



Research Article

EARLY SURGERY IN APPENDICULAR MASS: SURGICAL TECHNIQUES AND MORBIDITY

*Carlos de Jesús Hernández López, Luis A. Escobar Sánchez, Jon M. Rementería Vázquez, Rodolfo Enríquez Salinas, Juan J. Sánchez Sánchez, Iván E. Flores López, Zaid Toledo Guzmán, Michel Remes Vargas, Paola N. Andrade Silva and Juan A. Rodríguez González

General Surgery, ISSSTE Puebla Regional Hospital, Puebla, 72550, Mexico

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Abstract

It is unclear whether early appendectomy prevents complications compared to delayed appendectomy in patients with appendiceal mass (AM). To evaluate early surgical techniques for AM in terms of the evolution and morbimortality, a prospective comparative analysis of patients undergoing early surgery for AM using different surgical techniques was performed. A total of 102 patients with AM (mean age 59 years) were reviewed. The common site of appendiceal perforation was the base in 54 patients (52.9%). The surgical techniques used were primary closure plus omental patch in 42 patients (41.2%), conventional appendectomy in 41 patients (40.2%), ileocectomy resection in eight patients (7.8%), primary closure plus ileostomy in six patients (5.9%) and right hemicolectomy in five patients (4.9%). Drainage was placed in the pelvic cavity in all patients, and the average length of stay was six days. The most frequent early, postoperative, and systemic complications were fever (n=48, 47%), seroma (n=35, 34.3%), and nosocomial pneumonia, (n=49, 48%). Seven patients (6.8%) were readmitted, and three required reoperation (2.9%). The surgical technique associated with the highest mortality was ileocectomy (2%), and the technique most associated with early, postoperative, and systemic complications was primary closure plus omental patch (40%, 35%, and 27%, respectively). The 30-day mortality rate was 3.9%. Some surgical techniques had higher morbidity and mortality rates, and may affect the evolution of patients with AM, although the association was not significant. Our study suggests that certain surgical techniques may affect the evolution of patients with AM.

Keywords: Appendiceal mass, Emergency appendectomy, Early Appendectomy, Acute complicated appendicitis, Complicated appendicitis, Perforated appendicitis, Open appendectomy.

INTRODUCTION

An appendiceal mass (AM) occurs when the appendix develops a walled-off perforation representing a spectrum of pathological conditions ranging from an inflammatory mass to neoplasia [1]. Its prevalence is 2-6% [2,3], and it can be diagnosed either by palpation or imaging [4-7]. AM can be treated through immediate surgery, conservative management with interval surgery, or complete conservative management. However, there is significant variation in the treatment preferences of surgeons, as reported by two studies [5]. The effects of early versus delayed appendectomy are currently poorly understood due to the limited evidence available [1,2,5,8-10]. Cueto *et al.* [8] conducted a study that included two controlled trials, revealing that the morbidity rate in early surgery was 30%, the surgical site infection rate was 20%, and fecal fistula rate was 5%. Morbidity and mortality were not reported in a standardized way, indicating that the quality of the evidence was very low due to bias. Therefore, no significant differences were found in morbidity and mortality between the early appendectomy and late appendectomy groups. The lack of standardized data reporting makes it difficult to estimate the rate of postoperative complications, and most of the reports do not provide figures for morbidity and mortality. However, studies in general report a surgical morbidity rate ranging from 2% to 30% [8, 11-15]. The mortality rate in cases of AM is typically less than 1%, except in elderly patients where the rate increases to 5%. This rate can be as high as 6.4% in patients over 80 years old [8,12,16]. In cases of AM, colonic resection may be necessary due to its similarity to neoplasia [17-19].

