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ORIGINAL ARTICLE

Differences between computed tomoghaphy and surgical findings in acute complicated diverticulitis

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Summary *Background/Objective:* A preoperative reliable classification system between clinical and computed tomography (CT) findings to better plan surgery in acute complicated diverticulitis (ACD) is lacking. We studied the inter-observer agreement of CT scan data and their concordance with the preoperative clinical findings and the adherence with the intraoperative status using a new classification of diverticular disease (CDD).
Methods: 152 patients operated on for acute complicated diverticulitis (ACD) were retrospectively enrolled. All patients were studied with CT scan within 24 h before surgery and CT images were blinded reanalyzed by 2 couples of radiologists (A/B). Kappa value evaluated the inter-observer agreement between radiologists and the concordance between CDD, preoperative clinical findings and findings at operation. Univariate and multivariate analysis were used to evaluate the predicting values of CT classification and CDD stage at surgery on postoperative outcomes.
Results: Overall inter-observer agreement for the CDD was high, with a kappa value of 0.905 (95% CI = 0.850–0.960) for observers A and B, while the concordance between radiological

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and surgical findings was weak (kappa values = 0.213 and 0,248, respectively and 95% CI = 0.106 to 0.319 and 95% CI = 0.142 to 0.355, respectively). When overall morbidity, mortality and the need of a terminal colostomy were considered as main endpoints no concordance was observed between surgical and radiological findings and the CDD (P=NS).
Conclusions: The need for a more accurate classification of ACD, able to better stage this emergency, and to provide surgeons with reliable information for the best treatment is advocated.

1. Introduction

Diverticular disease of the colon is a common disease in Caucasian population showing growing incidence and prevalence according to lifestyle habits. Clinical manifestations may vary from simple inflammation to complicated form.[1–4] Treatment will depend on the severity of the disease: open or laparoscopic surgical approach,[5] being indicated in patients with free perforation and peritonitis, while conservative treatment is the mainstay for mild inflammation without perforation or covered perforation.[6–10]

Over the last years, computed tomography (CT) gained increasing importance and became the gold standard to radiologically stage the disease and to differentiate complicated from uncomplicated cases.[11,12] However, therapeutic decisions taken according to the CT findings, should presume an inflammatory stage matching among radiological, clinical and intraoperative findings,[13,14] which it is not always possible.

In the attempt to standardize treatment based on clinical and instrumental findings, several classifications were suggested. To date, the stages were stratified according to Hinchey et al.[15] as modified by Wasvary et al.[16] and according to Hansen and Stock.[17] However, these classifications are mainly used in the western countries literature but are often insufficient to decide upon treatment options for acute complicated diverticulitis (ACD) because colonic perforation without generalized peritonitis could be treated nonoperatively. Therefore, at the beginning of this century, Ambrosetti et al.[18] proposed a simple CT scan classification of the diverticulitis dividing into moderate or severe in accordance with the severity of the disease and, in 2015, Sartelli et al.[19] presented a new simple classification system dividing acute diverticulitis in uncomplicated and complicated. More recently, a new classification of diverticular disease (CDD)[20] was created based on the previous Hinchey and Hansen-Stock,[21] trying to turn them into a CT based classification.

The latter seems to overcome the limits of the previous classification including the latest scientific knowledge regarding ACD through a comprehensive review of the literature and with the aid of 6 work groups of German experts in the different fields of the disease.

The present study aimed to estimate, based on the CDD, the concordance between radiological and surgical findings in ACD and the inter-observer agreement of CT data between radiologists.

2. Material and methods

From a prospective database including patients affected with ACD observed from January 2006 to June 2016 at Policlinico Umberto I and St. Andrea Hospital, the two Academic hospitals of the "Sapienza" University, Rome, Italy, a retrospective study was performed, enrolling 152 consecutive patients who underwent emergent surgery for ACD.

Clinical data were collected from a retrospective chart review of individual patients and a review of the database. Indication for surgery was based on clinical and radiological data and intraoperative findings were retrieved from the surgical report with specific details of paracolic or mesocolic abscess with diameter, free air/fluid perforation and quantification of fluid.

