Surgery xxx (2023) 1–10

Contents lists available at ScienceDirect

Surgery

journal homepage: www.elsevier.com/locate/surg

Diverticulitis with abscess formation: Outcomes of non-operative management and nomogram for predicting emergency surgery: The Diplicab Study Collaborative Group

Juan Ocaña, MD, PhD[a,*], Juan Carlos García-Pérez, MD, PhD[a],
Daniel Fernández-Martínez, MD[b], Ignacio Aguirre, MD[c], Isabel Pascual, MD, PhD[d],
Paola Lora, MD[e], Eloy Espin, MD, PhD[f], María Labalde-Martínez, MD, PhD[g],
Carmen León, MD[h], Paula Pastor-Peinado, MD, PhD[a], Carlota López-Domínguez, MD[i],
Nerea Muñoz-Plaza, MD[j], Ainhoa Valle, MD[k], Paula Dujovne, MD, PhD[l], David Alías, MD[m],
Leticia Pérez-Santiago, MD[n], Alba Correa, MD[o], María Carmona, MD[p],
Manuel Mariano Díez, MD, PhD[q], Ander Timoteo, MD[r], Silvia Salvans, MD[s],
Rita Esther Medina, MD[t], Tatiana Gómez, MD[u], Laura Fernández-Vega, MD[v],
Emilio Peña, MD, PhD[w], José María García-González, MD[x],
Francisco Blanco-Antona, MD, PhD[y], Ana Isabel Fábregues, MD[z], Elena Sagarra, MD[aa],

Members of the Diplicab Study Collaborative Group who participated in the study as clinical investigators are as follows (all names to be PubMed citable together with names in headline authorship):

Araceli-Ballestero, Division of Coloproctology, Hospital Universitario Ramón y Cajal. Alfonso Muriel, Unidad de Bioestadística Clínica, Hospital Universitario Ramón y Cajal, IRYCIS CIBERESP. Ángel Luis Del Rey, Data Science Unit, Fundación para la Investigación Biomédica del Hospital Universitario Ramón y Cajal (IRyCIS). Tamara Díaz, General and Digestive Surgery, Hospital Central de Asturias, Oviedo, Spain. Ane Etxart Colorectal Surgery Unit, Hospital Universitario de Donostia, San Sebastián, Spain. María del March Olmed, General and Digestive Surgery, Hospital Universitario La Paz, Madrid, Spain. Christian Nuño, General and Digestive Surgery, Hospital Universitario Cabueñes, Gijón, Spain. Miquel Craft, Department of Colorectal Surgery, Hospital Universitari Vall đHebron, Universitat Autonoma de Barcelona, Barcelona, Spain. Alfredo Vivas, Division of Coloproctology, Hospital Universitario 12 de Octubre, Madrid, Spain. Pablo Peláez, Division of Coloproctology, Hospital Universitario 12 de Octubre, Madrid, Spain. Isabel Alonso, Division of Coloproctology, Hospital Universitario Puerta de Hierro, Majadahonda, Spain. Ángela Santana, Department of General and Digestive Surgery, Hospital Universitario Ramón y Cajal, Madrid, Spain. Manuel González-Bermúdez, Division of Coloproctology, Complejo Hospitalario Universitario A Coruña, A Coruña, Spain. Cristina González-Prado, Division of Coloproctology, Hospital Universitario Burgos, Burgos, Spain. Virginia Jiménez-Carneros, Division of Coloproctology, Hospital Universitario de Getafe, Getafe, Spain. Beatriz Laiz, Unit of Coloproctology, Hospital Universitario Rey Juan Carlos, Móstoles, Spain. David Moro, Division of Coloproctology, Hospital Clínico Universitario de Valencia, Valencia, Spain. Livia Delgado, General and Digestive, Hospital Universitario La Princesa, Madrid, Spain. Isabel Gallarín, Division of Coloproctology, Hospital Universitario de Badajoz, Badajoz, Spain. Cristina Vera, Division of Coloproctology, Hospital Universitario Príncipe de Asturias, Alcalá de Henares, Spain. Olga Delisau, Division of Coloproctology, Hospital Universitari Dr Josep Trueta, Gerona, Spain. Blanca Montcusí, Division of Coloproctology, Hospital del Mar, Barcelona, Spain. Daniel Serralta, Division of Coloproctology, Hospital Universitario Infanta Sofía, San Sebastián de los Reyes, Spain. Álvaro García-Granero, Division of Coloproctology, Hospital Universitari Son Espases, Palma, Spain. Pedro Antonio Parra, Division of Coloproctology, Hospital Universitario Reina Sofía, Murcia, Spain, José Antonio Alcázar, Division of Coloproctology, Hospital Universitario Salamanca, Salamanca, Spain. Francisco Mauri, Division of Coloproctology, Hospital Universitario Alicante, Alicante, Spain. Raquel Ríos, Division of Coloproctology, Hospital Universitario Infanta Cristina, Parla, Spain, María Luisa de FuenMayor, Division of Coloproctology, Hospital Universitario Infanta Leonor, Madrid, Spain. Pedro Abadía, Unit, Hospital Univeristario Ramón y Cajal, Madrid, Spain. Eva María Torres, Division of Coloproctology, Hospital Reina Sofía, Córdoba, Spain. Giana Pamela Ibero, Division of Coloproctology, Hospital Universitario Central de Asturias, Oviedo, Spain. Ainhoa Echeveste-Varela, Colorectal Surgery Unit, Hospital Universitario de Donostia, San Sebastián, Spain. Nuria Chavarrías, Colorectal Division, Hospital Universitario La Paz, Madrid, Spain. Nuria Ortega-Torrecilla, Department of Colorectal Surgery, Hospital Universitari Vall đHebron, Universitat Autonoma de Barcelona, Barcelona, Spain. Eduardo Ferrero, General and Digestive Surgery, Hospital Universitario 12 de Octubre, Madrid, Spain. Eva Iglesias, Division of Coloproctology, Hospital Universitario Puerta de Hierro, Majadahonda, Spain. Michelle Otero, Division of Coloproctology, Hospital Universitario Burgos, Burgos, Spain. Tamara Llamero, Division of Coloproctology, Hospital Universitario de Getafe, Getafe, Spain. César Lévano, Unit of Coloproctology, Hospital Universitario Rey Juan Carlos, Móstoles, Spain. Ana Benitez, Division of Coloproctology, Hospital Clínico Universitario de Valencia, Valencia, Spain. Julia Revuelta, Unit of Coloproctology, Hospital Universitario La Princesa, Madrid, Spain. María Inmaculada Lavado, Division of Coloproctology, Hospital Universitario de Badajoz, Badajoz, Spain. Belén Matías, Division of Coloproctology, Hospital Universitario Príncipe de Asturias, Alcalá de Henares, Spain. Lidia Cornejo, Division of Coloproctology, Hospital Universitari Dr Josep Trueta, Gerona, Spain. Anna Navarro, Division of Coloproctology, Hospital del Mar, Barcelona, Spain. José Alberto Rojo, Division of Coloproctology, Hospital Universitario Infanta Sofía, San Sebastián de los Reyes, Spain. Natalia Alonso, Division of Coloproctology, Hospital Universitari Son Espases, Palma, Spain. Clara Giménez, Division of Coloproctology, Hospital Universitario Reina Sofía, Murcia, Spain. Alisa Ángela Diego, Division of Coloproctology, Hospital Universitario Salamanca, Salamanca, Spain. Cristian Pérez-González, Division of Coloproctology, Hospital Universitario de Cruces, Barakaldo, Spain Antonio Zarco, Division of Coloproctology, Hospital Universitario Alicante, Alicante, Spain. Eduardo de San Pío, Division of Coloproctology, Hospital Universitario Infanta Cristina, Parla, Spain. Patricia Ortega, Division of Coloproctology, Hospital Universitario Infanta Leonor, Madrid, Spain. Javier López-Ruiz, Division of Coloproctology, Hospital Reina Sofía, Córdoba, Spain.

