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ORIGINAL ARTICLE

# The clinical significance of extraluminal air in Hinchey 1a diverticulitis: results from a retrospective cohort study with 10-year follow-up

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## Abstract

**Background** Some patients with uncomplicated diverticulitis have extraluminal air. Our objective was to determine if patients with Hinchey 1a diverticulitis and isolated extraluminal air present more severe episode than patients without extraluminal air.

**Methods** The present study is a monocentric observational retrospective cohort study. Computed tomographies of patients with diagnosed uncomplicated diverticulitis were retrospectively reviewed from the 01 January 2005 to the 31 December 2009. The presence of extraluminal air was determined. Leukocyte count, CRP value, and length of hospitalization were extracted from the patients' files. The follow-up period was from the time of diagnosis to the 15th of March 2019, the latest. Follow-up was censored for death and sigmoidectomy. Recurrence and emergency sigmoidectomy were documented during the follow-up period. The study was performed according to the STROBE guideline.

**Results** Three hundred and one patients with an episode of Hinchey 1a diverticulitis were included. Extraluminal air was present in 56 patients (18.60%). Leukocyte count (12.4 ± 4.1(G/l) versus 10.7 ± 3.5(G/l), $p = 0.05$), CRP value (156.9 ± 95.1(mg/l) versus 89.9 ± 74.8(mg/l), $p < 0.001$), and length of hospital stay (10.9 ± 5.5(days) versus 8.4 ± 3.6(days), $p < 0.001$) were significantly higher in patients with extraluminal air than in patients without extraluminal air. Seventy-two patients (23.92%) presented a recurrence during the follow-up period. Survival estimates did not differ between patients with or without extraluminal air ($p = 0.717$). Eleven patients (3.65%) required emergency surgery during the follow-up period. Patients with extraluminal air had shorter emergency surgery-free survival than patients without extraluminal air ($p < 0.05$).

**Conclusion** The presence of extraluminal air in Hinchey 1a diverticulitis indicates a more severe episode, with higher inflammation parameters at admission, longer length of stay, and an increased risk for emergency sigmoidectomy.

**Keywords** Diverticulitis · Classification · Extraluminal air · Free air

## Introduction

Diverticulosis is highly prevalent in Western societies, affecting more than 60% of patients aged 70 years old and above [1, 2] and constitutes a major burden for healthcare systems [3]. Diverticulitis develops in 10–25% of patients affected by diverticulosis [1, 4, 5] and is one of the main reasons for admission to inpatient care.

Diverticulitis may cause perforation of the inflamed diverticulum and result in abscess, free air, or peritonitis. Episodes of diverticulitis are usually classified according to the modified Hinchey score of Wasvary et al. [6–8], which grades episodes according to computed tomography (CT) and operative findings, from Hinchey 1a (localized inflammation), 1b (pericolic abscess), 2 (distant abscess), 3 (purulent peritonitis),

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and 4 (fecal peritonitis). Other classifications, such as the Neff [9] and Kaiser [10] classifications, are based on CT results. The aim of these classifications is to predict the prognosis and to define the most appropriate therapeutic management.

Efforts made to alleviate the costs generated by diverticulitis on healthcare systems rely in the early identification of patients with favorable course in order to treat them as outpatients, and sometimes without antibiotics [11]. This strategy has been adopted for patients with uncomplicated episode in many centers, such as Hinchey 1a or Hansen-Stock I/IIa episode.

However, isolated extraluminal air, without the presence of free liquid, is not taken into account by usual classifications, notably the widely used revised Hinchey classification, and patients with pericolonic air bubbles but otherwise no abscess or free liquid are therefore classified as Hinchey 1a episode. However, free air surrounding an inflamed diverticulum denotes its perforation, and one could reasonably hypothesizes that healing in these patients differs from patients with an inflamed diverticulum without pericolonic air.

The objective of the present study was to determine whether extraluminal air has an adverse impact on the prognosis of patients with uncomplicated diverticulitis and constitutes a risk factor for prolonged hospitalization, shortened recurrence-free survival, and/or shortened emergency surgery-free survival.

## Methods

### Type of study

The present study is a monocentric retrospective cohort study. The protocol was approved by the ethics committee of the University Hospitals of Geneva (reference number 09-247) where the study was performed. The study was performed according to the STROBE guideline (Table S1).

