European Journal of Trauma and Emergency Surgery (2022) 48:4283–4291
https://doi.org/10.1007/s00068-022-01911-4

ORIGINAL ARTICLE

How to strengthen the management of acute diverticulitis: the utility of the WSES classification—a prospective single-center observational study

Juan Carlos Sebastián-Tomás[1] · Segundo Angel Gómez-Abril[1] · Tomás Ripollés[2] · Andrea Manrique[2] · Teresa Torres-Sanchez[1] · María Jesús Martínez-Pérez[2]

Received: 8 September 2021 / Accepted: 29 January 2022 / Published online: 14 February 2022

Abstract

Purpose This study aimed to validate the World Society for Emergent Surgery (WSES) scale for the management of acute left-sided colonic diverticulitis (ALCD).

Methods An observational study based on a prospective database of patients with ultrasound (US) and computerized tomography (CT) confirmed ALCD was conducted at our center from April 2018 to May 2019. The primary outcome was the success rate of outpatient management. Secondary outcomes were the association between different WSES stages, clinical and analytical parameters, treatments modalities, and outcomes, and the accuracy of US for management decisions.

Results A total of 230 patients were included. Outpatient management was successful in 51/53 (96.23%) cases with ALCD stage 0 and 62/72 (86.11%) patients with stage 1A. There were no differences in age ($p=0.076$) or the presence of pericolic air bubbles ($p=0.06$) between patients who underwent admission or outpatient management. Clinical and analytical data, treatment decisions, and outcomes showed statistically significant differences between WSES stages. In 7/12 patients with stage 2A, percutaneous drainage or emergency surgery was required. All cases with stage 2B (distant air) underwent conservative management without the need for emergency or elective surgery. The accuracy of US WSES stages for management decisions, when compared with CT, was 96.96%.

Conclusion The WSES classification for ALCD seemed to be valid helping clinicians in the decision-making process to select between admission or outpatient management. Differences in clinical and analytical data, elected treatments, and outcomes were found between WSES stages. The US WSES stages showed high accuracy for management decisions.

Keywords Acute diverticulitis · Classification · Emergency surgery · Computed tomography

Introduction

The prevalence of diverticulosis of the colon is rapidly increasing worldwide [1]. Although diverticula are most frequent in elderly individuals, evidence is emerging that the condition has increased particularly in subjects under 45 years of age [2]. Diverticular disease, defined as clinically significant and symptomatic diverticulosis, is an important cause of hospital admissions and has significant healthcare-related costs in industrialized societies [3]. Among patients

✉ Juan Carlos Sebastián-Tomás
jcst1990@gmail.com

Segundo Angel Gómez-Abril
sean99cartu@yahoo.com

Tomás Ripollés
ripolles.tom@gmail.com

Andrea Manrique
andreaman13@gmail.com

Teresa Torres-Sanchez
mteresats@aecirujanos.es

María Jesús Martínez-Pérez
chusjmartinez@gmail.com

[1] Department of General and Digestive Surgery, Hospital Universitario Doctor Peset, Avenida Gaspar Aguilar 90, 46007 Valencia, Spain

[2] Department of Radiology, Hospital Universitario Doctor Peset, Valencia, Spain

with diverticulosis, acute colonic diverticulitis (ACD) occurs in approximately 4–25% of patients, and its incidence increases with age [4].

The sigmoid colon is usually the most frequently involved, while other locations are rarely affected [5]. Due to the discrepancy between clinical presentation and the extent of ACD, imaging evaluation is mandatory. Computerized tomography (CT) remains the gold standard in the assessment of ACD, although ultrasound (US) examination is considered an alternative as a first approach [6]. Although it has always been controversial, the value of US for complicated ACD has been recently reported with high sensitivity (84%) and specificity (95.8%) [7].

There are several proposed scales to grade the findings and the severity of ACD. The Hinchey classification [8] and its modification proposed by Wasvary et al. [9], have probably been the most employed in the international literature. Others like Kaiser et al. [10] staging system, the modified Neff classification [11], or the German Classification of Diverticular Disease [12] have been published to improve the limitations of the Hinchey classification, but none of them have prevailed on the daily practice. In 2015, the World Society for Emergency Surgery (WSES) developed a simple classification system of acute left-sided colonic diverticulitis (ALCD), that includes some new elements like staging distant air as an independent grade [13]. Although it was initially based on CT scan, its applicability to US findings has also been described [7]. However, after reviewing the literature and to the best of our knowledge, we have not identified any article validating this scale in a single-center day-to-day clinical practice.

We hypothesize that the WSES classification could help clinicians in the decision-making process to decide between admission or outpatient management and to choose the best option available for treatment and according to the different stages, with potential applicability of US and not only CT scan to this purpose. Therefore, this study aimed to validate the WSES classification for the management of ALCD by analyzing the success rate of outpatient treatment in low stages as well as the association between different WSES stages, clinical and analytical parameters, treatment modalities, and outcomes, and the accuracy of US to choose patient management.

