

Nonsurgical pneumoperitoneum detected using computed tomography: A retrospective study

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Abstract

Background Although several cases with pneumoperitoneum that does not require surgical intervention (nonsurgical pneumoperitoneum) have been reported, the characteristics of such cases remain unclear. The accurate diagnosis of nonsurgical pneumoperitoneum could minimize unnecessary surgery. The aim of this study was to clarify the clinical and radiological characteristics of cases with nonsurgical pneumoperitoneum detected using computed tomography. Methods This retrospective study was conducted at a single center. A total of 18513 abdominal computed tomography (CT) scans obtained between January 2010 and February 2017 were examined for pneumoperitoneum. Medical records of cases testing positive for extraluminal free air were analyzed. Results Extraluminal free air was detected in 254 examinations of 182 cases. Out of 88 examinations of 86 cases excluding iatrogenic air, colorectal perforation was the most common cause of extraluminal free air. Nonsurgical pneumoperitoneum was recognized in 25 examinations of 23 cases, and was the second most frequent. The frequency of nonsurgical pneumoperitoneum was 0.14% in all abdominal CT examinations. Most nonsurgical pneumoperitoneum cases did not exhibit severe general conditions, peritoneal signs, or leukocytosis. CT findings of bowel wall discontinuity, segmental bowel-wall thickening, perivisceral fat stranding, and abscess were not observed. Fluid collection was present in 8 of 23 cases, and the estimated volume of fluid collection was small. Pneumatosis intestinalis was simultaneously observed in 20 of 23 cases. No significant differences in the maximum diameter of intraperitoneal free air were observed between the grades of pneumatosis intestinalis ($p=0.999$). Follow-up CT examination, which was performed within 7 days after the detection of nonsurgical pneumoperitoneum, showed that the pneumatosis intestinalis and/or extraluminal free air often disappeared in a short time. Conclusions Nonsurgical pneumoperitoneum was common. The cause of extraluminal free air was pneumatosis intestinalis in most cases. Well-maintained general and local conditions and normal laboratory data were the clinical characteristics. The absence of CT findings indicative of peritonitis, little fluid collection, if any, and the presence of pneumatosis intestinalis were the radiological characteristics.

Background

Pneumoperitoneum is considered to be one of the most crucial signs of severe intraabdominal diseases. Diagnosis of pneumoperitoneum has been based on the presence of intraperitoneal free air under the diaphragm on upright plain radiography or between the free edge of the liver and the lateral wall of the peritoneal cavity on left lateral decubitus radiography [1]. Advances in computed tomography (CT) have enabled the detection of smaller amounts of extraluminal free air, including intraperitoneal free air [2-4]. The increasing use of CT scanning at many medical institutions and improvements in CT scanning resolution have improved diagnostic quality for acute abdomen.

Conversely, several cases with pneumoperitoneum caused by physiologic processes that does not require surgical intervention (nonsurgical pneumoperitoneum) have been reported [5-9]. Thus, not all cases of pneumoperitoneum require laparotomy since the presence of free air does not necessarily mean a life threatening intraperitoneal perforation. Despite the description of various nonsurgical causes of

pneumoperitoneum, unnecessary surgery has been performed because of the difficulty of accurate diagnosis. To minimize unnecessary surgery, we should elaborate on the findings specific to nonsurgical pneumoperitoneum.

By using CT, a small volume of extraluminal free air that does not require surgical treatment can also be detected. Most recent reports on nonsurgical pneumoperitoneum detected using CT, however, have been limited to case reports [10-14], and the clinical analysis of nonsurgical pneumoperitoneum cases is insufficient. This study retrospectively analyzed cases with extraluminal free air detected using CT to clarify the clinical and radiological characteristics of nonsurgical pneumoperitoneum.

Methods

This retrospective study was conducted at a single center, and was approved by the Fujimi-Kogen Medical Center Ethics Committee (Approval No. 54).

From January 2010 to February 2017, a total of 18513 abdominal CT examinations were performed at Fujimi-Kogen Hospital of Fujimi-Kogen Medical Center. The 18513 examinations were ordered by medical doctors in the out-patient, in-patient, and emergency departments. All CT examinations were performed using a 32-slice multi-detector CT scanner (Aquilion 32, Toshiba, Japan), and a collimated slice thickness of 1 mm was used. All findings of the CT scan images were reported in our database.

Clinical Analysis

The database was searched using “free air” as the keyword to find cases with extraluminal free air. Extraluminal free air consists of intraperitoneal, intramesenteric and retroperitoneal free air. In this study, intramesenteric or retroperitoneal free air was defined as the air not continuous to the air in the bowel wall. Extraluminal free air was detected in 254 examinations of 182 cases. Medical records of the 182 cases were reviewed to confirm the cause of the free air.