* Reprint requests: J. Ocaña, MD, Department of General and Digestive Surgery. Ramon y Cajal University Hospital, Madrid, Ctra. Colmenar Viejo, Km 9.100- 28034, Madrid, Spain.

E-mail address: jocajim@gmail.com (J. Ocaña);

Twitter: @juanocajim

https://doi.org/10.1016/j.surg.2023.05.016

Elena Viejo, MD[bb], Araceli Moreno, MD[cc], José María Fernández-Cebrián, MD, PhD[a], Javier Die, MD[a], and collaborators from The DIPLICAB Study Collaborative Group

[a] Division of Coloproctology, Department of General and Digestive Surgery, Hospital Universitario Ramón y Cajal, Madrid, Spain
[b] Division of Coloproctology, Hospital Universitario Central de Asturias, Oviedo, Spain
[c] Colorectal Surgery Unit, Hospital Universitario de Donostia, San Sebastián, Spain
[d] Colorectal Division, Hospital Universitario La Paz, Madrid, Spain
[e] Colorectal Division, Hospital Univseristario Cabueñes, Gijón, Spain
[f] Department of Colorectal Surgery, Hospital Universitari Vall dHebron, Universitat Autonoma de Barcelona, Spain
[g] Division of Coloproctology, Hospital Universitario 12 de Octubre, Madrid, Spain
[h] Division of Coloproctology, Hospital Universitario Puerta de Hierro, Majadahonda, Spain
[i] Division of Coloproctology, Complejo Hospitalario Universitario A Coruña, Spain
[j] Division of Coloproctology, Hospital Universitario Burgos, Spain
[k] Division of Coloproctology, Hospital Universitario de Getafe, Spain
[l] Division of Coloproctology, Hospital Universitario Gregorio Marañón, Madrid, Spain
[m] Unit of Coloproctology, Hospital Universitario Rey Juan Carlos, Móstoles, Spain
[n] Division of Coloproctology, Hospital Clínico Universitario de Valencia, Spain
[o] Unit of Coloproctology, Hospital Universitario La Princesa, Madrid, Spain
[p] Division of Coloproctology, Hospital Universitario de Badajoz, Spain
[q] Division of Coloproctology, Hospital Universitario Príncipe de Asturias, Alcalá de Henares, Spain
[r] Division of Coloproctology, Hospital Universitari Dr Josep Trueta, Gerona, Spain
[s] Division of Coloproctology, Hospital del Mar, Barcelona, Spain
[t] Division of Coloproctology, Hospital Universitario Infanta Sofía, San Sebastián de los Reyes, Spain
[u] Division of Coloproctology, Hospital Universitario Puerta del Mar, Cádiz, Spain
[v] Division of Coloproctology, Hospital Universitari Son Espases, Palma, Spain
[w] Division of Coloproctology, Hospital Universitario Reina Sofía, Murcia, Spain
[x] Division of Coloproctology, Hospital Universitario de Cruces, Barakaldo, Spain
[y] Division of Coloproctology, Hospital Universitario Salamanca, Spain
[z] Division of Coloproctology, Hospital Universitario Alicante, Spain
[aa] Division of Coloproctology, Hospital Universitario Infanta Cristina, Parla, Spain
[bb] Division of Coloproctology, Hospital Universitario Infanta Leonor, Madrid, Spain
[cc] Division of Coloproctology, Hospital Reina Sofía, Córdoba, Spain

ARTICLE INFO

Article history:
Accepted 24 May 2023
Available online xxx

ABSTRACT

Background: To assess short- and long-term outcomes from non-surgical management of diverticulitis with abscess formation and to develop a nomogram to predict emergency surgery.
Methods: This nationwide retrospective cohort study was performed in 29 Spanish referral centers, including patients with a first episode of a diverticular abscess (modified Hinchey Ib–II) from 2015 to 2019. Emergency surgery, complications, and recurrent episodes were analyzed. Regression analysis was used to assess risk factors, and a nomogram for emergency surgery was designed.
Results: Overall, 1,395 patients were included (1,078 Hinchey Ib and 317 Hinchey II). Most (1,184, 84.9%) patients were treated with antibiotics without percutaneous drainage, and 194 (13.90%) patients required emergency surgery during admission. Percutaneous drainage (208 patients) was associated with a lower risk of emergency surgery in patients with abscesses of ≥5 cm (19.9% vs 29.3%, $P = .035$; odds ratio 0.59 [0.37–0.96]). The multivariate analysis showed that immunosuppression treatment, C-reactive protein (odds ratio: 1.003; 1.001–1.005), free pneumoperitoneum (odds ratio: 3.01; 2.04–4.44), Hinchey II (odds ratio: 2.15; 1.42–3.26), abscess size 3 to 4.9 cm (odds ratio: 1.87; 1.06–3.29), abscess size ≥5 cm (odds ratio: 3.62; 2.08–6.32), and use of morphine (odds ratio: 3.68; 2.29–5.92) were associated with emergency surgery. A nomogram was developed with an area under the receiver operating characteristic curve of 0.81 (95% confidence interval: 0.77–0.85).
Conclusion: Percutaneous drainage must be considered in abscesses ≥5 cm to reduce emergency surgery rates; however, there are insufficient data to recommend it in smaller abscesses. The use of the nomogram could help the surgeon develop a targeted approach.

Introduction

Diverticulosis affects one-third of people older than 60 years living in developed countries.[1] Between 10% and 25% will develop diverticulitis; however, only a small percentage will a complication occur, such as perforation or abscess.[2–5] There are multiple classification systems for complicated diverticulitis,[6–9] with the modified Hinchey classification being the most widely used.[10]

Over the years, treatment strategies for diverticulitis with abscess formation have gradually shifted from surgical treatment to non-surgical management comprising antibiotics alone or antibiotics with percutaneous drainage (PCD),[11] which remains controversial.[12] Although most guidelines recommend treating small abscesses with antibiotics alone, adding PCD to antibiotics in cases of large abscesses (greater than 3–5 cm), no size has been specified in which PCD was found superior to antibiotics to avoid emergency surgery. However, these recommendations are based on retrospective small case series or clinical experience.[13–16] In addition, non-surgical treatment failure needs to be better studied to enable the selection of the optimal treatment choice.[17–19]

Therefore, the main objective of this retrospective multicenter study was to assess the short- and long-term outcomes of non-surgical management of diverticulitis with abscess formation

(Hinchey Ib and II). We focused our study on patients with Hinchey Ib (confined pericolic abscess) and Hinchey II (distant intra-abdominal, pelvic, or retroperitoneal abscess), with or without free pneumoperitoneum.[10,20] The secondary aim was to identify risk factors for emergency surgery after non-surgical management of diverticulitis with abscess formation to develop a nomogram and evaluate the impact of PCD on emergency surgery according to abscess size.

