right colectomies. For this reason, it seems difficult to propose not performing anastomosis in favor of immediate ileostomy. Ileostomy has its own specific morbidity with immediate postoperative complications (postoperative obstruction, disruption of the ileostomy) but also late complications (dehydration, peritoneal hernia) [15,16].

Conclusion

A CT scan of the arterial axes should be done systematically prior to right colectomy because a calcification score ≥ 3 correlates with an increased risk of anastomotic leak. This analysis is simple, easy and reproducible. The validity of this calcification score should be confirmed by a prospective study.

Disclosure of interest

The authors declare that they have no competing interest.

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