Patients included were those submitted to a contrast-enhanced CT scanning within 24 h before emergent surgery, to avoid any comparability bias between radiologic and surgical findings due to a longer interval. Indications for emergent surgery were patient instability, septic status, complicated disease with clinical sign of diffuse peritonitis, re-admission within 1-month for ACD previously treated conservatively and presently with clinical sign of peritonitis. Exclusion criteria were operations performed after 24 h of admission, patients who responded to medical therapy or underwent percutaneous drainage. Mortality was identified as any death occurring within the first 30 days from admission or during the entire hospital stay. Morbidity was evaluated according to Clavien–Dindo Classification[22] and according to Surgical Site Infection (SSI) Classification.[23]

All preoperative CT scans were independently reanalyzed by two couples of experienced consultant radiologists. They were asked to restage the disease severity according to the CDD (Table 1). In our centers, we usually classify patients affected with ACD with the Hinchey[15] classification, which is difficult to be adapted for CT scan purpose. Scans were evaluated for the presence of specific imaging features, including bowel wall thickening (≥5 mm), diverticulosis, an inflamed diverticulum, pericolonic inflammation, a pericolonic fluid collection, bowel obstruction, free fluid, extraluminal air (local or diffuse), bowel wall abscess, and colonic fistula. The observers were blinded for patient and clinical data, other imaging examinations, other CT readings and findings during follow-up.

Different CT scanners were used in the two hospitals including MX 8000 Philips, Philips Healthcare Medical

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Table 1 Classification of diverticular disease (CDD).

Type 0	Asymptomatic diverticulosis[a]
Type 1	Acute uncomplicated diverticular disease (DD)/diverticulitis
Type 1a	Diverticulitis/DD without reaction of surrounding tissue[b]
Type 1b	Diverticulitis with phlegmonous reaction of surrounding tissue[c]
Type 2	Acute complicated diverticulitis as in 1b, additionally:
Type 2a	Microabscesses (<1 cm)[d]
Type 2b	Macroabscesses (>1 cm)[e]
Type 2c	Free perforations[f]
Type 2c1	Purulent peritonitis
Type 2c2	Fecal peritonitis
Type 3	Chronic DD recurrent or chronic symptomatic disease
Type 3a	Symptomatic uncomplicated DD[g]
Type 3b	Recurrent diverticulitis without complications[h]
Type 3c	Recurrent diverticulitis with complications[i]
Type 4	Diverticular bleeding[j]

Legend: CD = Complicated Diverticulitis; DD = Diverticular Disease.
[a] Incidental finding; asymptomatic → no disease.
[b] Symptoms related to diverticula; signs of inflammation (laboratory); optional: typical cross-sectional imaging.
[c] Signs of inflammation (laboratory); obligatory: cross-sectional imaging → phlegmonous diverticulitis.
[d] Covered perforation, small abscess (≤1 cm); minimum paracolic air.
[e] Paracolic or mesocolic abscess (>1 cm).
[f] Free perforation, free air/fluid generalized peritonitis.
[g] Typical symptoms; signs of inflammation (laboratory): optional.
[h] Signs of inflammation (laboratory): present; cross-sectional imaging: typical.
[i] Detection of stenoses, fistulas, conglomerate.
[j] Detection of the sources of the bleeding.

(Philips North America Corporation, Andover, USA) and GE light speed 16 Pro, GE Healthcare. The CT scan protocols were comparable. For four-slice CT scanners the following protocol was used with an effective level of 200 mAs, 120 kV, 2.5 mm collimation, 3 mm slice width and 0.5 s rotation time. For 64-slice CT scanners the protocol was with an effective level of 165 mAs, 120 kV, 0.6 mm collimation, 3 mm slice width and 0.28 s rotation time. 125 mL contrast medium (Iomeron 350, Bracco U.K. Ltd) was injected intravenously at a rate of 3 or 3.5 mL and the CT was performed after 35- and 75-s delay.