### Management of acute diverticulitis in our center

The University Hospitals of Geneva (Switzerland) constitutes the only public hospital of Geneva and its region. Patients with suspicion of acute diverticulitis are sent to diagnostic CT. All patients with confirmed diverticulitis receive intravenous antibiotic treatment (3nd generation cephalosporin and metrodinazole) and are hospitalized. Patients with Hinchey 1a diverticulitis are monitored in the ward until clinical and biological improvement. Patients with Hinchey 1a diverticulitis but free air were usually monitored as patients with Hinchey 1a diverticulitis without free air. However, in case of unfavorable presentation or evolution, these patients were treated accordingly.

### Population

CT reports including keywords related to diverticulitis for the period from 1 January 2005 to 31 December 2009 were retrieved. This allowed us to obtain a minimum follow-up of 10 years and also to assess the length of hospitalization, as outpatient treatment of uncomplicated diverticulitis patients was not performed during that period. Reports were screened to exclusively include patients with Hinchey 1a acute sigmoid diverticulitis. Files of eligible patients were checked, and patients were excluded if the diagnosis at discharge was different from diverticulitis, if the episode of diverticulitis was > Hinchey 1a, or if patients were not hospitalized (in opposition with the institutional guidelines at the time of the study). CT of included patients were interpreted by a specialist in radiology (AC) to confirm the diagnosis of Hinchey 1a diverticulitis and to classify patients into subgroups with or without extraluminal air. The radiologist was blinded for the clinical outcomes.

### Variables of interest

Gender, age at time of CT, number of previous episodes of diverticulitis, leukocytes counts, and CRP values at admission were extracted from patients' files. The occurrence of a recurrence of acute diverticulitis or the necessity for emergency surgery related to a diverticulitis episode during the follow-up period was documented and dated. The follow-up period was defined from the time of CT to death (censored), surgery for diverticulitis (sigmoidectomy, censored), or until end of follow-up (defined as 15 March 2019).

### Statistical analyses

Continuous variables were expressed as means and standard deviations (SD). Leukocytes counts, CRP values, and lengths of hospitalization between patients with Hinchey 1a diverticulitis with or without extraluminal air were compared using the two-sided Student's test. Kaplan-Meier survivals of estimates curves were graphed for time to recurrence and time to emergency surgery. Curves were censored for death and surgery (sigmoidectomy). The log-rank test was performed to compare survivals between patients with Hinchey 1a diverticulitis with or without extraluminal air. All statistical analyses were performed using the STATA software [12]. The null hypothesis was rejected at $p < 0.05$.

## Results

### Patients

Three hundred and one patients were hospitalized for CT-proven Hinchey 1a acute sigmoid diverticulitis during the period 1 January 2005 to 31 December 2009. After reviewing the CT, 56 patients (18.6%) presented with extraluminal air and 245 (81.4%) without (Fig. 1). Patients had a mean age of 63.9 ± 15.2 years and 121 were males (40.2%). The episode of diverticulitis noted in this study was the first ever episode of diverticulitis for 203 patients (67.4%), the second episode for 58 patients (19.3%), the third for 32 patients (10.6%), and the fourth for 8 patients (2.7%) (Table 1).

### Inflammatory parameters at admission

Included patients had a mean leukocyte count and a mean CRP value at admission of 11.0 ± 3.7 G/l and 102.3 ± 83.0, respectively (Table 2). Leukocyte count and CRP values were significantly higher in patients with extraluminal air than in patients without extraluminal air (leukocytes: 12.4 ± 4.1 versus 10.7 ± 3.5 G/l, $p < 0.05$; CRP: 156.9 ± 95.1 versus 89.9 ± 74.8 mg/l, $p < 0.001$) (Fig. 2).

### Length of hospital stay

Patients with Hinchey 1a diverticulitis and extraluminal air had a significantly longer length of hospital stay than those without extraluminal air (10.9 ± 5.5 versus 8.4 ± 3.6 days, $p < 0.001$).

### Recurrence

Seventy-two patients (23.9%) presented a recurrence within a mean period of follow-up to recurrence or end of follow-up of 2366 ± 1861 days (Table 2). Time to recurrence was 1057 ± 1184 days. Survival estimates for recurrence did not differ between patients with or without extraluminal air ($p = 0.717$) (Fig. 3a).

### Emergency surgery

Eleven patients (3.7%) required emergency surgery within a mean period of follow-up to surgery or end of follow-up of 2602 ± 1853 days after the diagnosis of Hinchey 1a diverticulitis (Table 2). Time to emergency surgery was 406 ± 577 days. Within a month, one patient (0.4%) without extraluminal air and two patients (3.6%) with extraluminal air required emergency surgery. Within a year, two patients (0.8%) without extraluminal air and five patients (8.9%) with extraluminal air required emergency surgery. Patients with extraluminal air had shortened emergency surgery-free survival than patients without extraluminal air ($p < 0.05$) (Fig. 3b).