Material and methods

Data collection and study population

A nationwide retrospective cohort study was performed at 29 Spanish high-volume University Hospitals following the guidelines set out in the Strengthening the Reporting of Observational Studies in Epidemiology statement.[21] Ethical approval for the analysis was obtained by the Ramón y Cajal University Hospital Ethics Committee (approval date April 18, 2021, protocol number 120–21).

We included all consecutive patients older than 18 years who presented a first episode of left-sided complicated diverticulitis with abscess formation between January 1, 2015 and December 31, 2019, classified by computed tomography (CT) as modified Hinchey Ib or II[10] in the first CT scan performed during their admission. Additionally, we included patients with free gas during admission and first treated by non-surgical management (PCD or antibiotics alone). Free air/free pneumoperitoneum was considered when imaging tests showed free gas bubbles without associated clinical or hemodynamic instability and without peritonitis on physical examination**.** Patients with a small amount of pericolic or pelvic peritoneal fluid without peritoneal irritation on physical examination were also included. All centers participating in the study had to be able to perform a PCD if indicated. Patients with perforated diverticulitis (Hinchey III or IV), right or transverse diverticulitis, previous segmentary colectomy, emergency surgery within 24 hours of admission, or with only the use of abdominal ultrasound at diagnosis were excluded.

Medical records were retrospectively reviewed. The baseline patient characteristics recorded were sex, age, body mass index, age-adjusted Charlson Comorbidity Index score, American Society of Anesthesiologists (ASA) score, comorbidities (chronic kidney disease, heart disease, chronic obstructive pulmonary disease, and autoimmune disease), and medical therapy at the time of diagnosis (corticosteroid therapy, immunosuppressive therapy, biological therapy, and chemotherapy). Laboratory parameters (C-reactive protein [CRP], hemoglobin, coagulation [international normalized ratio], total proteins, and white blood cell [WBC] count) were collected at the diagnosis. Radiological details of the number, size of the abscess and location, and local or diffuse intra-abdominal fluid (without associated clinical or hemodynamic instability and without peritonitis on physical examination) were recorded. The largest reported abscess size was used. Patients were stratified to assessment according to abscess size in the following 3 groups: <3 cm, 3 to 4.9 cm, and ≥5 cm. Clinical signs and symptoms of diverticulitis (nausea, vomiting, bowel complaints, rectal bleeding) were also collected. The type of treatment was recorded, including type and duration of antibiotic therapy, type of analgesia (non-steroidal anti-inflammatory drugs [morphine], and PCD. The use of morphine at the hospital was restricted to high-intensity pain and when the use of acetaminophen, metamizole, non-steroidal anti-inflammatory drugs, and weak opioids proved to be insufficient. The surgical procedure during the admission was also recorded, if applicable (type of procedure, surgical complications according to Clavien–Dindo scale[22]), and elective postadmission procedures. Colonoscopy findings in the follow-up period were also noted. The statistical analysis of the study was performed by treatment received at admission. Not all the data were properly completed or collected due to the study's retrospective nature, and no imputation techniques were used to impute missing data.

Outcomes

Short-term outcomes were the development of complications due to the inflammatory process (colonic obstruction, perforation, and fistula formation) and the need for emergency surgery (considered as unscheduled operations due to clinical deterioration or absence of improvement within 30 days after admission). All variables included in the multivariate study were recorded at admission. Long term-outcomes were recurrent diverticulitis (considered in new episodes of diverticulitis if the patient was asymptomatic >3 months after discharge and was classified according to modified Hinchey classification, considering outpatient management if non-complicated diverticulitis), elective surgery (type of procedure and complications), and consecutive admissions for repeated diverticulitis episodes. Lastly, the carcinoma incidence assessed by colonoscopy in the follow-up after the first episode was also reported.

Statistical analysis

Continuous variables were reported as medians (IQR), with categorical variables presented as absolute and relative frequencies. Univariable analysis was performed, assessing the impact of the type of initial non-operative treatment and the demographic and patient data on the occurrence of emergency surgery, employing the χ^2 analysis and Mann-Whitney *U* test, where appropriate. A multivariable analysis with logistic regression was then performed to determine factors independently associated with emergency surgery. A maximum model was performed by variables associated with emergency surgery, and a backward stepwise regression was applied to select the independent predictors. Risk factor selection for the model was driven by available knowledge and the biological plausibility of potential confounders, considering the hypothesis of interest. The adjusted odds ratio and its 95% CI were calculated for each risk factor in the presence of others in the final model.

A nomogram was developed based on the independent predictors and offers a visual display that directly predicts the risk of emergency surgery based on a calculated score. The score of an individual patient was associated with each risk factor. We used the area under the receiver operating characteristic curve to quantify the model's discrimination. Statistical significance was defined as $P < .05$. A calibration plot and the Hosmer-Lemeshow test were used to evaluate the model's goodness of fit. Analyses were performed using SPSS version 24.0 software (IBM SPSS, Inc, Armonk, NY) and Stata 17.1 (StatCorp, LLC, College Station, TX).

Results

Study population

Patient and disease characteristics according to the modality of non-operative treatment (antibiotic versus PCD) are shown in Table I. A total of 1,395 patients from 29 Spanish referral centers for colorectal surgery were included in the analysis—1,078 were Hinchey Ib, and 317 were Hinchey II patients. The patients' median age (IQR) was 61 (50–73) years, and 54.2% were men. The median body mass index of the entire cohort was 26.9 (24–30) kg/m^2, and 310 (22.4%) patients had an ASA fitness grade >II and a median age-adjusted Charlson Comorbidity Index of 3 (2–4). Free peritoneal fluid and free pneumoperitoneum were also observed in the CT scan at diagnosis in 388 (27.9%) and 369 (26.6%) patients,