A randomized controlled trial by Mällinen *et al.* [20] showed an alarming 20% incidence of appendiceal neoplasia in patients over 40 years who underwent interval appendectomy, leading to the premature termination of the study. Meta-analyses have reported neoplasms detection rates of 0.9% to 1.4%, while recent studies have reported incidences between 5.9%- 12% [1-4,9,10,12,16,20-25]. In addition to neoplasms, other conditions such as Crohn's disease, diverticulitis, endometriosis, parasitosis, sarcoidosis, actinomyces infection, among others, have been found [6,7,14,26,27]. Immediate surgery may be technically demanding due to inflammation, resulting in colon resections being required instead of appendectomy in 25-30% of patients, and a high frequency of postoperative complications. However, early surgery is generally considered superior as it reduces the need for longitudinal follow-up, readmissions, misdiagnosis, and treats any ileocecal pathology that mimics AM [2,6,8,9,28]. In another study, the complication frequency in early surgery ranged from 0% to 57%, with major complications of 19% and a risk of bowel resection of 10%. However, few clinical trials have compared different types of treatment, and they are of low quality, leading to no uniform consensus on this issue [6,29-30]. This study aims to evaluate whether early surgery in AM can affect the evolution of morbidity and mortality, as well as comparing different surgical techniques in terms of surgical time, bleeding, length of hospital stay, readmission, and postoperative morbidity and mortality.

MATERIALS AND METHODS

A prospective study was conducted at ISSSTE Puebla Regional Hospital, a tertiary care center of regional reference with around 380,000 beneficiaries, from 2020 to 2022. The

*Corresponding Author: Carlos de Jesús Hernández López, General Surgery, ISSSTE Puebla Regional Hospital, Puebla, 72550, Mexico

study analyzed variables such as sex, age, comorbidities, surgical history, BMI, variables at admission (temperature, SOFA, hours of evolution, type of antibiotic used, days of administration, leukocyte, neutrophil, fibrinogen, INR, ASA score, diagnostic method), intraoperative variables (surgical approach, surgical technique, time and operative bleeding, appendiceal perforation site), and postoperative variables (early, surgical and systemic complications, reoperation, readmission, MAGS score, Clavien-Dindo score, day of oral route restart (re intake), start of gas canalization, day of drainage removal, discharge, and mortality). All patients were over 18 years old and grouped based on the surgical technique used: primary closure of the perforation plus omental patch, 42 patients (41.2%); conventional appendectomy, 41 patients (40.2%); ileocectomy with end ileostomy, 8 patients (7.8%); closure of cecal perforation plus end ileostomy, 6 patients (5.9%); and right hemicolectomy with ileostomy, 5 patients (4.9%). All surgeries were performed at the hospital. The sample was obtained in a non-probabilistic manner, and patients with AM who underwent total or partial surgical treatment in another hospital were excluded. Statistical analyses were performed using SPSS Statistics version 28 and Microsoft Excel. Descriptive variables were analyzed using the Kruskal-Wallis test, while ordinal and categorical variables were analyzed using the chi-squared test. Some sets of quantitative variables were analyzed using multiple linear regression, and the Kolmogorov-Smirnov normality test and Spearman's correlation coefficient were used. The sets of categorical dependent variables were analyzed using multinomial logistic regression analysis. A value of $p \leq 0.05$ or 5% (α error) was considered statistically significant for a two-tailed hypothesis test. The study protocol was reviewed and approved by the hospital's Research and Ethics Committee (Registration No. 1592022).

RESULTS

A total of 486 patients with acute appendicitis were included in this study, of whom 102 (20.9%) had AM.

Table 1. Characteristics of patients with AM

Variable	n= 102/Freq. (%)
Sex	
Women	61 (59.8)
Man	41 (40.2)
Comorbidities	
SH	56 (54.9)
DM	46 (38.3)
Obesity	37 (36.2)
ASA score	
I	12 (11.8)
II	52 (51.0)
III	38 (37.3)
Surgical history	
Lower abdomen surgery	38 (37.3)
At hospital admission	
Intestinal occlusion	23 (22.5)
Diagnostic method	
Clinical	96 (94.1)
CT	4 (3.9)
Ultrasound	2 (1.9)
Surgical approach	
middle supra-infraumbilical	52 (51)
infraumbilical middle	50 (49)

AM: Appendicular Mass; Freq.: Frequency; SH: Systemic Hypertension; DM: Diabetes Mellitus type 2; CKD: Chronic Kidney Disease; COPD: Chronic Obstructive Pulmonary Disease; ASA: American Society of Anesthesiologists; CT: computerized axial tomography; COVID-19: coronavirus disease 2019; MAGS: Modified Accordion Grading System.

