International Journal of Surgery 25 (2016) 123–127

Contents lists available at ScienceDirect

International Journal of Surgery

journal homepage: www.journal-surgery.net

Original research

Is aortoiliac calcification linked to colorectal anastomotic leakage? A case-control study

G.S.A. Boersema [a, *], K.A. Vakalopoulos [a], M.C.J.M. Kock [b], P.M.A. van Ooijen [c], K. Havenga [d], G.J. Kleinrensink [e], J. Jeekel [e], J.F. Lange [a]

[a] Department of Surgery, Erasmus University Medical Center, Rotterdam, The Netherlands
[b] Department of Radiology, Albert Schweitzer Hospital, Dordrecht, The Netherlands
[c] Department of Radiology, Medical University of Groningen, University Medical Center Groningen, Groningen, The Netherlands
[d] Department of Surgery, Medical University of Groningen, University Medical Center Groningen, Groningen, The Netherlands
[e] Department of Neuroscience-Anatomy, Erasmus University Medical Center, Rotterdam, The Netherlands

HIGHLIGHTS

- Left-sided colon anastomoses are associated with a higher leakage risk.
- Correlation of abdominal atherosclerotic calcifications and leakage was investigated.
- No association is found between the calcium score/volume and anastomotic leakage.
- Visualization of the collateral network around the anastomosis may be helpful.

ARTICLE INFO

Article history:
Received 21 October 2015
Received in revised form
16 November 2015
Accepted 4 December 2015
Available online 14 December 2015

Keywords:
Calcium volume
Calcium score
Anastomotic leakage
Prognostic factor
Colorectal surgery

ABSTRACT

Background: Anastomotic leakage in bowel surgery remains a devastating complication. Various risk factors have been uncovered, however, high anastomotic leakage rates are still being reported. This study describes the use of calcification markers of the central abdominal arteries as a prognostic factor for colorectal anastomotic leakage.
Methods: This case-control study includes clinical data from three different hospitals. Calcium volume and calcium score of the aortoiliac tract were determined by CT-scan analysis. Cases were all patients with anastomotic leakage after a left-sided anastomosis (n = 30). Three controls were randomly matched for each case. Only patients with a contrast-enhanced pre-operative CT-scan were included.
Results: The measurements of the calcium score and calcium volume of the different trajectories showed that there was one significant difference with regard to the right external iliac artery. Multiple regression analysis showed a significant different *negative* odds ratio of the presence of calcium in the right external iliac artery.
Conclusion: This study demonstrates that calcium volume and calcium score of the aortoiliac trajectory does not correlate with the risk of colorectal anastomotic leakage after a left-sided anastomosis.

1. Introduction

The occurrence of anastomotic leakage (AL) after colorectal surgery remains a severe complication leading to high morbidity and mortality. Literature has identified the main risk factors for colorectal anastomotic leakage: male gender, pre-operative radiotherapy, low anastomosis (<10 cm from the anal verge), high BMI, high comorbidity, ligation above the left colonic artery, advanced age, and a history of vascular disease [1–8]. Despite the accumulation of knowledge and the improvements brought by novel surgical techniques, the incidence of AL for left sided anastomosis remains high, in the literature leakage rates of approximately 8–18% are mentioned [4,9–14].

Smoking, high BMI, hypertension and hypercholesterolemia are risk factors for AL but also for atherosclerosis [15]. An atherosclerotic plaque is made up of fat, cholesterol, and calcium, hardening

* Corresponding author. Room Ee-173: Laboratory of Experimental Surgery, Erasmus MC, Postbus 2040, 3000 CA, Rotterdam, The Netherlands.
E-mail address: g.boersema@erasmusmc.nl (G.S.A. Boersema).

http://dx.doi.org/10.1016/j.ijsu.2015.12.008
1743-9191/

and narrowing the arteries with limitation of oxygen-rich blood flow. Atherosclerosis is correlated with tissue ischemia and anastomotic leakage caused by poor microcirculation [16–21]. The calcium in the atherosclerotic plaques in the arteries can be scored on computed tomography (CT) by dedicated scoring software. The Agatston calcium score, which is the most validated and most frequently used scoring system as a predictor in previous studies, is the product of the density factor and the area of the calcified plaques (mm^2) [22]. The calcium volume score represents an actual volume of calcium in the artery and reduces calcium measurement variability between scans [23]. The presence of calcium is considered to stabilize the plaque, which decreases the chance of plaque rupture and subsequent ischemic disease [24]. Nevertheless, several studies have shown a correlation between the calcium score and cardiac events [22,25]. Patients with high Agatston scores have a higher frequency of cardiac adverse events whereas a calcium score of zero portrays a very low risk for short-term and midterm cardiac events [26,27]. A correlation has also been described between higher Agatston score, calcium mass, and calcium volume in various abdominal arteries and the risk of AL after colorectal surgery [28].