Methods

Study design and participants

This observational study was based on a supplementary analysis of a prospective database including 240 adults (≥ 18 years old) with ACD diagnosed from April 2018 to May 2019 at our center. The original study attempted to evaluate prospectively the diagnostic value of intestinal US in the differentiation between uncomplicated and complicated ACD in a consecutive cohort of patients [7]. It was performed according to the last version of the Declaration of Helsinki. The protocol was reviewed and approved by the local ethics committee (CEIC:19/18). Written informed consent was obtained from all patients.

For the present study, we included all subjects with CT diagnosis of ALCD during the previously mentioned period. Initial management after diagnosis was protocolized and varied depending on patients' comorbidities, clinical presentation, blood test results, and the grade of ALCD determined by CT. After evaluation at our emergency department, the surgeon decided between outpatient management or admission with or without invasive treatment based on clinical data, blood tests data, and image findings.

Subjects selected for outpatient management were discharged from the hospital and given oral amoxicillin and clavulanic acid (875 mg per 125 mg every 8 h) or, in case of penicillin allergy, the combination of ciprofloxacin (500 mg every 12 h) and metronidazole (500 mg every 8 h). Treatment was prolonged for 10 days. Pain control was achieved with paracetamol (1000 mg every 8 h), metamizole (575 mg every 8 h), or dexketoprofen (25 mg every 8 h), if necessary. Diet recommendations (restricted oral intake to a liquid diet for 3 days and a low-fiber diet for 2 weeks) were given in the detailed written information sheets and explained to the patient before discharge. Patients were visited in the outpatient clinic around day 7 after discharge.

Those patients who required hospitalization (abscess, distant free air, diffuse fluid, or those with mild ALCD but with extensive sigmoid inflammation or poor clinical condition) were treated with intravenous antibiotics: amoxicillin and clavulanic acid (1 g per 125 mg every 8 h) or Ertapenem (1 g every 24 h) in case of a mild condition, or Meropenem (1 g every 8 h) in case of a severe condition. If penicillin allergy, the combination of intravenous ciprofloxacin (500 mg every 12 h) and metronidazole (500 mg every 8 h) was of choice. Intravenous analgesics were similar to those given in the case of discharged patients. We associated an initial restricted oral intake with a liquid diet followed by progressive oral tolerance. Blood test was performed on day 3. Oral antibiotics were continued after discharge to complete 10 days of treatment. Percutaneous drainage was indicated in patients with an abscess size ≥ 5 cm. Emergency surgery was performed by the surgeon on call in cases of diffuse peritonitis or an abscess that was not resolved with percutaneous drainage associated with a poor clinical condition.

During follow-up, patients were visited in the outpatient clinic after 1, 3, and 12 months. Colonoscopy was performed after 8 weeks according to our protocol in patients with a first complicated case of ACD, suspicion of neoplasm, or recurrent ACD.

Imaging evaluation

All patients with clinically suspected ACD underwent imaging evaluation with intestinal US and subsequent contrast-enhanced abdominopelvic CT. Both US and CT evaluations were performed by the on-call emergency radiologist. The data collection form for image findings was completed during this evaluation. Protocolized intestinal US on days 7–10 was performed by an experienced abdominal radiologist.

Primary and secondary outcomes

The primary outcome was to determine the success rate of outpatient treatment in patients with stages 0 and 1A. Secondary outcomes were to analyze the discrepancies between the different WSES stages, in terms of clinical and analytical parameters, treatment modalities, and patient outcomes as well as to evaluate the accuracy of US examination to decide patient management when applying the WSES classification to US findings.

Data collection and definitions

The WSES classification (Table 1), proposed in 2015 by Sartelli et al. [13], was selected for grading ALCD, as it presented a very good agreement with the individual outcomes evaluated. Although it was initially designed for CT scan, we also investigated its applicability for US findings. For statistical purposes, patients with stages 0 and 1A were combined and considered as mild ALCD, as most of these patients could be managed with outpatient treatment according to our protocol. Stages 1B–4 were regarded as severe ALCD.

Following data were registered: demographic data and comorbidities; symptomatology; physical examination; blood test analysis; US and CT findings; WSES stage for both image techniques; treatment and management (outpatient vs. admission) and re-admissions, defined as admission during the first 30 days after ALCD diagnosis. The follow-up was one year.

Table 1 WSES classification stages according to Sartelli et al.

Uncomplicated diverticulitis
Diverticula, thickening of the wall, increased density of the pericolic fat
Complicated diverticulitis
1A Pericolic air bubbles or little pericolic fluid without abscess
1B Abscess ≤ 4 cm
2A Abscess > 4 cm
2B Distant air (> 5 cm from inflamed bowel segment)
3 Diffuse fluid without distant free air (no hole in colon)
4 Diffuse fluid with distant free air (persistent hole in colon)

Invasive treatments were percutaneous drainage and emergency surgery. The success rate of outpatient treatment was considered in those patients who did not need readmission during the first 30 days following the diagnosis of ALCD after ambulatory management. The accuracy of US WSES stages for management decision was defined as the percentage of patients who underwent the same management as decided based on CT findings.