All patients were referred from the second level of care, and antibiotics were administered before referral. Surgical management was performed in all patients. Of the total, 61 (59.8%) were women and 41 (40.2%) were men. (Table 1). The mean age of the patients were 59 years. On average, 101 hours elapsed from the onset of symptoms to surgery, the mean Body Mass Index (BMI) was 29.2, and the most frequent comorbidities were Systemic Hypertension (SH) (56, 54.9%) and diabetes mellitus (DM) (46, 38.3%). Of the total, 38 (37.3%) patients had undergone lower abdominal surgery, and 23 (22.5%) met the criteria for intestinal occlusion (Table 2).

Table 2. Descriptive characteristics of patients with AM

Variable	n=102 ± SD
Age (years)	59.4 ± 10.4
BMI (kg/m ²)	29.2 ± 2.9
At admission	
Temperature (degrees fahrenheit)	98.6 ± 33.8
SOFA	4.1 ± 1.8
Onset of symptoms (hours)	101.1 ± 28.1
Leukocytes (per microliter)	11457.0 ± 4837.2
Neutrophils (per microliter)	9787.0 ± 4834.9
Fibrinogen (g/L)	558.1 ± 241.9
INR	1.1 ± 0.4
days with antibiotics	3.9 ± 1.3
Intraoperative	
Operative time (minutes)	114.7 ± 40.1
Intraoperative bleeding (ml)	197.1 ± 98.4
Postoperative (days)	
Re intake	3.6 ± 1.6
Gas channeling	3.1 ± 1.1
Drain removal	4.3 ± 1.95
Discharge	6.0 ± 2.0

AM: Appendicular mass; SD: Standard Deviation; BMI: Body Mass Index; SOFA: Sequential Organ Failure Assessment score; g/L: grams/liter; INR: International normalized ratio; min: minutes; ml: milliliters.

The most frequent ASA score was II (51%), the average SOFA score was 4.1, and the number of days of antibiotic administration before surgery was 3.9. In total, 51 patients (50%) had received trimethoprim/ sulfamethoxazole treatment prior to being sent to our hospital.

Morbidity: The most frequent early complication was fever (48 patients; 47.1%). The most frequent postoperative complications were seroma (35 patients; 34.3%) and superficial wound dehiscence (22 patients; 21.6%), while the most frequent systemic complication was septic shock (35 patients; 34.3%). Primary closure plus omental patch was the surgical technique associated that had the highest incidence of early complications, affecting 41 patients (40%, $p < 0.05$), while postoperative complications were observed in 36 patients (35%, $p > 0.05$), and systemic complications were observed in 28 patients (27%, $p > 0.05$). See Table 3 for details. In multiple linear regression, the variables associated with early complications were comorbidities (rheumatoid arthritis and systemic hypertension, $p < 0.05$), surgical technique (primary closure of appendiceal perforation with end ileostomy, $p < 0.05$), and surgical time > 90 min ($p < 0.05$). There was no significant relationship between technique and postoperative complications. Variables related to systemic complications were ASA score ≥ 2 , preoperative septic shock, and history of lower abdominal surgery. Variables related to postoperative complications on the MAGS scale ≥ 5 were age > 60 years, ASA score ≥ 2 , and a history of lower abdominal surgery. A predictor of Clavien-Dindo postoperative complications ≥ 4 was a SOFA score ≥ 6 points (with weak correlation, using multiple linear regression, Kolmogorov-Smirnov test, and Spearman's test) and fibrinogen levels > 350 .