## Discussion

In our center and for the studied period, all patients with suspected diverticulitis episode underwent CT and were hospitalized for inpatient antibiotic treatment and monitoring. We showed that 18.6% of patients with Hinchey 1a diverticulitis had extraluminal air present on the initial CT. Extraluminal air usually results from perforation of a hollow viscera, such as in diverticulitis. This can lead to more advanced Hinchey stages as bacteria proliferate in the peritoneal cavity and liquid and/or stools leak from the bowel.

Isolated extraluminal air was taken into account by some CT classification systems for diverticulitis, such as the one developed by Dharmarajan et al. [13]. The authors proposed these patients to be managed conservatively, even if abscesses were present, but considered the presence of free fluid to be a surgical indication. However, outcomes of patients with extraluminal air were not compared to patients without extraluminal air.

In our study, we studied these outcomes. We included patients with exclusively a Hinchey 1a episode, and as stated in the definition, showing no other features of an advanced diverticulitis episode, such as abscess, or purulent/fecaloid peritonitis at surgical exploration. First, we demonstrated that patients with Hinchey 1a diverticulitis and extraluminal air presented at the emergency department with higher inflammatory parameters than patients without extraluminal air, suggesting a more severe ongoing inflammatory process. Inflammatory parameters indicate a severe episode of diverticulitis [14]. Second, these patients required prolonged inpatient care, suggesting the need for longer parenteral antibiotic therapy or additional measures, such as surgery due to disadvantaged short-term evolution. Third, by analyzing the outcomes of these patients over a period of more than 10 years, we showed

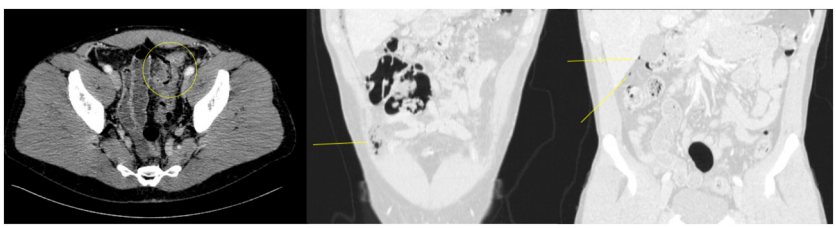

**Fig. 1** Computed tomography of a patient with Hinchey 1a diverticulitis and free air. Circle and lines indicate pericolonic and distant free air bubbles

**Table 1** Demographics of included patients

| Mean ± SD | | Total | H1a without extraluminal air | H1a with extraluminal air |
|---|---|---|---|---|
| Patients (*n*) | | 301 | 245 (81.40%) | 56 (18.60%) |
| Gender (male) | | 121 (40.20%) | 98 (40.00%) | 23 (41.07%) |
| Age (year) | | 63.88 ± 15.19 | 64.59 ± 14.81 | 60.78 ± 16.55 |
| Number of previous episodes (*n*) | 0 | 203 (67.44%) | 161 (65.71%) | 42 (75.00%) |
| | 1 | 58 (19.27%) | 50 (20.41%) | 8 (14.29%) |
| | 2 | 32 (10.63%) | 27 (11.02%) | 5 (8.93%) |
| | 3 | 6 (1.99%) | 5 (2.04%) | 1 (1.79%) |
| | ≥ 4 | 2 (0.66%) | 2 (0.82%) | 0 (0%) |

that patients with extraluminal air required emergency surgery to a larger extent than patients without extraluminal air. As shown by the Kaplan-Meier curve, the need for emergency surgery mostly occurred during the short-term period after diagnosis, suggesting an unfavorable evolution of the diverticulitis episode.

Our findings are supported by those of Garcia-Gomez et al. The authors detected pericolic air bubbles in 29 out of 124 patients (23.4%). They described patients with pericolic air bubbles to have more peritoneal signs, leukocytosis, band count, longer hospital stay, and later tolerance of liquids than patients without pericolic air bubbles. However, the studied population was not limited to Hinchey 1a patients, who represented only 68.5% of the cohort, but also included patients with more advanced Hinchey stages, which increases the heterogeneity of the cohort and might include bias due to different management of these patients [15].

Further, Bolkenstein et al. included 109 diverticulitis patients with pericolic air. Among the 57 patients who received antibiotics, seven (13%) failed conservative management and required either percutaneous abscess drainage or emergency surgery within 30 days after presentation. Increased CRP level at presentation was an independent predictor for treatment failure [16]. Therefore, the failure rate of conservative management was important and—according to us—require close monitoring of these patients.