A case with extraluminal free air that did not retrospectively require surgical intervention or intensive therapy was defined as a nonsurgical pneumoperitoneum case. Nonsurgical pneumoperitoneum case was a case with pneumoperitoneum from nonsurgical cause. Nonsurgical pneumoperitoneum cases included a case receiving unnecessary surgery, but did not include a case receiving intensive therapy instead of surgery. For example, a case with perforated duodenal ulcer treated by conservative therapy without surgery was not included in nonsurgical pneumoperitoneum cases. Medical doctors who participated in this study analyzed the medical records of nonsurgical pneumoperitoneum cases in detail.

Imaging Analysis

One radiologist with 32 years of experience and one gastrointestinal surgeon with 38 years of experience reevaluated the CT examinations of nonsurgical pneumoperitoneum cases. CT findings evaluated were bowel wall discontinuity, segmental bowel-wall thickening, perivisceral fat stranding, intraabdominal abscess, intraperitoneal fluid collection, extraluminal free air, and pneumatosis intestinalis.

In each case, the maximum diameter of the largest pocket of intraperitoneal free air located either under the abdominal wall or in the perihepatic space was measured to estimate the amount of extraluminal free air. We did not measure intramesenteric or retroperitoneal free air (Fig.1), because the maximum diameter of intramesenteric or retroperitoneal air could not be correctly measured. The anteroposterior, lateral, and vertical diameters of the fluid collection were measured, and the estimated volume was determined using a formula for calculating ellipsoid volume.

Pneumatosis intestinalis was defined as the presence of air in the bowel wall identified using lung window settings [15]. The grade of pneumatosis intestinalis was classified by our criteria as follows. Bubbly, linear, or circular air (Fig. 2 and 3) in or along less than 10 cm of the bowel wall was defined as mild. Air in or along more than or equal to 10 cm of the bowel wall or air not only in the bowel wall but also in the mesentery (Fig.4) was defined as severe.

Statistical analysis

Statistical analysis was performed by Mann-Whitney U-test using a StatView 5.0 statistical software package (Abacus Concepts, Berkeley, CA, USA). P<0.05 was considered to be significant.

Results

1) Frequency of nonsurgical pneumoperitoneum

Out of the 18513 abdominal CT examinations, extraluminal free air was detected in 254 examinations of 182 cases. Fifty-seven follow-up CT examinations out of the 254 examinations were performed to observe the clinical course after the detection of extraluminal free air. Out of the 197 examinations of 182 cases excluding the 57 follow-up examinations, iatrogenic air was detected in 109 examinations. The iatrogenic air consisted of air after laparotomy in 87 examinations, air after gastrointestinal endoscopic therapeutic procedure in 14 examinations, and air after other therapeutic procedures in 8 examinations. Out of the 88 examinations of 86 cases excluding iatrogenic air, nonsurgical pneumoperitoneum was recognized in 25 examinations of 23 cases. The frequency of nonsurgical pneumoperitoneum was 0.14% in all abdominal CT examinations, as shown in Table 1.

2) Causes of extraluminal free air

The causes of extraluminal free air in the 86 cases excluding iatrogenic air were studied, and are summarized in Table 2. Colorectal perforation was the most common cause of extraluminal free air. The frequency of nonsurgical pneumoperitoneum cases was 26.7% constituting the second most common finding. Perforated duodenal ulcer was the third most common cause. One case with pneumoretroperitoneum caused by pneumothorax was not included in nonsurgical pneumoperitoneum, because the case was required intensive therapy for pneumothorax.

3) Clinical features of nonsurgical pneumoperitoneum cases

The clinical features of nonsurgical pneumoperitoneum cases are presented in Table 3. The ages of nonsurgical pneumoperitoneum cases were high. The chief complaints of the cases varied. All cases showed good general condition, and many cases did not show peritoneal signs or leukocytosis. One case underwent emergent laparotomy because of slight peritoneal signs and severe leukocytosis. This case showed no pathological intraabdominal findings. Nine cases received antibiotic therapy. The antibiotics were administered for a short period of time, or used for other diseases.

Twenty-two of the 23 cases had comorbidities, such as cardiovascular, digestive, neurological, and endocrine disorders. One case had bronchial asthma, three cases received steroids, one case received α-glucosidase, and one case received chemotherapy for cancer. No specific comorbidities were shared among the nonsurgical pneumoperitoneum cases.

4) CT findings of nonsurgical pneumoperitoneum cases

The CT findings of 23 nonsurgical pneumoperitoneum cases are summarized in Table 4. Bowel wall discontinuity, segmental bowel-wall thickening, perivisceral fat stranding and abscess were not recognized. Fluid collection was not observed in 15 of 23 cases, and the estimated total volume of fluid collection was small in other cases. Pneumatosis intestinalis was simultaneously detected in 20 cases, and the average age of the 20 cases was 79.8 ± 9.8 (mean \pm SD) years. Intraperitoneal free air was detected in 21 cases, and the maximum diameter of intraperitoneal free air varied.