Table 3: Characteristics of patients with AM, by groups

Variable	Conventional Appendectomy	Ileocecectomy With Ileostomy	Right Hemicolectomy With Ileostomy	Primary Closure Plus Omental Patch	Perforation Closure Plus Ileostomy	*p
	N=41; freq. (%)	N=8; freq. (%)	n=5; freq. (%)	N=42; freq. (%)	N=6; freq. (%)	
Early Complications						
Ileus	3 (7.3)	2 (25.0)	3 (60.0)	5 (12)	1 (16.7)	<0.001
Vomit	13 (31.7)	1 (12.5)	0 (0.0)	13 (31)	1 (16.7)	<0.001
Fever	16 (39.0)	5 (62.5)	2 (40.0)	23 (54)	2 (33.3)	<0.001
Post-surgical complications						
Intra abdominal abscess	2 (4.9)	0 (0.0)	0 (0.0)	1 (2.4)	0 (0.0)	<0.001
Intestinal occlusion	1 (2.4)	0 (0.0)	0 (0.0)	3 (7.1)	0 (0.0)	<0.001
Surgical site infection (superficial)	2 (4.9)	6 (75.0)	0 (0.0)	3 (7.1)	1 (16.7)	<0.001
Wall abscess	1 (2.4)	0 (0.0)	0 (0.0)	5 (12)	0 (0.0)	<0.001
Superficial Dehiscence seroma	7 (17.1)	1 (12.5)	4 (80.0)	9 (21.4)	1 (16.7)	<0.001
15 (36.6)	1 (12.5)	1 (20.0)	15 (35)	3 (50.0)	<0.001	
Systemic Complications						
Septic shock	9 (22.0)	4 (50.0)	1 (20.0)	19 (45)	2 (33.3)	<0.001
Delirium	2 (4.9)	0 (0.0)	0 (0.0)	5 (12)	0 (0.0)	<0.001
Heart attack	0 (0.0)	2 (25.0)	0 (0.0)	3 (7)	0 (0.0)	<0.001
Covid-19 pneumonia	1 (2.4)	3 (37.5)	1 (20.0)	3 (7)	1 (16.7)	<0.001
Nosocomial pneumonia	2 (4.9)	1 (12.5)	1 (20.0)	2 (4.8)	0 (0.0)	<0.001
Readmission	1 (2.4)	1 (12.5)	1 (20.0)	4 (9.6)	0 (0.0)	0.720
Re-operation	1 (2.4)	0 (0.0)	0 (0.0)	2 (4.8)	0 (0.0)	0.890
Mortality	0 (0.0)	2 (25.0)	1 (20.0)	1 (2.4)	0 (0.0)	<0.001

* The difference in frequencies was analyzed with Chi square and a value of $p < 0.05$ was considered statistical significance.

AM: appendicular mass; freq.: frequency; SAH: systemic arterial hypertension; DM: Diabetes Mellitus; CKD: Chronic kidney disease; COPD: Chronic Obstructive Pulmonary Disease; ASA: American Society of Anesthesiologists; CT: computerized axial tomography; COVID-19: coronavirus disease 2019; MAGS: Modified Accordion Grading System

Table 4. Descriptive characteristics of patients with AM, by groups

Variable	Conventional Appendectomy	Ileocecectomy	Right hemicolectomy	Primary closure plus omental patch	Perforation Closure Plus Ileostomy	*p
	n=41 $\bar{X} \pm SD$	n=41 $\bar{X} \pm SD$	n=5 $\bar{X} \pm SD$	n=42 $\bar{X} \pm SD$	n=6 $\bar{X} \pm SD$	
Age (years)	58.1 \pm 10.1	63.6 \pm 6.3	49.2 \pm 17.4	61.8 \pm 9.7	55.3 \pm 10.7	0.133
Operative time (min)	89.3 \pm 25.1	147.3 \pm 31.9	226.0 \pm 29.7	118.6 \pm 24.7	126.7 \pm 27.3	<0.001
Intraoperative bleeding (ml)	138.7 \pm 58.6	258.5 \pm 64.0	476.0 \pm 43.4	211.0 \pm 74.9	185.0 \pm 41.8	<0.001
Start of the oral route (days)	2.7 \pm 1.3	5.0 \pm 1.8	6.6 \pm 1.5	4.1 \pm 1.3	2.5 \pm 0.5	<0.001
Start of gas channeling (days)	2.5 \pm 0.7	4.5 \pm 1.7	4.2 \pm 0.8	3.4 \pm 1.0	2.5 \pm 0.5	<0.001
Discharge (days)	4.8 \pm 1.6	7.9 \pm 3.3	9.0 \pm 1.6	6.5 \pm 1.5	5.2 \pm 1.2	<0.001
Drain removal (days)	3.9 \pm 1.6	4.4 \pm 1.8	7.0 \pm 2.3	4.7 \pm 2.1	3.0 \pm 0.0	<0.001

* The data were analyzed with the Kruskal-Wallis test.

AM: appendicular mass; SD: standard deviation; min: minutes; ml: milliliters.