In this case-control study we investigated whether the calcium score using Agatston or volume score also can be used as a predictive factor for left-sided colorectal anastomotic leakage, based on enhanced CT measurements.

2. Methods

2.1. Study population

During 2009 and 2011 all patients undergoing a primary left sided colorectal anastomosis, operated by colorectal surgeons or surgical residents, who preoperatively received a contrast enhanced abdominal CT-scan with a 5 mm slice thickness, were included. Data was obtained from the following teaching hospitals; the Erasmus University Medical Center Rotterdam (EMC), Albert Schweitzer hospital Dordrecht (ASD), and the University Medical Center Groningen (UMCG). In this retrospective case-control study cases were patients who had radiographically confirmed anastomotic leakage within 30 days postoperatively. At least 3 controls per case were randomly selected and matched by sex, age, ASA classification, diverting stoma and operation, some cases having 4 controls.

Data collection included age, sex, body mass index (BMI), American Society of Anaesthesiologists (ASA) score, medication use, smoking, alcohol use, operative procedure, postoperative complications and postoperative course.

This study was approved by the Medical Ethical Committee of the Erasmus University Medical Center, Rotterdam, Netherlands, in accordance with the Dutch law on medical research in humans. Permit number MEC-2011-121.

2.2. Measurements of calcium score and calcium volume

Two different types of CT-scanner were used in this study. UMCG and EMC used Siemens Somatom Sensation 16 or 64 (Forcheim, Germany) and ASD used Philips Brilliance 40 or 64(Eindhoven, The Netherlands). The calcium scores and volumes were retrospectively determined by two researchers, with Siemens software (Syngo.via® 2009–2012, serial number 100106, Siemens AG, Germany). The score was determined for the total aortoiliac trajectory starting from the T12-L1 disk space (just above the superior mesenteric artery) up to the internal iliac arteries, with a convolution kernel (CK) of 30f, slice thickness of 5 mm, and kV of 120 as described by Komen et al. [28,29]. The calcium score and calcium volume were determined at a threshold level of 500 Hounsfield Units (HU) according to Komen et al. We used a higher threshold, than standard 130 HU, because of the intra-arterial contrast.

Calcium score and volume were determined on the CT-scan at 7 different segments in the aortoiliacal trajectory. The presence of atherosclerotic plaques were computed at several segments: in the abdominal aorta (starting from vertebra T12-L1 up to the aortic bifurcation), the left and right common iliac arteries, the left and right internal iliac arteries, and the left and right external iliac arteries. These segments are representative for the entire aortoiliac trajectory and are important for the vascularisation of the colon and rectum. The vascularisation of the descending colon, sigmoid colon and rectum, which have an important role in the perfusion of the left-side anastomosis, partly arise from the inferior mesenteric artery (IMA). The origin of the IMA is at the ventral side of the abdominal aorta. The IMA is branching into the left colic artery, the sigmoid arteries, and the superior rectal artery. Vascularisation of the rectum originates from the superior, middle and inferior rectal arteries. The latter originates from the internal iliac artery (hypogastric artery) [30].

2.3. Statistical analysis

The statistical analysis was carried out using the Statistical Product and Service Solutions (SPSS Inc., Chicago, USA, version 20.0 for Windows). Univariate analysis between the groups with or without AL was done by the median and mean values of the Mann-Whitney *U* test or chi-square test. Data in the tables on the calcium score and volume are displayed in the original scale of measurement. However, these data were normalized by a logarithmic transformation prior to formal analysis. To determine whether there were significant differences between calcium score and calcium volume in relation to AL or no AL we performed multiple regression by generalized linear models. All reported *P* values were two-sided; a *P* value < 0.05 was considered to indicate statistical significance.

3. Results

In total 36 cases and 167 controls were included in the database, six cases and 62 controls were excluded from further analyses because they could not be matched properly, implicating 135 patients (30 cases and 105 controls) were included. The included patients are from all three hospitals, no significant differences between cases and controls between the centra. Table 1 illustrates the demographic, clinical, and operative characteristics of the included patients. Univariate analysis of the patient and operative characteristics showed significant differences in cardiac comorbidity and packed cell use during or after the operation between patients with or without AL. The mortality rate in the group with AL was not significantly different to the group without AL ($P = 0.533$; Table 2). Significant differences were found for postoperative bleeding, wound infection, postoperative ileus, intra-abdominal abscess, and urinary tract infection in the AL group, ($P < 0.05$; Table 2).

Table 3 presents the mean and standard deviation (SD) of the calcium score and calcium volume of the different trajectories. The measurements show that there is only one significant difference in one trajectory (right external iliac artery), indicating that patients without anastomotic leakage had a significant higher calcium volume in that specific trajectory.

Multiple regression analysis showed significant differences in the odds ratio for AL after higher calcium score in the right external iliac artery (Table 4). Negative odds ratio indicates a negative relationship between the probability of anastomotic leakage and the calcium score or calcium volume.