Table I
Baseline characteristics and modality of non-surgical management

	Missed data, n	ATB	PCD	*P* value
Sex, *n* (%)	0			.230
Male		632 (53.7)	126 (58.2)	
Female		546 (46.3)	91 (41.8)	
Age, median (IQR), y	0	61 (24.3–30.5)	64 (51.5–77.5)	.018
BMI, median (IQR), kg/m^2	0	22.6 (24.3–30.5)	27.4 (24.9–30.9)	.445
Heart disease, *n* (%)	0	58 (4.9)	19 (9.1)	.507
Chronic kidney failure, *n* (%)	0	50 (4.3)	11 (5.3)	.507
COPD, *n* (%)	0	67 (5.7)	14 (6.7)	.564
Autoimmune disease, *n* (%)	0	42 (3.6)	9 (4.3)	.599
ASA risk, *n* (%)	13			.002
I		347 (29.8)	44 (21.5)	
II		574 (49.4)	97 (47.3)	
III		211 (18.1)	59 (28.8)	
IV		31 (2.7)	5 (2.4)	
ACCI, *n* (%)	7	3 (2.5)	4 (2.5)	.05
Previous abdominal surgery, *n* (%)	5	318 (27.3)	54 (26.1)	.713
Immunosupression treatment, *n* (%)	0	40 (3.4)	9 (4.3)	.513
Biologic treatment, *n* (%)	4	8 (0.7)	3 (1.4)	.662
Previous corticoid therapy, *n* (%)	0	71 (6.1)	7 (3.4)	.122
Chemotherapy, *n* (%)	0	24 (2.1)	3 (1.4)	.542
Symptoms at admission, *n* (%)	3			
Pain		1125 (95.9)	193 (92.8)	.05
Vomiting		84 (7.2)	12 (5.8)	.467
Obstruction		17 (1.4)	12 (5.8)	.607
High temperature		296 (25.2)	58 (27.9)	.420
Rectal bleeding		26 (2.2)	6 (2.9)	.576
Level leukocyte, median (IQR), $\times 10^9$/L	0	13.11 (10.39–15.54)	15.40 (12.48–18.24)	< .001
C-reactive protein, median (IQR), mg/L	3	101 (45.5–164)	152 (93–232)	< .001
Proteins level at admission, median (IQR), mg/dL	5	7.1 (6.2–7.6)	7.1 (6.1–7.7)	.999
Hemoglobin level at admission, median (IQR), g/dL	0	13.3 (11.8–14.6)	13.1 (11.2–14.6)	.539
INR at admission, median (IQR)	2	1.11 (1.03–1.2)	1.16 (1.06–1.28)	.656
Length of stay, median (IQR)	0	8 (5–13)	13 (8.5–19)	.008
Multiple abscesses, *n* (%)	0	121 (10.4)	46 (22.5)	< .001
Abscess location, *n* (%)	0			< .001
Pericolic		962 (83.7)	115 (55.3)	
Pelvic		160 (13.9)	74 (35.6)	
Retroperitoneal		9 (0.8)	11 (5.3)	
Distant		17 (1.5)	7 (3.4)	
Other		2 (0.2)	1 (0.5)	
Free peritoneal fluid, *n* (%)	0	330 (28.2)	54 (26.2)	.552
Free pneumoperitoneum, *n* (%)	0	306 (26.2)	61 (29.5)	.327
Hinchey classification, *n* (%)	0			< .001
IB		968 (81.9)	110 (51.4)	
II		213 (18.1)	104 (48.6)	
Abscess size, *n* (%), cm	0			< .001
0–2.9		491 (41.9)	10 (4.8)	
3–4.9		436 (37.2)	42 (20.2)	
>5		246 (21)	156 (75)	

ACCI, age-adjusted Charlson Comorbidity Index; *ASA*, American Society of Anesthesiologists; *ATB*, Antibiotics alone as initial treatment; *BMI*, body mass index; *COPD*, chronic obstructive pulmonary Disease; *INR*, international normalized ratio; *PCD*, Percutaneous drainage and antibiotics as initial treatment.

respectively. Abscesses were stratified into the following 3 groups in the analysis: <3 cm (504, 36.1%), 3 to 4.9 cm (484, 34.7%), and ≥5 cm (407, 29.2%) to obtain a more homogeneous sample. The mean CRP was 106 (28.5–186) mg/L for the entire cohort, and the mean WBC was 13.45 (10.79–16.4) $\times 10^9$/L. Piperacillin-tazobactam was the most commonly used antibiotic (497 [36.3]), followed by amoxicillin-clavulanic acid (303 [22.1]), a combination of cephalosporin and metronidazole (220 [16.1]), and carbapenem (221 [16.1]). Most (1,184, 84.9%) patients were initially treated with antibiotics without PCD. The median duration of hospital stay was 8 (6–13) days, and the median follow-up after discharge was 12.5 (4–27) months. A total of 243 patients out of 1395 (17.4%) were lost to follow-up after discharge.

The median age of the patients who were initially treated with PCD was slightly older (64 vs 61 years, $P = .018$) and had a higher proportion of ASA grade III (28.8% vs 18.1%, $P = .002$) than patients treated with antibiotics alone. Inflammatory parameter levels were higher in the PCD group, with a median WBC count of 15.4 (12.48–18.24) $\times 10^9$/L than in the antibiotics group with 13.11 (10.39–15.54) $\times 10^9$/L ($P < .001$), as well as a median CRP of 152 (93–232) mg/L in the PCD group versus 101 (45.5–164) mg/L in the antibiotics group ($P < .001$). A larger proportion of patients in the PCD group was classified as having Hinchey II disease (48.6% vs 18.1%; $P < .001$) with multiple abscesses (22.5% vs 10.4%; $P < .001$). The pelvic abscess proportion was higher in the PCD group (35.6% vs 13.9%; $P < .001$), and the pericolic abscess proportion was higher in the antibiotics group (83.7% vs 55.3%; $P < .001$). Abscesses in the PCD group tended to be larger than in the antibiotics group, with a higher proportion of ≥5 cm abscesses (75% vs 21%; $P < .001$). The median length of hospital stay was longer in the PCD group (13 [8.5–19] days vs 8 [5–13] days; $P = .008$).

Short- and long-term outcomes

Univariate analysis of short- and long-term outcomes according to initial treatment, antibiotics or PCD, and abscess size are

Table II
Short- and long-term outcomes of type of treatment and abscess size (univariate analysis)

	Missed data	Treatment		P value and/or OR (95 CI%)	Abscess size*					
		ATB, n (%)	PCD, n (%)		<3 cm	P value OR (95 CI%)	3 to <5 cm	P value and/or OR (95 CI%)	≥5 cm	P value and/or OR (95 CI%)
Short-term outcomes	0									
Complications		114 (9.7)	42 (20.2)	< .001 2.35 (1.59–2.47)	30 (6)	< .001 0.38 (0.25-0.57)	48 (9.9)	.249	79 (19.4)	< .001 2.81 (2.01–3.93)
Obstruction		9 (0.8)	4 (1.9)	.151	3 (0.6)	.325	2 (0.4)	.142	8 (2)	.010 3.94 (1.28–2.12)
Perforation		60 (5.1)	19 (9.1)	.021 1.86 (1.08–3.19)	13 (2.6)	< .001 0.32 (0.17–0.59)	24 (5)	.36	43 (10.6)	< .001 3.03 (1.92–4.79)
Fistula		26 (2.2)	18 (8.7)	< .001 4.17 (2.24–7.7)	4 (0.8)	< .001 0.17 (0.06–0.47)	19 (3.9)	.45	21 (5.2)	.006 2.28 (1.24–4.79)
Emergency surgery	0	154 (13.1)	40 (19.2)	.020 1.57 (1.07–2.31)	32 (6.3)	< .001 0.3 (0.2–0.47)	59 (12.2)	.145	105 (25.8)	< .001 3.24 (2.51–4.67)
Procedure	6			.402						.156
Hartmann		62 (41.3)	18 (47.4)		13 (40.6)		22 (38.6)		47 (46.5)	
Lavage and drain		48 (32)	7 (18.4)		8 (25)		25 (26.3)		32 (31.7)	
Resection + anastomosi		38 (25.3)	12 (31.6)		11 (34)		19 (33.3)		20 (19.8)	
Resection + anastomosis + stoma		2 (1.3)	1 (2.6)		0		1 (1.8)		2 (2)	
Surgical complication (CD)	0			0309		.562		.602		1.0
I–II		24 (58.5)	6 (42.9)		8 (61.5)		10 (50)		12 (54.5)	
III–V		17 (41.1)	8 (57.1)		5 (38.5)		10 (50)		10 (45.5)	
Deaths	0	8 (0.7)	6 (2.15)	.012 4.32 (1.45–7.08)	1 (0.2)	.023 0.13 (0.01–0.89)	3 (0.6	.295	10 (2.5)	< .001 5.19 (1.93–8.54)
Long-term outcomes										
Carcinoma in colonoscopy	27	15 (1.47)	9 (5.6)	.007 3.49 (1.5–8.08)	4 (1.2)	.668	10 (2.1)	.574	11 (2.7)	.100
Second episode	19	284 (27.2)	60 (35.1)	.033 1.48 (1.02–2.04)	119 (27.9)	.626	119 (27.9)	.860	105 (29.7)	.483
Hinchey (s)	19			.858		.893		.494		.769
IA		140 (49.5)	32 (54.2)		59 (49.8)		59 (49.6)		54 (51.9)	
IB		89 (31.4)	18 (30.5)		38 (31.4)		42 (35.3)		29 (27.9)	
II		45 (15.9)	7 (11.9)		19 (15.7)		16 (13.4)		17 (16.3)	
III		9 (3.2)	2 (3.4)		5 (4.1)		2 (1.7)		4 (3.8)	
Complications (s)	19	49 (17.5)	6 (10)	.149	20 (17.1)	.809	23 (19.3)	.289	13 (12.4)	.789
Treatment (s)	19			.953		.193		.497		.497
ATB		203 (91)	54 (90)		95 (94.1)		76 (89.4)		76 (89.4)	
PCD		49 (17.5)	6 (10)		6 (5.9)		9 (10.6)		9 (10.6)	
Third episode	31	83 (8.2)	4 (8.7)	.158	43 (10)	.239	30 (7.4)	.226	9 (10.6)	.984
Elective surgery	12	166 (15.4)	51 (25.1)	.001 1.83 (1.28–2.62)	62 (13.4)	.012 0.66 (0.48-0.91)	75 (16.4)	.729	81 (21.9)	.002 1.62 (1.18–2.17)
Elective procedure	0			.572		.572		.269		.435
Hartmann		10 (6.1)	5 (9.8)		4 (65)		3 (4.1)		8 (9.9)	
Resection + anastomosis		145 (87.9)	44 (86.3)		57 (91.9)		66 (89.2)		67 (82.7)	
Resection + anastomosis + stoma		10 (6.1)	2 (3.9)		1 (1.6)		5 (6.8)		6 (7.4)	
Elective surgical complication (CD)	0			.538		.592		.614		.367
I–II		69 (71.1)	20 (76.9)		15 (68.2)		33 (70.2)		43 (76.8)	
III–IV		28 (28.9)	6 (23.1)		7 (31.8)		14 (29.8)		23 (23.2)	
Deaths in elective surgery	0	1 (0.1)	1 (0.5)	.167	0	.287	0	.302	2 (0.5)	.026 2.06 (1.87–3.45)