Similarly, fibrinogen levels greater than 350 ng/mL were found to be associated with postoperative septic shock. Additionally, perforation of the appendiceal base was linked to postoperative complications with a MAGS score of 5 or greater. Among the patients (23 patients, 22.5%) diagnosed with AM and preoperative intestinal occlusions, primary closure plus omental patch was the most commonly used surgical technique used in these patients was in 12 patients (52%), followed by ileocecectomy with ileostomy in 5 patients (21.7%). There were statistically significant differences between those who presented with occlusion and those who did not ($p < 0.05$), MAGS ≥ 5 ($p < 0.05$), and Clavien-Dindo ≥ 4 ($p < 0.05$). However, there were no statistically significant differences between those who underwent occlusion and those who did not in terms of early complications, systemic complications, reoperation, and readmission rates. In the multinomial logistic regression analysis, it was found that fever and vomiting were significantly associated ($p < 0.05$) with primary closure plus omental patch and intraoperative bleeding > 250 ml. The presence of a seroma was associated with intraoperative bleeding > 250 ml, age > 60 years, and INR on admission > 1.5 . Superficial wound dehiscence was significantly associated ($p < 0.05$) with bleeding > 250 ml, BMI > 30 , and preoperative neutrophil count $> 10,000/\mu\text{L}$.

Additionally, the presence of a wall abscess was found to be associated with age > 60 years ($p < 0.05$).

COVID-19: Of the total number of patients with AM, nine (8.8%) had pneumonia due to COVID 19. The group with the highest percentage underwent ileocecectomy (12.5%). Among the patients with pneumonia due to COVID-19, two (22.2%) were readmitted due to postoperative complications ($p < 0.05$). A preoperative diagnosis of COVID-19 pneumonia was significantly associated with postoperative septic shock ($p < 0.5$ %).

Mortality: The surgical technique that had a higher mortality rate was ileocecectomy with Ileostomy (2%). In comparison, Right Hemicolectomy with Ileostomy and Primary Closure plus Omental Patch had a total mortality of 0.9% each, but the multivariable analysis did not show any significance, $p > 0.05$ %. The group with the highest mortality rate was those who presented with intestinal occlusion on admission, with three deaths (13%) ($p < 0.05$). The 30-day mortality rate overall was 4 (3.9%).

Technical aspects: The incision used in the surgery was medium supra-infraumbilical in 52 patients (51%) and medium

infraumbilical in 50 patients (49%). In 54 patients (52.9%), perforation of the cecal appendix was found at the base. Primary closure plus omental patch was the most commonly used surgical technique in 42 patients (41.2%). The average operating time was 114 minutes, the average bleeding volume was 197 mL, and a drain was placed in the pelvic cavity in all patients. The patients were discharged on an average of day 6 (Table 4).

Length of hospital stay: The average length of postoperative stay was six days. A stay longer than three days was associated with cardiac comorbidity and a history of lower abdominal surgery, clinical evolution longer than five days, perforation at the appendiceal base, and primary closure plus omental patch ($p < 0.05$). It was also associated with an operating time longer than 90 minutes, tolerance of the oral intake after the third day, the presence of post-surgical complications, and drain removal after the third day ($p < 0.05$). Variables associated with drain removal after three days included the use of preoperative antibiotics for three or more days and operative bleeding greater than 250 ml.

Re-operation: Out of the total patients, three (2.9%) underwent re-operation, and postoperative septic shock was found to have a significant association with reoperation ($p < 0.05$). Except for patients with MAGS scores ≥ 5 ($p < 0.06$; OR 8.3), no other group was significantly associated with reoperation.

Readmission: A total of seven patients (6.8%) were readmitted, and variables associated with readmission were drain removal after three days, history of rheumatoid arthritis, history of lower abdominal surgery, and neutrophil count $> 10,000/\mu\text{L}$. The right hemicolectomy group ($n = 1$) had the highest percentage of readmissions at 20%, but this was not statistically significant. The primary closure plus omental patch group had the highest number of admissions, with 4 out of 42 patients (9.5%, $p > 0.05$). Among the patients who experienced septic shock, six (17.1%) were readmitted ($p < 0.05$).

DISCUSSION

The incidence of AM in our environment (20.9%) was found to be higher than that reported in most series, ranging from 5% to 17.8% [3,6,8,10,16,28,30]. Moreover, our patients had a higher average age (59.4 years) than those in other studies, with an age range of 32-53 years [3,6,7]. The average number of days of evolution (4.2 ± 1.1) in our study was consistent with other studies reporting 3-12 days [7,14,28,30], as was the average BMI (28,30). However, the average ASA score ($\text{ASA} \geq 2$: 88.3%) was higher than that of other series ($\text{ASA} \geq 2$: 27%-41.1%) [14,30]. Clinical diagnosis was the predominant diagnostic method in our study, which varies in the literature, as some reports rely primarily on clinical diagnosis [3,30] while others use imaging [6,7,14]. The clinical presentation is like that reported in other studies, in which the patient did not have fever upon hospital admission [3,14,30]. The leukocyte range (11457.0 ± 4837.2) in our study was consistent with other studies reporting a range of 11500-31500 [3,7,14].