Interestingly, and in oppostion with the findings described above, we note that some authors tried to manage patients with extraluminal air as outpatients. For instance, Mora Lopez et al. proposed a revision of the CT-based Neff classification by including substages Ia (localized pneumoperitoneum) and Ib (local abscess). They successfully managed as outpatients 94% of patients with uncomplicated diverticulitis or localized pneumoperitoneum. However, the investigators applied very extensive exclusion criteria, excluding for example patients with elevated inflammatory parameters (which we found to be higher in patients with extraluminal air), and only retained 14 patients with pericolic air bubbles for outpatient management [17].

Regarding long-term outcomes, Sallinen et al. did not identify extraluminal air as a risk factor for recurrence [18]. In our study, patients with extraluminal air had higher CRP value at admission, a parameter that was identified as a risk factor for recurrence [19–21], but no difference in terms of recurrence between the two subpopulations of patients could be found. Recurrence occurred in 23.9% of patients over the follow-up period, within a mean period of 1056 days. Therefore, the presence of extraluminal air did not lead to higher recurrence rate of diverticulitis in our cohort.

**Table 2** Main outcomes of patients with Hinchey 1a diverticulitis with or without extraluminal air

| Mean ± SD | Total | H1a without extraluminal air | H1a with extraluminal air | *p* value |
|---|---|---|---|---|
| Patients (*n*) | 301 | 245 (81.40%) | 56 (18.60%) | – |
| Leukocytes (G/l) | 11.01 ± 3.65 | 10.69 ± 3.47 | 12.41 ± 4.09 | 0.0013 |
| CRP (mg/l) | 102.33 ± 83.02 | 89.86 ± 74.81 | 156.91 ± 95.08 | 0.0000 |
| Hospitalization length (days) | 8.88 ± 4.13 | 8.43 ± 3.60 | 10.86 ± 5.54 | 0.0001 |
| Recurrence (*n*) | 72 (23.92%) | 62 (25.31%) | 10 (17.86%) | 0.2399 |
| Emergency surgery (*n*) | 11 (3.65%) | 6 (2.45%) | 5 (8.93%) | 0.0197 |
| Follow-up to recurrence (days)[a] | 2365.90 ± 1860.68 | 2459.73 ± 1830.08 | 1955.38 ± 1953.28 | – |
| Follow-up to emergency surgery (days)[b] | 2602.03 ± 1853.47 | 2689.20 ± 1797.93 | 2220.68 ± 2053.16 | – |

[a] Censored for: death, elective surgery, emergency surgery

[b] Censored for: death, elective surgery

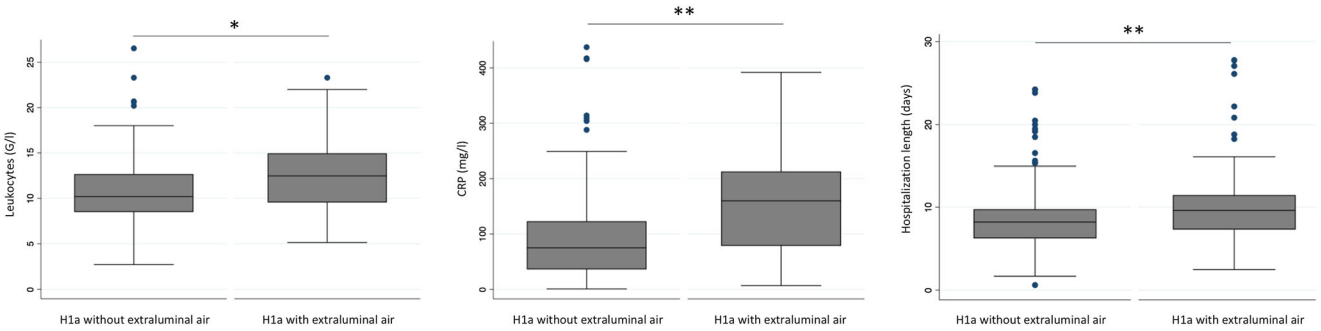


**Fig. 2** Inflammatory parameters at admission and length of hospitalization in Hinchey 1a patients with/without free air. Box-plots reporting the main outcomes (leukocyte count, CRP, length of hospitalization). Whiskers represent 95% confidence intervals. *$p < 0.05$, **$p < 0.001$

The present study has the following strengths: (1) patients with diverticulitis were followed over a 10-year period in a single institution, which is also the only public hospital of the region of Geneva, Switzerland, allowing to accurately monitor any rehospitalization; (2) this study has clinical implications by helping identifying patients not suitable for outpatient treatment—those with a Hinchey 1a episode but with extraluminal air. This is highly significant in a time where resources need to be prioritized. The main limitation of the study is its retrospective design, which did not allow to identifying potential follow-up dropouts and its observational design, leaving the possibility of overtreatment if isolated extraluminal air is found.