Statistical analysis

All categorical data are presented as the number of cases and percentages. Kolmogorov–Smirnov test was used for normality verification. Continuous nonparametric data were expressed as the median with percentiles 25 and 75 (P_{25}–P_{75}), and normal variables were expressed as the mean with standard deviation (SD). Pearson's chi-square or Fisher's exact tests and Mann–Withney or Kruskal–Wallis test were used, when indicated, to compare data between patients included in the different stages proposed by the WSES classification. Sensitivity (*S*), specificity (*E*), positive predictive value (PPV), negative predictive value (NPV), and accuracy of US were evaluated. Results with a p value < 0.05 were considered statistically significant. Statistical analysis was carried out using IBM SPSS Statistics 25® (IBM, Armonk, NY, USA).

Results

From the original database, 230 patients with CT confirmed ALCD were included, while 10 patients with ACD in other locations were excluded. There were 122 (53%) women and the overall median age was 59 (P_{25}–P_{75} = 50–72) years. One-hundred and ninety-nine (86.52%) cases of ALCD were located in the sigmoid colon and 31 (13.48%) in the descending colon. Demographic data, comorbidities, and other clinical features are displayed in Table 2. No statistical differences were identified between patients in different WSES stages.

Patients' outcomes divided by stage are described in Table 3. There were 192 (83.48%) patients with mild ALCD (stages 0 and 1A) and 38 (16.52%) with severe ALCD (stages 1B to 4). Kruskal–Wallis test revealed a variety of analytical parameters between different ALCD stages with statistically significant differences, except for serum albumin and serum creatinine. The same occurred with the length of hospital stay (LoHS). An invasive treatment modality was required in 13 (5.65%) patients. In all cases, percutaneous drainage was successful and the abscess was smaller or had resolved in subsequent imaging studies. The six cases of ALCD stage 2B were managed with conservative treatment after initial evaluation without the need of emergency

Table 2 Demographic data and comorbidities ($n = 230$)

Age (year), median (P_{25}–P_{75})	59 (50–72)
Gender, *n* (%)	
Male	108 (47%)
Female	122 (53%)
BMI, median (P_{25}–P_{75})	27.08 (25.24–31.16)
Arterial hypertension, *n* (%)	92 (40%)
Diabetes mellitus, *n* (%)	26 (11.3%)
Dyslipidemia, *n* (%)	69 (30%)
Renal disease, *n* (%)	9 (3.9%)
Liver disease, *n* (%)	6 (2.6%)
Immunosuppression, *n* (%)	6 (2.6%)
Smoker, *n* (%)	32 (13.9%)
Alcoholism, *n* (%)	5 (2.2%)
Diverticulosis, *n* (%)	121 (52.6%)
Previous episode of ACD, *n* (%)	101 (43.9%)
Number of previous episodes of ACD, median (P_{25}–P_{75})	2 (1–3)
Previous complicated ACD, *n* (%)	25 (10.9%)
Previous ACD surgical intervention, *n* (%)	3 (1.3%)

BMI body mass index, *ACD* acute colonic diverticulitis

surgery, as well as two patients with stage 3 that had a small amount of diffuse fluid and good conditions. Emergency surgery was performed in 5 (2.17%) patients: (1) One patient with ALCD stage 1A on CT scan developed a clinical worsening with shock septic 2 days after admission. Repeated TC scan revealed a progression to stage 3; (2) Two patients with an abscess > 4 cm. (stage 2A) that were not eligible for percutaneous drainage; (3) Another 2 patients with diffuse fluid with or without distant free air on CT scan and poor clinical condition. All of them were operated on during the first 24 h after admission, except one patient that underwent surgery on day 4.

Patients discharged from the emergency department were mainly classified in stages 0 and 1A, with 53/70 (75.71%) and 72/122 (59.02%), respectively ($p = 0.027$). The two patients with ALCD stage 1B who underwent outpatient treatment were young people with an abscess less than 1.5 cm and excellent clinical condition. The discharge was consensual and none of them required readmission. Differences between patients with ALCD stages 0 and 1A admitted to hospital vs. those with outpatient treatment are shown in Table 4. There were no differences in age ($p = 0.076$) or the presence of pericolic air bubbles ($p = 0.06$) between patients who underwent admission or outpatient management.