ATB, antibiotics as only treatment; *CD*, Clavien–Dindo scale; *OR*, odds ratio, *PCD*, percutaneous drain.
* In the statistical analysis according to abscess size, multiple comparisons were made based on the reference group 3 to <5 cm.

shown in Table II. A total of 194 (13.90%) patients required emergency surgery due to non-surgical treatment failure at admission. The Hartmann procedure was the most commonly performed surgery in 80 (41.23%) patients. Moderate-to-severe complications (Clavien–Dindo III–IV) occurred in 25 (12.88%) patients after emergency surgery, and 14 (7.21%) of 194 patients died after undergoing emergency surgery. Postoperative mortality was found to be significantly higher in the ≥5 cm abscess group and the PCD group ($P < .001$ and $P = .012$, respectively). Diverticulitis complications were found in 226 (16.2%) patients. Of these, perforation and colonic fistula were significantly associated with abscesses ≥5 cm and PCD, and only obstruction was more

Table III
Univariate and multivariate logistic regression analyses of emergency surgery

Emergency surgery	Missed data, *n*	No, *n* (%)	Yes, *n* (%)	Univariate analysis *P* value	Multivariate analysis *P* value OR (95% CI)
Sex, *n* (%)	0			.268	.639 0.97 (0.60–1.56)
Male		658 (86.9)	99 (13.1)		
Female		541 (84.8)	97 (15.2)		
Age, median (IQR)	0	61.5 (51–76)	71 (52.5–81.7)	.127	.697 1.00 (0.97–1.02)
BMI, median (IQR)	7	26.96 (24.4–30.4)	25.45 (23.4–27.6)	.106	.217
Heart disease, *n* (%)	0	67 (84.8)	12 (15.2)	.764	.845 1.30 (0.50–3.36)
Chronic kidney failure, *n* (%)	0	48 (76.2)	15 (23.8)	.023	.876 0.98 (0.34–2.79)
COPD, *n* (%)	0	66 (81.5)	15 (18.5)	.233	.657 0.98 (0.21–4.46)
Autoimmune disease, *n* (%)	0	44 (86.3)	7 (13.7)	.946	.295 0.42 (0.11–1.55)
ASA risk, *n* (%)	13			.003	.310 0.88 (0.62–1.23)
I		349 (87.9)	48 (12.1)		
II		590 (87.4)	85 (12.6)		
III		216 (78.8)	58 (21.2)		
IV		31 (86.1)	5 (13.9)		
ACCI, median (IQR)	7	3 (2–5)	4.5 (2–6)	.029	.287 1.05 (0.97–1.13)
Previous abdominal surgery, *n* (%)	5	329 (87)	49 (13)	.522	.955 0.96 (0.57–1.61)
Immunosuppression treatment, *n* (%)	0	35 (71.4)	14 (28.6)	.003	< .001 4.72 (2.08–10.72)
Biologic treatment, *n* (%)	4	6 (60)	4 (40)	.018	.443 2.19 (0.31–15.32)
Previous corticoid therapy, *n* (%)	0	63 (80.8)	15 (19.2)	.175	.433 0.71 (0.29–1.75)
Chemotherapy, *n* (%)	0	22 (81.5)	5 (18.5)	.496	.387 0.24 (0.05–1.08)
Symptoms at admission, *n* (%)	3				
Pain		1145 (86)	186 (14)	.711	.780
Vomiting		74 (77.1)	22 (22.9)	.010	.174
Obstruction		17 (81)	4 (19)	.507	.570
High temperature		300 (84)	57 (16)	.227	.842
Rectal bleeding		28 (84.4)	5 (15.2)	.854	.826
Level leukocyte, median (IQR), $\times 10^9$/L	0	13.44 (10.86–15.53)	12.80 (8.72–17.89)	< .001	.168 1.00 (0.98–1.02)
C-reactive protein, median (IQR), mg/L	3	97 (24–162)	85 (22–218)	< .001	.001 1.003 (1.001–1.005)
Proteins level at admission, median (IQR), mg/L	5	7.1 (6.2–7.7)	6.55 (5.2–7.3)	.344	.457 1.00 (0.96–1.04)
Hemoglobin level at admission, median (IQR), g/dL	0	13.4 (11.7–14.8)	12.95 (10.4–14.7)	.06	.275 0.99 (0.81–1.12)
INR at admission, median (IQR)	2	1.1 (1–1.2)	1.16 (1–1.2)	.887	.097 1.10 (0.97–1.24)
Multiple abscesses, *n* (%)	0	130 (76.9)	39 (23.1)	< .001	.545 1.01 (0.56–1.83)
Abscess location, *n* (%)	0			< .001	.125 0.96 (0.55–1.95)
Pericolic		980 (90)	109 (10)		
Pelvic		166 (70.3)	70 (29.7)		
Retroperitoneal		14 (70)	6 (30)		
Distant		20 (83.3)	4 (16.7)		
Other		22 (66.7)	1 (33.3)		
Free peritoneal fluid, *n* (%)	0	315 (81.2)	73 (18.8)	.002	.256 0.98 (0.38–2.52)
Free pneumoperitoneum, *n* (%)	0	269 (72.9)	100 (27.1)	< .001	< .001 3.01 (2.04–4.44)
Hinchey Classification, *n* (%)	0			< .001	< .001 2.15 (1.42–3.26)
IB		970 (90.7)	100 (9.3)		
II		227 (72.5)	86 (27.5)		
Abscess size, *n* (%), cm	0			< .001	< .001
0–2.9		472 (93.7)	32 (6.3)		.250
3–4.9		425 (87.8)	59 (12.2)		.029 1.87 (1.06–3.29)
>5		302 (74.2)	105 (25.8)		< .001 3.62 (2.08–6.32)