2.1. End-points of the study

Primary endpoint of our study was to assess the inter-observer reliability and concordance of computed tomography CDD; secondary endpoint was to assess the concordance and agreement between computed tomography CDD and macroscopic findings at surgical exploration in acute complicate diverticulitis; and tertiary endpoint was to assess the sensitivity, specificity, positive and negative predictive values of CT for all stages of disease and for post-operative outcomes.

2.2. Statistics

Statistical analyses were performed using MedCalc for Windows, version 14.0 (MedCalc Software, MariaKerke, Belgium). Patient demographics were analyzed using means ± SD for quantitative variables and using frequencies and percentage for categorical variables. Differences in distribution were calculated using the Mann–Whitney and ANOVA test for continuous variables, and the chi-square or Fisher's exact test depending on the number of cases in each subgroup for categorical variables. Multiple logistic regression analysis was used, including in the model only the variables resulted significant at univariate analysis. To test the concurrent validity between observers and tools (CT and surgery), agreement and chance-corrected agreement (k) between pairs of tools applied to the same patients were assessed. A k value of 1.000 indicates perfect agreement, a k of 0.000 no agreement and a k of −1.000 complete disagreement. On the other hand, k values between 0.400 and 0.750 are considered to indicate 'fair - good' agreement and k values superior to 0.750 'excellent' agreement beyond chance.[24]

3. Results

3.1. Patient and surgical characteristics

From a total of 657 patients admitted for acute complicated diverticulitis, 152 patients (76 males, 76 females; median age 63.4 years) underwent emergent surgery after an early (within 24-h) CT-scan examination. ASA status was I in 9 (5.9%) patients, II in 61 (40.1%), III in 51 (33.5%), IV in 28 (18.5%) and V in 3 (2.0%) patients (mean 2.5). Thirty-one (20.4%) patients had no comorbidities, 46 (30.3%) had one comorbidity, 28 (18.4%) had 2 comorbidities and 47 (30.9%) had more than 2 comorbidities.

All patients had nausea and/or vomiting, sharp pain in the left lower flank with peritonitis and rebound tenderness. Abdominal distension was present in 43 (28.3%) patients, a palpable mass in 24 (15.8%), and fever was associated in 76 (50%). Inflammatory laboratory tests were always abnormal. Mean white blood cell count was 14.35 10^9/L (range 0.49–51.77 10^9/L). Mean fibrinogen was 778 mg/dL (range 689–1334 mg/dL), mean C-reactive protein (CRP) was 12 678 mg/L (range 8745–15 491 mg/L) and mean procalcitonin was 3.2 ng/mL (range 2.5–6.3 ng/mL).

A total of 89 (58.6%) patients underwent a sigmoid resection with anastomosis (conventional 69 and laparoscopic 20, either protected - 21 patients - or unprotected by lateral ileostomy - 68 patients), 45 (29.6%) patients were treated by a sigmoid resection without anastomosis (Hartmann procedure), 13 (8.5%) patients were treated by a diverting lateral ostomy (either ileal or colic) followed by a colon resection during another hospitalization and 5 (3.3%) patients underwent laparoscopic colorrhaphy with toilette and drainage.

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3.2. Inter-observer agreement of CT-scan

Inter-observer agreement for the CDD was high, with a k value of 0.912 (95% CI 0.856 to 0.969) for the two couples of radiologists A and B. They disagreed in 13 (8.5%) cases, specifically, in 11 out of 13 (84.6%) for one CDD class, and for two CDD classes in 2 cases.

3.3. Concordance between CT-scan and surgical findings

The adherence between findings at surgery and at preoperative CT-scan regarding CDD classification was weak. The weighted k values demonstrating agreement among CDD at surgery and radiologist A and B were 0.240 and 0.277, respectively (95% CI = 0.122 to 0.358 and 95% CI = 0.162 to 0.391). The concordance was low with a discrepancy rate of 28.9%. Specifically, 30 patients belonged to surgical class 2b, 81 to class 2c1 and 41 to class 2c2. Overall there were 84 disagreements between CDD at CT-scan and findings at surgery; in 62 (73.8%) for one CDD class and in 22 (26.2%) for two CDD classes.