Readmission occurred in 7/103 (6.80%) patients admitted to hospital and 12/127 (9.45%) patients with outpatient treatment ($p = 0.467$). The latter was successful in 51/53 (96.23%) cases with ALCD stage 0 and 62/72 (86.11%) patients with stage 1A ($p = 0.112$). During follow-up, we noticed that less than half of patients with stage 2A were asymptomatic after 1 month, while in all the rest of the groups, the percentage of asymptomatic patients was at least 75%. Subjacent neoplasm simulating ALCD was diagnosed during follow-up in one (0.43%) case with initially suspected stage 0 ALCD.

Although WSES classification was developed for CT, the radiologist did not identify any problems applying the WSES classification for US evaluations. This fact allowed us to assess a reliable correlation between US and CT in 193 (83.91%) cases. That corresponded to 165/192 (85.94%) patients with mild ALCD and 28/38 (73.68%) with severe presentation ($p = 0.06$). Patients with ALCD stage 2B were all misdiagnosed with US (0/6). According to US findings, 30 patients were under-diagnosed and 7 were overdiagnosed by US. However, management decision might have only differed in 7 patients: (1) Six patients with CT stage 1B (2 patients) and 2B (4 patients) that were under-diagnosed by US because of a small abscess or distant free air that was not identified by this technique; (2) one patient with CT stage 1A overdiagnosed by US (stage 3) that finally received ambulatory treatment instead of hospital admission. Thus, the accuracy of US when applying WSES stages to decide the management when compared with CT was 96.96%. Particularly, the sensitivity, specificity, PPV, and NPV of US WSES stages to choose between admission or outpatient treatment were 94.44%, 99.18%, 99.03%, and 95.27%, respectively. All patients who underwent invasive treatment based on CT findings had been managed similarly according to US WSES stages.

Discussion

The present study suggested that the WSES classification seemed to be valid for the decision-making process when evaluating patients with ALCD. It was expected to have an important contribution to determining the best available option for treatment. Outpatient treatment was successful in selected patients with stages 0 (96.23%) and 1A (86.11%). Patients with stages 1B to 4 were selected for admission and underwent the majority of invasive procedures. The different stages of the classification properly assessed the findings obtained by CT and correlated well with both clinical and analytical data and the treatments decided. Although initially described for CT, WSES classification seemed to be also applicable for US findings with high accuracy (96.96%) to decide the correct management, extending the value of the classification for an initial assessment avoiding radiation exposure.

Patients with ALCD stages 0 and 1A who meet the previously mentioned criteria should be considered as mild condition disease and ambulatory treatment can be offered with a success rate higher than 96% and 86%, respectively. Our

Table 3 Clinical and analytical parameters, treatment modalities, and outcomes comparison between different WSES stages for ALCD