(*continued on next page*)

Table III (*continued*)

Emergency surgery	Missed data, *n*	No, *n* (%)	Yes, *n* (%)	Univariate analysis *P* value	Multivariate analysis *P* value OR (95% CI)
NSAID, *n* (%)	8	604 (83.9)	116 (16.1)	.022	.417 1.13 (0.72–1.77)
Use of morphine, *n* (%)	11	103 (62.8)	61 (27.2)	< .001	< .001 3.68 (2.29–5.92)
Antibiotic scheme, *n* (%)	26				
Amoxicilin-clavulanic		275 (90.8)	28 (9.2)		
Piperacilin-tazobactan		415 (83.5)	82 (16.5)		
Cefalosporin + metronidazole		189 (85.9)	31 (14.1)		
Carbapenem		184 (83.3)	37 (16.7)		
Quinolone + metronidazole		94 (94.9)	5 (5.1)		
Other		21 (72.4)	8 (27.6)		
Non-oral intake, *n* (%)	8	968 (84.2)	181 (15.8)	.022	.18 1.84 (0.91–3.70)
Percutaneous drain, *n* (%)	0	168 (80.8)	40 (19.2)	.020	.056 0.60 (0.36–1.01)

ACCI, age-adjusted Charlson Comorbidity Index; *ASA*, American Society of Anesthesiologists; *BMI*, body mass index; *COPD*, chronic obstructive pulmonary disease; *INR*, international normalized ratio; *NSAID*, non-steroidal anti-inflammatory drugs.

frequent in the abscesses ≥5 cm group, but without statistical significance.

During long-term follow-up, 344 (28.28%) patients experienced a second episode of diverticulitis, of which 172 (50%) were non-complicated diverticulitis, and only 3.1% were purulent peritonitis. Elective surgery was performed in 216 (15.48%) patients, of whom 189 underwent colon resection and primary anastomosis. The elective surgery rate was higher in the PCD group compared with the antibiotics group (25.1% vs 14.4%; *P* = .001) and in patients who had a ≥5-cm abscess compared with small-sized abscesses (*P* = .002). Postoperative mortality decreased to 0.92% (2 patients) in elective surgery.

Table IV
Abscess size, treatment and emergency surgery

Abscess size, *n* (%)	Emergency surgery No	Emergency surgery Yes	*P* value OR (95% CI)
<3 cm			.020 6.80 (1.10–31.60)
ATB	462 (94.1)	29 (5.9)	
PCD	7 (70)	3 (30)	
3–4.9 cm			.689
ATB	383 (87.8)	53 (12.2)	
PCD	36 (85.7)	6 (14.3)	
≥5 cm			.035 .59 (0.37–0.96)
ATB	174 (70.7)	72 (29.3)	
PCD	125 (80.1)	31 (19.9)	

ATB, Antibiotic as only treatment; *OR*, odds ratio; *PCD*, percutaneous drain.

Multivariate analysis and nomogram developed for the prediction of emergency surgery

The results of the univariate and multivariate logistic regression analyses of emergency surgery are summarized in Table III. Given the retrospective nature of the study and the missing data, the sample size for the final multivariable model of emergency surgery was 1,071 out of 1,395 patients. In the multivariate logistic regression analysis, immunosuppression treatment (odds ratio [OR] 4.72; 95% CI 2.08–0.72; *P* < .001), CRP (OR 1.003; 95% CI 1.001–1.005; *P* = .001), free pneumoperitoneum (OR 3.01; 95% CI 2.04–4.44; *P* < .001), Hinchey II (OR 2.15; 95% CI 1.42–3.26; *P* < .001), abscess size 3.0 to 4.9 cm (OR 1.87; 95% CI 1.06–3.29; *P* = .029), abscess size ≥5 cm (OR 3.62; 95% CI 2.08–6.32; *P* < .001), and use of morphine (OR 3.68; 95% CI 2.29–5.92; *P* < .001) were significantly associated with emergency surgery.

Emergency surgery according to abscess size and treatment is shown in Table IV. Percutaneous drainage was associated with a lower risk of emergency surgery in patients with an abscess of ≥5 cm (19.9% vs 29.3%; *P* = .035) than antibiotics alone but also with a higher risk of emergency surgery in the small abscess group (30% vs 5%; *P* = .02) than antibiotics alone.

A nomogram was established by these 6 independent predictors (Figure 1). An area under the receiver operating characteristic curve of 0.808 (95% CI 0.771–0.845; *P* < .001) with good discrimination was shown in the newly developed prediction model (Figure 2). The calibration plot (Figure 2) and the Hosmer-Lemeshow test results showed a *P* = .971, indicating a good fit.

Discussion

In this nationwide, retrospective cohort study of patients undergoing non-operative treatment for diverticulitis with abscess from 2015 to 2019, multivariate analysis showed that initial non-operative management (antibiotics or PCD) did not appear to be independently associated with treatment failure and emergency surgery (*P* = .056); nevertheless, in a stratified analysis by initial treatment and abscess size, a higher risk of emergency surgery was found in the antibiotics alone group compared with PCD in patients with ≥5 cm abscesses. Moreover, PCD was not associated with a lower incidence of emergency surgery in abscesses of 3 to 4.9 cm but with a higher risk of treatment failure and surgery in abscesses <3 cm. Some published studies have corroborated these outcomes. Elagili et al found that 21% of treatment with antibiotics alone failed as initial treatment compared with 18% of the PCD group in abscesses of ≥3 cm in a cohort of 164 patients; however, it did not reach statistical significance (*P* = .21).[12] In a recent study, Mali et al showed a similar treatment failure rate between antibiotics and PCD in a cohort of 241 patients with abscesses of 4 cm or more (44% for antibiotics and 33% for drainage), with non-statistical differences.[23] Gregersen et al,[24] in a systematic review including 23 studies and 1,206 patients in the analysis of treatment failure, found a treatment failure of 18.8% to 34.4% from antibiotics alone in abscesses with a median size of 4 cm and concluded that the association between larger abscess size and treatment failure is unclear.[24] Similar results were reported by other published

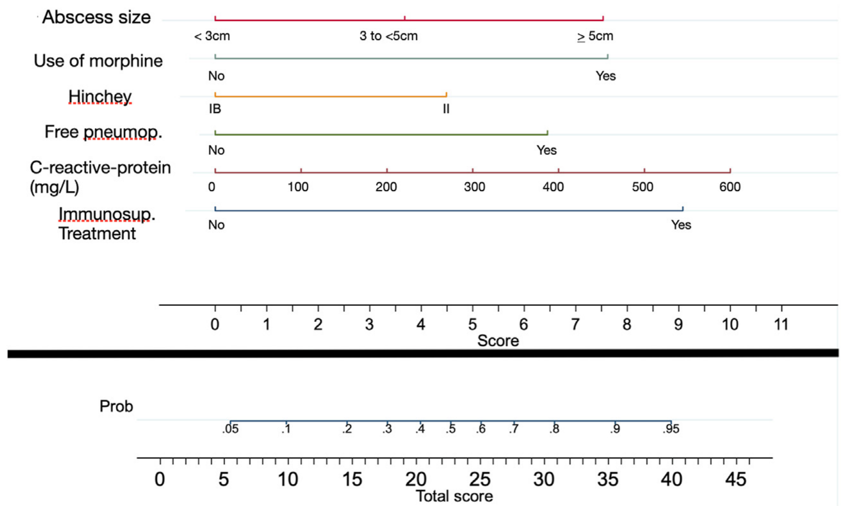

Figure 1. Emergency surgery risk calculation nomogram. Above: individual scores. Below: summation of individual scores (total score) and risk of emergency surgery.