Morbidity: The morbidity rate of 34.3%-47.1% was higher than the rates reported in other studies which ranged from 17.6-22.2% [6,14,30]. When examining the relationships

between techniques and early, postoperative, and postoperative complications, statistical significance was not obtained, which is consistent with most reported studies [8,30], except for early complications associated with primary closure plus an omental patch ($p < 0.05$). The rates of surgical site infection (11.8%) and intra-abdominal abscess (2.9%) were lower than those reported in most studies, which ranged from 14-27.3% [3,6,8,14,28,30] and 7.4- 8% [6,14,28], respectively, and these differences were not statistically significant.

COVID-19: The morbidity of surgical techniques did not differ significantly between patients with COVID-19 and those without, as reported in the literature [17].

Mortality: Most studies did not report the mortality rate [6,8,14,30], or reported no mortality [3,8], in our study, the mortality rate was 3.9%, which was lower than the rates reported for our age group (5%-6.4%) [8,12,16].

Technical aspects: Approach: Most studies included two types of approach (open and laparoscopic) [25-30]; in our setting, 100% of the cases were performed using the open approach.

Surgical technique: Appendectomy was performed in 41 patients (40%), which is within the range reported in other series (11%-96.5%) [6,7,14]. Right hemicolectomy was performed in five patients (4.9%), with another series reporting a range of 3%-16.6% [6,7,14,28]. Ileocectomy was performed in eight patients (7.8%), which is similar to that reported in other studies (18.5%-24.5%) [6,14]. In all patients, either suction or passive drainage was left in the pelvic cavity, which coincides with some series [3,30].

Operative time: The average duration of surgery in our hospital (114 min) was in accordance with that reported in the literature (50-117 min) [3,6,28,30].

Re-intake: It was started on average 3.6 ± 1.6 days after the operation, which is within the range reported in the literature (> 24 hrs) [14].

Hospital stay: The average hospital stay was six days, which is reported in the literature to range from 2-21.4 days. [3,6,8,28], with no statistically significant difference between the groups studied.

Re-operation: In our hospital, the reoperation rate was 2.9%, which was lower than that reported (5.9%-6.6%), but without statistical significance between the groups studied [30].

Readmission: The readmission rate was 6.8% (7 patients), which is within the range reported in other studies (5.9-12%) [14,28], and without statistical significance in our study.

Malignancy: The percentage of malignant cases in our study (2.9%) was similar to that reported in other studies (2.3%-14%) [6,14,30].

Conclusion

Some surgical techniques had higher morbidity and mortality rates, and may affect the evolution of patients with AM, although the association was not significant. Intestinal occlusion on admission, fibrinogen level, ASA score, and SOFA score were significantly associated with morbidity. Our approach was completely open, and we reported the different

techniques used according on preoperative and intraoperative findings, resulting in a low reoperation rate. The postoperative outcomes of patients with COVID-19 were not significantly different from those of patients without COVID-19. Accumulated evidence is heterogeneous. Our study utilized scales to grade complications, but there are limitations, including a non-randomized design, small sample size, exclusion of pediatric patients, and limited experience from a single institution. Larger randomized multicenter studies are needed to determine the optimal treatment approach. Given these limitations, the associations should be interpreted with caution.

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List of Abbreviations: AM: appendicular mass; freq.: frequency; SH: systemic hypertension; DM: Diabetes Mellitus type 2; CKD: Chronic kidney disease; COPD: Chronic Obstructive Pulmonary Disease; ASA: American Society of Anesthesiologists; CT: computerized axial tomography; COVID-19: coronavirus disease 2019; MAGS: Modified Accordion Grading System. SD: standard deviation; BMI: body mass index; SOFA: Sequential Organ Failure Assessment score; g/L: grams/liter; INR: International normalized ratio; min: minutes; ml: milliliters. SD: standard deviation; min: minutes; ml: milliliters.

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