	Total ($n=230$)	0 ($n=70$)	1A ($n=122$)	1B ($n=16$)	2A ($n=12$)	2B ($n=6$)	3 ($n=3$)	4 ($n=1$)
Abdominal pain, *n* (%)	230 (100%)	70 (100%)	122 (100%)	16 (100%)	12 (100%)	6 (100%)	3 (100%)	Yes
Days of abdominal pain, median (P_{25}–P_{75})	2 (1–3)	2 (1–3)$^{\#}$	2 (1–3)§	4 (1–6.25)§	3 (2–7)*	1 (1–1.50)†,‡	2 (1–11.50)	3
Abdominal guarding, (%)	128 (55.65%)	35 (50%)§	65 (53.28%)	12 (75%)	6 (50%)§	6 (100%)*,$^{\#}$	3 (100%)	Yes
Fever > 38 °C, *n* (%)	49 (21.30%)	12 (17.14%)	27 (22.13%)	3 (18.75%)	5 (41.67%)	1 (16.67%)	2 (66.67%)	Yes
HR > 90 bpm, *n* (%)	39 (16.96%)	10 (14.29%)¶	21 (17.21%)	4 (25%)	1 (8.33%)	1 (16.67%)	1 (33.33%)*	Yes
WBC, median (P_{25}–P_{75})	11.9 (9.55–14.5)	10.4 (8.3–13.7)$^{\dagger,\ddagger,\#,\P}$	12.2 (9.7–14.2)*,$^{\#,\P}$	13.9 (10.5–17.6)*	14.3 (12.9–17.8)*,†	13.1 (11.4–15.5)¶	17.9 (17.8–)*,†,§	12.6
Neutrophils (%), median (P_{25}–P_{75})	75 (68.15–79.70)	72.25 (68.78–76.05)$^{\dagger,\ddagger,\#,\S,\P}$	78.30 (74.83–80.80)*,§,¶	75.70 (63.73–87.28)*	79.40 (76.35–81.55)*,§,¶	86.95 (81.10–91.30)*,$^{\dagger,\#}$	84.75 (82.6–)*,$^{\dagger,\#}$	93.7
Lymphocytes (%), median (P_{25}–P_{75})	15 (11.40–20.43)	17.35 (15.35–22.15)$^{\dagger,\ddagger,\#,\S,\P}$	11.85 (9.33–15.25)*,§,¶	14.20 (11.90–21.35)*,§,¶	11.70 (8.05–14.60)*	8.30 (3.98–12.55)*,†,‡	8 (7.90–)*,†,‡	5.4
NLR, median (P_{25}–P_{75})	5 (3.31–7.02)	4.16(3.15–4.89)$^{\dagger,\ddagger,\#,\S,\P}$	6.60 (5.06–8.36)*,§,¶	5.33 (2.63–6.39)*,§	6.63 (5.23–10.25)*	10.86 (6.65–23.44)*,†,‡	10.54 (10–)*,†	17
CRP, median (P_{25}–P_{75})	68 (29–126)	45.50 (14–95.25)$^{\dagger,\#,\P}$	70 (35.25–124.75)*,$^{\#,\P}$	72.50 (30.75–108.25)¶	149 (105–201)*,†,¶	93 (5–253.25)	252 (208–)*,$^{\dagger,\ddagger,\#}$	151
Fibrinogen, median (P_{25}–P_{75})	632 (538.50–690.75)	551 (517.25–704.05)†,¶	673 (599–715.75)*,¶	635 (513–677)¶	659 (531.50–740.50)	631 (355.75–869.75)	867 (668–)*,†,‡	736
INR, median (P_{25}–P_{75})	1.12 (1.07–1.21)	1.13 (1.09–1.18)$^{\#,\P}$	1.16 (1.08–1.28)$^{\#,\P}$	1.14 (1.05–1.22)$^{\#,\P}$	1.21 (1.15–1.29)*,†,‡	1.15 (1.04–1.24)	1.27 (1.26–)*,†,‡	1.32
Serum Albumin, median (P_{25}–P_{75})	4.4 (4.1.–4.6)	4.2 (4–4.68)$^{\#}$	4.35 (4.10–4.50)$^{\#}$	4.35 (4.20–4.60)	3.9 (3.25–4.45)*,†	4 (3.78–4.65)	4.15 (4–)	3.7
Serum Creatinine, median (P_{25}–P_{75})	0.84 (0.73–0.94)	0.80 (0.75–0.87)¶	0.87 (0.75–0.95)¶	0.78 (0.68–0.89)	0.70 (0.62–0.98)	0.90 (0.69–0.99)	1.28 (0.86–)*,†	0.88
Admission to hospital, *n* (%)	103 (44.78%)	17 (24.29%)$^{\dagger,\ddagger,\#,\S,\P}$	50 (40.98%)*,$^{\ddagger,\#,\S}$	14 (87.50%)*,†	12 (100%)*,†	6 (100%)*,†	3 (100%)*	Yes
Length of stay (days), median (P_{25}–P_{75})	5 (4–7.50)	5 (4–6.75)$^{\#,\P}$	5 (4–6)$^{\#,\S,\P}$	5 (5–6)$^{\#}$	12 (6.50–22)*,†,‡	6.5 (5.75–15)†	9 (8–)*,†	9
Outpatient treatment, *n* (%)	127 (55.22%)	53 (75.71%)$^{\dagger,\ddagger,\#,\S,\P}$	72 (59.02%)*,$^{\ddagger,\#,\S}$	2 (12.50%)*,†	0 (0%)*†	0 (0%)*,†	0 (0%)*	No
Readmission, *n* (%)	19 (8.26%)	3 (4.29%)	14 (11.48%)	2 (12.50%)	0 (0%)	0 (0%)	0 (0%)	No
Previously admitted/outpatient	7/12	1/2	4/10	2/0	0/0	0/0	0/0	–/–
Percutaneous drainage, *n* (%)	8 (3.47%)	0 (0%)$^{\#}$	3 (2.46%)$^{\#}$	0 (0%)$^{\#}$	5 (41.67%)*,†,‡	0 (0%)	0 (0%)	No

Table 3 (continued)

	Total ($n=230$)	0 ($n=70$)	1A ($n=122$)	1B ($n=16$)	2A ($n=12$)	2B ($n=6$)	3 ($n=3$)	4 ($n=1$)
Emergency surgery, *n* (%)	5 (2.17%)	0 (0%)$^{\#,\P}$	1 (0.82%)$^{\#,\P}$	0 (0%)	2 (16.67%)*,†	0 (0%)	1 (33.33%)*,†	Yes
Asymptomatic 1-month, *n* (%)	189 (82.17%)	57 (81.42%)	104 (85.25%)$^{\#}$	13 (81.25%)	5 (41.66%)†	4 (66.66%)	3 (100%)	Yes
Recurrence 1-year, *n* (%)	57 (27.78%)	18 (25.71%)	28 (22.95%)	4 (25%)	5 (41.66%)	2 (33.33%)	0 (0%)	No
Lower GI endoscopy, *n* (%)	29 (12.61%)	26 (37.14)	43 (35.25%)	7 (43.75%)	2 (16.67%)	4 (66.67%)	1 (33.33%)	No
Neoplasm during follow-up, *n* (%)	1 (0.43%)	1 (1.43%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	No
Elective surgery, *n* (%)	12 (5.22%)	2 (2.86%)$^{\#}$	3 (2.70%)$^{\#}$	2 (12.50%)	5 (41.67%)*,†	0 (0%)	0 (0%)	No