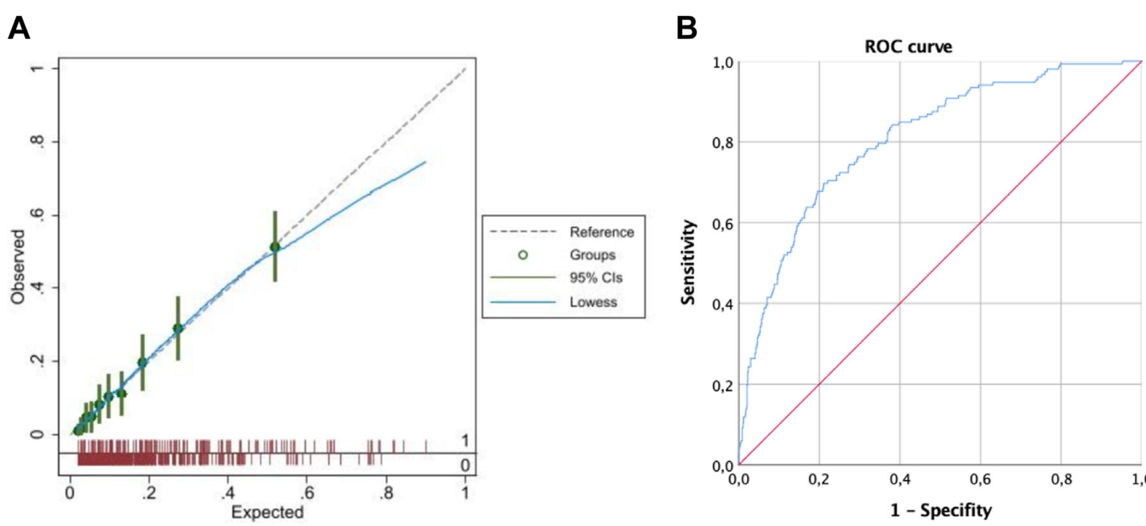

Figure 2. (A) Calibration plot used to evaluate the model's goodness-of-fit. (B) Receiver operating characteristic curve. Area under the receiver operating characteristic curve of 0.81 (95% CI: 0.77–0.85), $P < .001$. *ROC*, receiver operating characteristic.

studies.[12,25] Conversely, Lambrichts et al, in a large cohort of 447 patients, showed a significantly higher rate of emergency surgery ($P = .03$) in the PCD group (13.9%) than in the antibiotics alone group (7.2%). However, given that these findings were not stratified by abscess size, potentially introducing a bias by the inclusion of a large number of small abscesses, they concluded that an abscess size of ≥5 cm was an independent risk factor for short-term emergency surgery.[26] Despite the lack of quality evidence, international guidelines recommend PCD according to abscess size; yet, there are disagreements in the recommendations for the exact abscess size in which PCD provides a better outcome.[9,13–16,27]

The results of this multivariate analysis were similar to previous findings that showed an increased emergency surgery rate in abscesses ≥5 cm (OR 2.96)[26] and in immunosuppressed patients (OR 13).[28]

In our cohort, comparing PCD with no PCD showed that patients who underwent PCD appeared to have poorer short-term outcomes in terms of a greater likelihood of complications, such as perforation and fistula, which is in accordance with previous publications.[26] However, confounding by indication of initial treatment cannot be ruled out from this analysis, and differences could primarily reflect disease and clinical severity at admission. In fact, PCD patients were more likely to have ASA score III, multiple abscesses, Hinchey II, higher CRP and leukocyte levels, and larger abscesses. Indeed, patients with larger abscesses (≥5 cm) had significantly more associated diverticulitis complications. Emergency surgery rates of 13.9% are also largely in accordance with the pooled average of 12.1%.[24] A mortality rate of 0.2% of the total cohort and 7.21% in patients who underwent emergency surgery is comparable to pooled average mortality rates.[24,29,30]

Our study's recurrence rate was 28.8%, consisting mostly of uncomplicated diverticulitis or Hinchey grade Ib and II (50% and 46.7%, respectively). Our findings are in accordance with the reported rates of recurrent diverticulitis of 23% to 28%,[11,24,31,32] and these rates could be higher in the PCD group, which appears to be in line with previous reports.[24,33] Gregersen et al found that most recurrences occurred within the first year after primary admission,[32] which explains that, although the median follow-up in our series was 12 months, the recurrence rates were in line with those previously published. During follow-up, 217 (15.5%) patients underwent elective surgery, which is in accordance with the 16.2% rate reported by Gregersen et al.[32] The rate of elective surgery was significantly increased in the PCD group with ≥5 cm abscesses. The role of interval elective surgery after successful treatment of diverticular abscess remains controversial, as is the timing of when to perform it, and over the past decades, there has been an evolution of approaches and guidelines.[33] However, there has not been sufficient evidence to recommend interval resection after successful non-operative treatment of diverticular abscess.[16,34] Our study is not focused on answering that question, and further studies should provide more evidence.

Adverse outcome rates in patients with diverticular abscesses remain high and present a great burden for the patient and a challenge for surgeons. In our study, although PCD was not shown to be an independent risk factor for emergency surgery in the multivariate analysis, the stratified analysis showed a decreased rate of emergency surgery in the ≥5-cm subgroup and poorer outcomes in abscesses <3 cm. However, the findings in this subgroup of patients should be evaluated in larger studies given the small number of patients with abscesses <3cm undergoing PCD in our study. These results could, however, support the PCD approach for larger abscesses. It remains unclear whether PCD is an independent risk factor for developing diverticulitis complications such as fistula or perforation and for long-term poorer outcomes such as recurrence. Further targeted studies are warranted to address this issue.

Another aim of the present study was to identify potential risk factors related to emergency surgery. Immunosuppressive treatment, CRP, free pneumoperitoneum, Hinchey II, abscess size of 3 to 4.9 and ≥5 cm, and the use of morphine were independent risk factors, and a nomogram was developed to help improve individual patient management.

Study limitations

An important limitation of this study was its retrospective design, which introduces the potential for selection bias, insufficient sample size resulting in type 1 error, and confounding by indication. However, registration of a wide range of baseline patient and disease characteristics allowed the correction of potential known confounders in the multivariable logistics. Another inevitable consequence of retrospective observational research is the potential risk of missing data, given that the availability of baseline and outcome data largely depends on the completeness of the medical records. However, the multicenter setting had beneficial effects by increasing the study's generalizability. To our knowledge, this is one of the largest cohorts of patients with non-operative treatment of Hinchey Ib and II diverticulitis, and our results could help refine recommendations. In our opinion, this nomogram could help surgeons to anticipate urgent surgery and perform it in better conditions and, conversely, give the patient an opportunity for non-surgical management if the risk of urgent surgery is low. However, further studies will help to validate this nomogram.