3.4. Post-operative outcomes

Mean operative time was 134 ± 63 min (range 89–204 min) and mean length of stay was 13.6 ± 3.8 days (range 2–105 days). Mortality rate was 12.5% (19/152) and overall and abdominal morbidity rates were 35.2% and 29.4%, respectively. Tables 2 and 3 show the univariate and multivariate analyses considering factors affecting overall morbidity, specific abdominal morbidity, mortality and the need of a terminal colostomy. CDD at preoperative CT scan was able to predict, at univariate analysis, abdominal morbidity and mortality, while age and ASA status were independent prognostic indicators at multivariate analysis for mortality and surgical CDD was able to predict mortality and the need for colostomy.

4. Discussion

The principal finding of our research was that the concordance between surgery and contrast-enhanced CT scan was limited thus directly reflecting on the widespread applicability of the CDD. The underestimation of the CT scan findings when compared to the clinical patient status' influences, at least theoretically, the decision to perform an emergent operation especially, at present days, where noninvasive therapeutic options are available. The ideal algorithm for ACD depends, in fact, on the severity of disease staged at admission according to a classification system. In particular, conservative medical management, interventional radiology with abscess drainage, minimally invasive surgery, standard resective open surgery, up-to damage control surgery[25–27] can be chosen once the ACD is adequately staged. A classification which include CT scan and clinical findings, should be able to determine the extent of the disease and surgeons should use its results to better plan an optimal treatment. The CDD appears the more detailed and recent classification, but at present had no clinical confirmation of its sensitivity and specificity.

The endpoints of our study were to determine the effective agreement between radiologists in analyzing the CT findings, as well as the concordance between CT staging and the macroscopic findings at surgical exploration, with the intent to evaluate if CT scan was able to give a homogenous and precise preoperative stage of ACD, thus offering to surgeons the correct information. Our study showed a high concordance between observers in staging ACD; k value demonstrated homogeneity in the evaluation of CT findings between radiologists, with a discrepancy rate of 8.5%, corresponding, in the majority of cases to a disagreement for only one CDD class.

Conversely, we observed that the high inter-observer agreement was not associated with the surgical findings. We noted, in fact, that CT staging based on the CDD understaged ACD for at least one class. Our study showed that CT scan has a high specificity and a low sensitivity for CDD 2c1

Table 2 Univariate analysis considering factors affecting overall morbidity, abdominal morbidity, terminal colostomy and mortality.

	Overall morbidity	Abdominal morbidity	Terminal colostomy	Mortality
	P	*P*	*P*	*P*
Sex	.03	.852	.402	.02
Age (mean, years)	.0001	.981	.005	.0001
ASA	.0003	.737	.002	.0001
Comorbidities	.0007	.615	.118	.0007
WBC (mean, 10^9/L)	.364	.417	.911	.407
Fibrinogen (mean, mg/dL)	.287	.516	.439	.831
CRP (mean, mg/L)	.598	.451	.621	.878
Procalcitonin (mean, ng/mL)	.198	.319	.201	.307
Surgical CDD	.472	.01	.0001	.001
CDD Radiologist A	.151	.01	.151	.04
CDD Radiologist B	.235	.05	.116	.04
Operative time (mean, minutes)	.975	.126	.673	.78
ICU stay (mean, days)	.041	.0641	.673	.78
Surgery (Open/Laparoscopy)	.857	.982	–	.19

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Table 3 Multivariate analysis considering factors affecting overall morbidity, mortality and terminal colostomy.

	Overall morbidity	Mortality	Terminal colostomy
	P (OR; CI)	*P* (OR; CI)	*P* (OR; CI)
Sex	.285 (.569; .202–1.6)	–	–
Age	.019 (1.052; 1.008–1.099)	.038 (1.112; 1.005–1.23)	.156 (1.033; .987–1.080)
ASA	.417 (1.307; .684–2.498)	.002 (7.926; 2.042–30.79)	.938 (.974; .510–1.863)
Comorbidities	.141 (1.305; .915–1.863)	–	–
Surgical CDD	.616 (1.150; .665–1.989)	.012 (2.361; 1.840–9.633)	.0001 (5.206; 2.485–10.9)
CDD Radiologist A	.068 (.135; .015–1.169)	–	–
CDD Radiologist B	.117 (5.688; .646–50.01)	–	–