Chi-square test (categorical variables) and Mann–Whitney *U* test (continuous variables) results: $^{*}p$ value < 0.05 compared with 0, $^{\dagger}p$ value < 0.05 compared with 1A, $^{\ddagger}p$ value < 0.05 compared with 1B, $^{\#}p$ value < 0.05 compared with 2A, $^{\S}p$ value < 0.05 compared with 2B, $^{\P}p$ value < 0.05 compared with 3. Stage 4 ($n=1$) was not included in the analysis

HR heart rate, *SBP* systolic blood pressure, *WBC* white blood cells, *NLR* neutrophil–lymphocyte ratio, *CRP* C reactive protein, *INR* international normalized ratio, *GI* for gastrointestinal

study suggested that the ideal case for outpatient treatment were cases with the first episode of ALCD stages 0 or 1A, without fever or tenderness and low levels of inflammatory markers. Neither age ($p=0.076$) nor pericolic air bubbles in patients with ALCD 1A ($p=0.06$) seemed to be determining factors to decide whether the patient was admitted or discharged. The DIVER randomized controlled trial (RCT) reported similar outcomes concerning hospitalization and outpatient treatment in patients with uncomplicated ALCD Hinchey Ia, but no references were made to pericolic air bubbles [14]. Our results proved that patients with complicated ALCD who associate pericolic air bubbles or little pericolic fluid without abscess can be successfully managed with outpatient treatment. Recently, Cirocchi et al. [15] published a systematic review including 21 studies (only 1 RCT), with an overall failure rate in an outpatient setting of 4.3%. Consistent with our results, comorbidities or pericolic gas were not factors that influence the rate of failure.

In our opinion, the WSES classification met the conditions for clinical usage. We identified that clinical, analytical data and treatment modalities carried out were consistent when patients were grouped in the different WSES stages: (1) analytical parameters between different ALCD stages except for serum albumin and serum creatinine, as well as LoHS, showed a variation between WSES stages with statistically significant differences; (2) 125/127 (98.43%) patients with outpatient treatment were in stages 0 and 1A; (3) Stage 2A grouped 5/8 (62.5%) cases that required percutaneous drainage; (4) All patients with ALCD stage 2B were managed successfully with conservative treatment; (5) regarding emergency surgery, 4/5 (80%) patients were stage 2A, 3, or 4. That means patients have been grouped adequately and it could potentially help clinicians to choose the best available option for treatment, but other aspects such as clinical condition, physical examination, and analytical data must be always taken into account.

Intestinal US imaging has been our initial imaging technique in patients with suspected ACD for the last 20 years [16]. US has yielded similar results to those obtained by computerized tomography (CT) for the diagnosis of ACD, with a high sensitivity between 84 and 100 [17–19]. Specifically for complicated ACD, the utility of US remains controversial [20]. Our team has reported good results with a sensitivity of 84% and specificity of 95.8% [7]. Although the WSES classification was originally validated only for CT, we were able to describe the WSES stage by US in 100% of the cases. The standardized report of US and CT of every finding planned on the study protocol was extremely useful. Therefore, US WSES stages showed a high concordance (83.91%) when compared to CT. Moreover, in patients with a wrong staging by US, the management decision could have differed only in 7/37 cases. The US findings applying the

Table 4 Differences between patients admitted vs. outpatient treatment in stages 0 and 1A ($n=192$)