In conclusion, diverticulitis with abscess formation remains a high-morbidity process. Non-operative treatment shows optimal control, although the recurrence rate is still moderate. The results of our study suggest the use of PCD in abscesses ≥5 cm to reduce emergency surgery rates. However, there is insufficient data to recommend it in smaller abscesses, for which an antibiotics-only approach has been proven to be effective. Using the nomogram could help surgeons tailor the optimal approach for each patient.

Funding/Support

This research did not receive any specific funding from any agencies in the public, commercial, or not-for-profit areas.

Conflict of interest/Disclosure

The authors have no conflicts of interests or disclosures to report.

References

1. Parks TG. Post-mortem studies on the colon with special reference to diverticular disease. *J R Soc Med*. 1968;61:932–934.
2. Parks TG. Natural history of diverticular disease of the colon. *Clin Gastroenterol*. 1975;4:53–69.
3. Heise CP. Epidemiology and pathogenesis of diverticular disease. *J Gastrointest Surg*. 2008;12:1309–1311.
4. Bolkenstein HE, van de Wall BJM, Consten ECJ, Broeders IAMJ, Draaisma WA. Risk factors for complicated diverticulitis: systematic review and meta-analysis. *Int J Colorectal Dis*. 2017;32:1375–1383.
5. Etzioni DA, Mack TM, Beart RW, Kaiser AM. Diverticulitis in the United States: 1998-2005: changing patterns of disease and treatment. *Ann Surg*. 2009;249: 210–217.
6. Mora Lopez L, Serra Pla S, Serra-Aracil X, Ballesteros E, Navarro S. Application of a modified Neff classification to patients with uncomplicated diverticulitis. *Colorectal Dis*. 2013;15:1442–1447.
7. Ambrosetti P, Becker C, Terrier F. Colonic diverticulitis: impact of imaging on surgical management – a prospective study of 542 patients. *Eur Radiol*. 2002;12:1145–1149.
8. Neff CC, VanSonnenberg E. CT of diverticulitis. Diagnosis and treatment. *Radiol Clin North Am*. 1989;27:743–752.
9. Fugazzola P, Ceresoli M, Coccolini F, et al. The WSES/SICG/ACOI/SICUT/AcEMC/SIFIPAC guidelines for diagnosis and treatment of acute left colonic diverticulitis in the elderly. *World J Emerg Surg*. 2022;17:5.
10. Wasvary H, Turfah F, Kadro O, Beauregard W. Same hospitalization resection for acute diverticulitis. *Am Surg*. 1999;65:632–635;discussion 636.
11. Lamb MN, Kaiser AM. Elective resection versus observation after nonoperative management of complicated diverticulitis with abscess: a systematic review and meta-analysis. *Dis Colon Rectum*. 2014;57:1430–1440.
12. Elagili F, Stocchi L, Ozuner G, Kiran RP. Antibiotics alone instead of percutaneous drainage as initial treatment of large diverticular abscess. *Tech Coloproctol*. 2015;19:97–103.
13. Galetin T, Galetin A, Vestweber KH, Rink AD. Systematic review and comparison of national and international guidelines on diverticular disease. *Int J Colorectal Dis*. 2018;33:261–272.
14. Schultz JK, Azhar N, Binda GA, et al. European Society of Coloproctology: guidelines for the management of diverticular disease of the colon. *Color Dis*. 2020;22:5–28.
15. 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;15:32.
16. Hall J, Hardiman K, Lee S, et al. The American Society of Colon and Rectal Surgeons clinical practice guidelines for the treatment of left-sided colonic diverticulitis. *Dis Colon Rectum*. 2020;6:728–747.
17. Garfinkle R, Boutros M. Elective surgery for diverticulitis – What does the surgeon need to consider? *Semin Colon Rectal Surg*. 2021;32:100800.
18. Kim NE, Hall JF. Acute diverticulitis: surgical management. *Semin Colon Rectal Surg*. 2020;32, 100799.
19. Rose J, Parina RP, Faiz O, Chang DC, Talamini MA. Long-term outcomes after initial presentation of diverticulitis. *Ann Surg*. 2015;262:1046–1053.
20. Kaiser AM, Jiang J-K, Lake JP, et al. The management of complicated diverticulitis and the role of computed tomography. *Am J Gastroenterol*. 2005;100: 910–917.
21. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *Int J Surg*. 2014;12: 1485–1499.
22. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg*. 2004;240:205–213.
23. Mali J, Mentula P, Leppäniemi A, Sallinen V. Determinants of treatment and outcomes of diverticular abscesses. *World J Emerg Surg*. 2019;14:31.
24. Gregersen R, Mortensen LQ, Burcharth J, Pommergaard HC, Rosenberg J. Treatment of patients with acute colonic diverticulitis complicated by abscess formation: a systematic review. *Int J Surg*. 2016;35:201–208.
25. Durmishi Y, Gervaz P, Brandt D, et al. Results from percutaneous drainage of Hinchey stage II diverticulitis guided by computed tomography scan. *Surg Endosc*. 2006;20:1129–1133.

26. Lambrichts DPV, Bolkenstein HE, van der Does DCHE, et al. Multicentre study of non-surgical management of diverticulitis with abscess formation. *Br J Surg*. 2019;106:458–466.
27. Nagata N, Ishii N, Manabe N, Tomizawa K, Urita Y, Funabiki T, et al. Guidelines for colonic diverticular bleeding and colonic diverticulitis: Japan Gastroenterological Association. *Digestion*. 2019;99:1–26.
28. Felder SI, Barmparas G, Lynn J, Murrell Z, Margulies DR, Fleshner P. Can the need for colectomy after computed tomography-guided percutaneous drainage for diverticular abscess be predicted? *Am Surg*. 2013;79:1013–1016.
29. Brandt D, Gervaz P, Durmishi Y, Platon A, Morel P, Poletti PA. Percutaneous CT scan-guided drainage vs. antibiotherapy alone for Hinchey II diverticulitis: a case-control study. *Dis Colon Rectum*. 2006;49:1533–1538.
30. Gregersen R, Andresen K, Burcharth J, Pommergaard H-C, Rosenberg J. Short-term mortality, readmission, and recurrence in treatment of acute diverticulitis with abscess formation: a nationwide register-based cohort study. *Int J Colorectal Dis*. 2016;31:983–990.
31. Garfinkle R, Kugler A, Pelsser V, et al. Diverticular abscess managed with long-term definitive nonoperative intent is safe. *Dis Colon Rectum*. 2016;59:648–655.
32. Gregersen R, Andresen K, Burcharth J, Pommergaard HC, Rosenberg J. Long-term mortality and recurrence in patients treated for colonic diverticulitis with abscess formation: a nationwide register-based cohort study. *Int J Colorectal Dis*. 2018;33:431–440.
33. Beresneva O, Donohue K, Kuhnen AH. Abscess management in left-sided diverticulitis. *Semin Colon Rectal Surg*. 2021;32:13–16.
34. Jalouta T, Jrebi N, Luchtefeld M, Ogilvie JW. Diverticulitis recurrence after percutaneous abscess drainage. *Int J Colorectal Dis*. 2017;32:1367–1373.