Legend: OR=Odds Ratio; CI=Confidence Interval.

and 2c2, meaning that a significant number of patients were under-staged (as CDD 2b or 2c1) at the CT scan assessment. The discrepancy may be related to the relatively small amount (<150 mL) of free intra-abdominal pus or fecal material found at surgery and missed at the emergent CT scan. The risk of bias linked to an unprecise or misdescription of surgical reports was very limited because operative reports always included the presence and diameter of paracolic or mesocolic abscess, and quantification of fluids in generalized peritonitis, and all patients who underwent emergent surgery only belonged to classes 2b-2c2 of the CDD classification.

Similar findings were reported by Gielens et al.[6] in a recent study assessing the accuracy of preoperative staging of perforated diverticulitis by CT scan. In this retrospective study on 75 patients, they observed in 42% of cases, an erroneous CT evaluation of perforated diverticulitis and concluded that the preoperative CT scanning accuracy is low.[6] Moreover, Fung et al.[28] demonstrated that the use of a CT grading system for acute complicated diverticulitis can predict the need for acute radiological or operative intervention only in 66% of cases.

Conversely, some Authors claimed a high positive predictive value of CT scanning for ACD diagnosis.[14,28] Lohrmann et al.[29] demonstrated that CT scanning correctly staged in 93% of patients, but in their series, there were only 7 patients with perforated diverticulitis and generalized purulent or fecal peritonitis, suggesting a large heterogeneity of patients, with a small amount of perforated diverticulitis with peritonitis. Ritz et al.[14] in a retrospective series of 204 patients, showed a high positive predictive value of CT scanning for perforated diverticulitis with generalized purulent or fecal peritonitis (100 and 94%), but in 79% of their patients, surgery was performed after a mean of 7 days from admission and CT scan assessment, with a possible bias due to the potential critical modifications and negative evolution of clinical findings. Moreover, this series demonstrated that for a confined pericolic phlegmonous ACD, the positive predictive value of CT for a correct diagnosis, was only 52%.

Shaikh and Krukoski,[30] using the Ambrosetti classification,[18] found that patients affected with a severe diverticulitis on CT scan had a greater need for surgery either at admission or during the follow-up. Similarly, Trenti et al.[31] studied the recurrence rate according to the Ambrosetti classification guided by CT scan and observed a significant risk of recurrence after an initial severe diverticulitis.

We also observed that CDD has a low efficacy to predict the postoperative outcome. At the multivariate analysis, in fact, preoperative CDD was not significantly related to mortality, morbidity, and the need of a terminal colostomy. A more accurate preoperative staging between CDD 2b and 2c1 ACD should be pursued in order to plan a correct surgical strategy, because the previous surgical dogmas are questioned, and free air in the abdomen is no more a strict indication to surgery.

Surgical treatment of ACD is an area of controversy among surgeons[32–35]; we choose different strategies, which can be resumed to open or laparoscopic resection with primary anastomosis or Hartmann procedure. The selection of the appropriate treatment was influenced by patient status considerations' and surgical preference. Our population was affected with an acute abdomen requiring emergent treatment and the majority of them had critical medical conditions. The conventional Hartmann procedure was performed especially in the first five-year of the experience and was used in patient affected with acute perforated diverticulitis with peritonitis. However, colon resection with primary anastomosis was performed in the majority of our patients associated with a diverting loop ileostomy because of generalized intrabdominal contamination or caliber mismatch from the two colic segments unwarranted primary anastomosis.

We are also well aware that our study has several limitations. Firstly, the relatively small number of patients included in the present series; secondly, the retrospective nature of the study; thirdly, our series encompass a period of 10 years in which the indication of surgery varied greatly.

In conclusion, we recommend a major integration of the CDD with the clinical status and the addition of more detailed radiological findings to better classify patients affected with ACD in order to provide the most detailed information to plan a correct surgical strategy.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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