Variables	Admission ($n=67$)	Outpatient ($n=125$)	p value
Age (year), median (P_{25}–P_{75})	78 (65.50–81.50)	61 (48–70.50)	0.076
Gender, *n* (%)			0.929
Male	31 (46.27%)	57 (45.60%)	
Female	36 (53.73%)	68 (54.40%)	
BMI, median (P_{25}–P_{75})	28.41 (25.97–32.68)	27.50 (25.69–31.66)	0.281
Arterial hypertension, *n* (%)	29 (43.28%)	49 (39.20%)	0.583
Diabetes mellitus, *n* (%)	10 (14.93%)	12 (9.60%)	0.269
Dyslipidemia, *n* (%)	20 (29.85%)	43 (34.40%)	0.522
Renal disease, *n* (%)	4 (5.97%)	2 (1.60%)	0.186
Liver disease, *n* (%)	2 (2.99%)	4 (3.20%)	0.901
Immunosuppression, *n* (%)	1 (1.49%)	3 (2.40%)	1.000
Smoker, *n* (%)	8 (11.94%)	13 (10.4%)	0.744
Alcoholism, *n* (%)	2 (2.99%)	1 (0.80%)	0.279
Previous episode of ACD, *n* (%)	20 (29.85%)	64 (51.20%)	0.004
Abdominal pain (days), median (P_{25}–P_{75})	3 (1–4.50)	3 (1–3)	0.214
Tenderness, *n* (%)	51 (76.12%)	49 (39.20%)	0.000
Fever, *n* (%)	22 (32.84%)	17 (13.60%)	0.002
Tachycardia, *n* (%)	15 (22.39%)	16 (12.80%)	0.188
Constipation, *n* (%)	20 (29.85%)	36 (28.80%)	0.906
Diarrhea, *n* (%)	10 (14.93%)	12 (9.60%)	0.278
Previous antibiotics, *n* (%)	5 (7.46%)	0	0.005
WBC, median (P_{25}–P_{75})	13.1 (9.70–15.45)	10.5 (9.15–13.45)	0.000
Neutrophils (%), median (P_{25}–P_{75})	77.15 (72.53–80.55)	71.70 (65.38–76.90)	0.000
Lymphocytes (%), median(P_{25}–P_{75})	12.70 (9.58–17.58)	17.90 (13.40–22.95)	0.006
NLR, median (P_{25}–P_{75})	6.31 (4.52–7.91)	5.26 (3.13–7.12)	0.000
CRP, median (P_{25}–P_{75})	98 (48.50–147.50)	49 (14–96.50)	0.000
Fibrinogen, median (P_{25}–P_{75})	624 (544–708)	642 (482–692)	0.028
INR, median (P_{25}–P_{75})	1.14 (1.09–1.28)	1.11 (1.07–1.16)	0.001
Serum albumin, median (P_{25}–P_{75})	4.30 (4–4.40)	4.40 (4.25–4.60)	0.013
Serum creatinine, median (P_{25}–P_{75})	0.78 (0.73–1.04)	0.82 (0.72–0.99)	0.828
CT findings[a], *n* (%)			
Pericolic fluid	47 (94%)	69 (95.83%)	0.692
Pericolic air bubbles	10 (20%)	6 (8.33%)	0.060

BMI body mass index, *WBC* white blood cells, *NLR* neutrophil–lymphocyte ratio, *CRP* C reactive protein, *INR* international normalized ratio, *CT* computerized tomography

[a]Only includes patients with acute left-colonic diverticulitis stage 1A ($n=122$); admission $n=50$ vs. outpatient $n=72$

WSES classification showed high accuracy (96.96%), and the majority of patients had undergone similar management as decided based on CT. The main limitation was to identify distant air (stage 2B) during US evaluation. Overall, US was an adequate technique to evaluate patients with suspected ALCD, allowing the use of the WSES staging system with high accuracy. Our team considers that the best results were obtained with the performance of a conditional CT, only in case of doubt or inconclusive US findings.

Some questions still need to be solved and require further investigation. The possibility of offering an ambulatory treatment to patients with ALCD stage 1B (abscess < 4 cm.) remains under discussion. We successfully managed two young patients with an excellent clinical condition and small pericolic abscess lower than 1.5 cm. Although there is no evidence on this issue, the intra-abdominal abscess has not been identified as a factor that influenced the rate of outpatient therapy failure [15]. Non-operative management of patients with distant air (stage 2B) without diffuse fluid is another controversial aspect. In our series, all these patients were treated conservatively, without the need for emergency surgery. Moreover, 75% were asymptomatic after a 1-month evaluation and none of them underwent elective surgery during

a 1-year follow-up. These findings suggested a less severe evolution for patients in this WSES stage. Some articles have alluded to this option with low failure rates [21, 22]. The keys to successful non-operative management are a careful selection of the patients and close monitoring during the first 48 h. Hemodynamic instability and abundant distant intraperitoneal air and fluid in the fossa Douglas were identified as risk factors for failure and patients should be driven to emergency surgery [22].

This study presents some potential limitations that must be highlighted. First, it is an observational trial with no randomization. As secondary analysis of a prospective database, methodology did not ensure an appropriate statistical power for some results. Second, few cases of severe ALCD stages were included in our series, due to their low incidence and the relatively small sample is another limitation. As a single-center study, the external validity of the WSES classification needs to be confirmed in other independent populations. Finally, the study was conducted in a hospital with extensive experience in the intestinal US, so these results may not be easily extrapolated to other centers.

In conclusion, the WSES classification for ALCD seemed to be valid helping clinicians in the decision-making process to select between admission or outpatient management. Statistically significant differences were found between WSES stages in terms of clinical and analytical data, treatment modalities, and patient outcomes. The US WSES stages showed high accuracy for management decisions and correlated well with the chosen patient management based on CT findings.

Acknowledgements Special thanks to the staff of Radiology and General Surgery Departments, Doctor Peset University Hospital, for their contribution in making possible this study,

Author contributions Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work: JC-S, SA-G, T-R, A-M. Drafting the work or revising it critically for important intellectual content: All authors. Final approval of the version to be published: All authors.