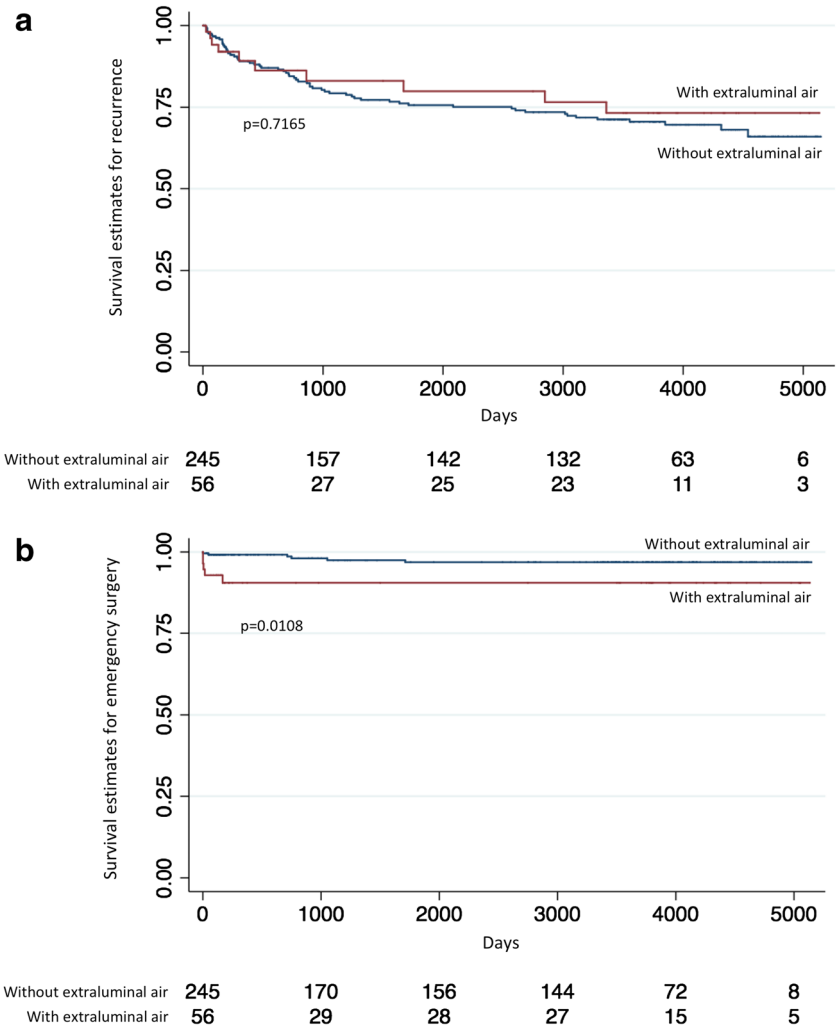


**Fig. 3** Kaplan-Meier survivals of estimates curves for recurrence and emergency surgery in Hinchey 1a patients with/without free air. Kaplan-Meier survivals of estimates curves for time to recurrence and time to emergency surgery. Curves were censored for death and surgery (sigmoidectomy). The log-rank test was performed to compare survivals between patients with Hinchey 1a diverticulitis with or without extraluminal air

To conclude, the presence of extraluminal air in patients with uncomplicated diverticulitis is a risk factor for prolonged length of stay, shortened recurrence-free survival, or shortened emergency surgery-free survival. The presence of extraluminal air in patients with uncomplicated diverticulitis calls for inpatient monitoring and may be used as a marker for potential unfavorable evolution of disease.

**Authors' contribution** JM, NCB, and PAP conceived and designed the study. JM and AC acquired the data. JM and ER analyzed the data. JM, AC, ER, AB, CT, PAP, FR, and NCB interpreted the data. JM, AC, ER, AB, CT, PAP, FR, and NCB contributed to the writing of the manuscript and to its critical revision. JM, AC, ER, AB, CT, PAP, FR, and NCB approved the final version of the manuscript.

## Compliance with ethical standards

**Conflict of Interest** The authors disclose no conflict of interest.

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