Funding The authors did not receive support from any organization for the submitted work.

Availability of data and material The data that support the findings of this study are available from the corresponding author, JC-S, upon reasonable request.

Declarations

Conflict of interest The authors declare that there is no conflict of interest.

Ethics approval The protocol was reviewed and approved by the local ethics committee (Ceic:19/18).

Consent to participate Written informed consent was obtained from all patients.

References

1. Heise CP. Epidemiology and pathogenesis of diverticular disease. J Gastrointest Surg. 2008;12(8):1309–11.
2. Etzioni DA, Mack TM, Beart RW Jr, et al. Diverticulitis in the United States: 1998–2005: changing patterns of disease and treatment. Ann Surg. 2009;249(2):210–7.
3. Everhart JE, Ruhl CE. Burden of digestive diseases in the United States part II: lower gastrointestinal diseases. Gastroenterology. 2009;136(3):741–54.
4. Shahedi K, Fuller G, Bolus R, et al. Long-term risk of acute diverticulitis among patients with incidental diverticulosis found during colonoscopy. Clin Gastroenterol Hepatol. 2013;11(12):1609–13.
5. Fischer MG, Farkas AM. Diverticulitis of the cecum and ascending colon. Dis Colon Rectum. 1984;27(7):454–8.
6. Sartelli M, Weber DG, Kluger Y, et al. 2020 update of the WSES guidelines for the management of acute colonic diverticulitis in the emergency setting. World J Emerg Surg. 2020;15(1):32.
7. Ripollés T, Sebastián-Tomás JC, Martínez-Pérez MJ, et al. Ultrasound can differentiate complicated and noncomplicated acute colonic diverticulitis: a prospective comparative study with computed tomography. Abdom Radiol (NY). 2021;46:3826–34.
8. Hinchey EJ, Schaal PG, Richards GK. Treatment of perforated diverticular disease of the colon. Adv Surg. 1978;12:85–109.
9. Wasvary H, Turfah F, Kadro O, et al. Same hospitalization resection for acute diverticulitis. Am Surg. 1999;65(7):632–5 (**discussion 6**).
10. Kaiser AM, Jiang JK, Lake JP, et al. The management of complicated diverticulitis and the role of computed tomography. Am J Gastroenterol. 2005;100(4):910–7.
11. Mora López L, Flores Clotet R, Serra Aracil X, et al. The use of the modified Neff classification in the management of acute diverticulitis. Rev Esp Enferm Dig. 2017;109(5):328–34.
12. Lauscher JC, Lock JF, Aschenbrenner K, et al. Validation of the German Classification of Diverticular Disease (VADIS)-a prospective bicentric observational study. Int J Colorectal Dis. 2021;36(1):103–15.
13. Sartelli M, Moore FA, Ansaloni L, et al. A proposal for a CT driven classification of left colon acute diverticulitis. World J Emerg Surg. 2015;10:3.
14. Biondo S, Golda T, Kreisler E, et al. Outpatient versus hospitalization management for uncomplicated diverticulitis: a prospective, multicenter randomized clinical trial (DIVER Trial). Ann Surg. 2014;259(1):38–44.
15. Cirocchi R, Randolph JJ, Binda GA, et al. Is the outpatient management of acute diverticulitis safe and effective? A systematic review and meta-analysis. Tech Coloproctol. 2019;23(2):87–100.
16. Ripollés T, Agramunt M, Martínez MJ, et al. The role of ultrasound in the diagnosis, management and evolutive prognosis of acute left-sided colonic diverticulitis: a review of 208 patients. Eur Radiol. 2003;13(12):2587–95.
17. Pradel JA, Adell JF, Taourel P, et al. Acute colonic diverticulitis: prospective comparative evaluation with US and CT. Radiology. 1997;205(2):503–12.
18. Hollerweger A, Macheiner P, Rettenbacher T, et al. Colonic diverticulitis: diagnostic value and appearance of inflamed diverticula-sonographic evaluation. Eur Radiol. 2001;11(10):1956–63.
19. Laméris W, van Randen A, Bipat S, et al. Graded compression ultrasonography and computed tomography in acute colonic

diverticulitis: meta-analysis of test accuracy. Eur Radiol. 2008;18(11):2498–511.
20. Nielsen K, Richir MC, Stolk TT, et al. The limited role of ultrasound in the diagnostic process of colonic diverticulitis. World J Surg. 2014;38(7):1814–8.
21. Dharmarajan S, Hunt SR, Birnbaum EH, et al. The efficacy of nonoperative management of acute complicated diverticulitis. Dis Colon Rectum. 2011;54(6):663–71.
22. Sallinen VJ, Mentula PJ, Leppäniemi AK. Nonoperative management of perforated diverticulitis with extraluminal air is safe and effective in selected patients. Dis Colon Rectum. 2014;57(7):875–81.