The maximum diameter of intraperitoneal free air was compared between mild and severe grades of pneumatosis intestinalis, as shown in Figure 5. No significant differences in the maximum diameter of intraperitoneal free air were observed between the grades ($p=0.999$).

5) Follow-up of CT findings in nonsurgical pneumoperitoneum cases

The follow-up CT examination, which was performed to observe the clinical course within 7 days after the detection of nonsurgical pneumoperitoneum, was performed in eight cases. The CT findings when nonsurgical pneumoperitoneum was detected and the follow up CT findings in the 8 cases were compared, and presented in Table 5. When the follow-up CT was performed, pneumatosis intestinalis alone disappeared in 2cases, extraluminal free air alone disappeared in one case, and both pneumatosis intestinalis and extraluminal free air disappeared in three cases.

Discussion

In this study, we demonstrated that the frequency of nonsurgical pneumoperitoneum was 0.14% among all abdominal CT examinations. When the causes of extraluminal free air in the cases excluding those with iatrogenic air were studied, nonsurgical pneumoperitoneum was observed in 26.7% of the cases. This frequency was the second highest and next to the frequency of colorectal perforation. These results indicate that nonsurgical pneumoperitoneum cases are common. Mularski et al [16] reported in their review article that pneumoperitoneum was caused by visceral perforation in 85% to 95% of all

occurrences and, in 5% to 15% of cases, pneumoperitoneum resulted from another source that did not require emergency surgery. Their 2000 study was based on many reports using plain radiography rather than CT examination; since 2000, CT has improved and been increasingly adopted by many medical institutions worldwide. The present study is the first to clarify the frequency of nonsurgical pneumoperitoneum cases detected using CT.

The main causes of nonsurgical pneumoperitoneum were reported as being intrathoracic, gynecologic, abdominal, and idiopathic [9,16]. Pneumothorax, pneumomediastinum, cardiopulmonary resuscitation, positive pressure ventilation, etc. have been reported as intrathoracic causes. Vaginal douching, post-partum exercises, oral-genital insufflation, and coitus have been reported as gynecologic causes. Abdominal causes were classified as iatrogenic and pneumatosis intestinalis. The common iatrogenic causes of pneumoperitoneum were following abdominal surgery and following gastrointestinal endoscopy [9,16]. In the present study, the cases with iatrogenic pneumoperitoneum were not analyzed as nonsurgical pneumoperitoneum cases, because iatrogenic pneumoperitoneum could be easily diagnosed as iatrogenic with an accurate medical history.

Benign pneumatosis intestinalis can result in pneumoperitoneum caused by rupture of subserosal cysts [17]. Jamart [18] reported that pneumoperitoneum was present in 9%, and Saito et al [19] reported that intraperitoneal free air was detected in 26.4% of cases with pneumatosis intestinalis. In the present study, simultaneous pneumatosis intestinalis was detected in 20 (87.0%) of the nonsurgical pneumoperitoneum cases. Pneumatosis intestinalis was considered to be a cause of extraluminal free air in the 20 cases, and the remaining 3 cases without pneumatosis intestinalis were classified as idiopathic. Our follow-up CT findings showed that the pneumatosis intestinalis and/or extraluminal free air often disappeared in a short time. These findings indicated that extraluminal free air alone could be detected in nonsurgical pneumoperitoneum cases caused by pneumatosis intestinalis when CT examination was delayed. These results suggest that pneumatosis intestinalis may be one of the causes of extraluminal free air in idiopathic nonsurgical pneumoperitoneum cases.

The average age of patients with both nonsurgical pneumoperitoneum and pneumatosis intestinalis was 79.8 ± 9.8 (mean \pm SD) years. The mean ages of the patients with pneumatosis intestinalis reported by Wu et al [20], DuBose et al [21], and Saito et al [19] were 45.3, 53.3, and 64.7 years, respectively. The ages of our cases were particularly high compared with those of the patients enrolled in the aforementioned studies. Our study may indicate that pneumatosis intestinalis readily leads to ruptures in older patients, resulting in nonsurgical pneumoperitoneum.

Mularski et al [8] reported that nonsurgical causes of pneumoperitoneum should be considered when abdominal pain and distension are minimal and peritoneal signs, fever, and leukocytosis are absent. Tang et al [14] reported that nonsurgical pneumoperitoneum cases often present with minimal pain and typically have no fever, leukocytosis, peritoneal signs, or metabolic acidosis. The results for many of the cases in the present study resembled those of the aforementioned studies. Based on these reports, well-

maintained general and local conditions and normal laboratory data were the clinical characteristics of nonsurgical pneumoperitoneum cases.

Radiological findings of nonsurgical pneumoperitoneum cases were described by Williams et al [9]. However, the CT findings of nonsurgical pneumoperitoneum cases have not been studied. From this analysis of CT findings, bowel wall discontinuity, segmental bowel-wall thickening, perivisceral fat stranding, and abscess were not observed in nonsurgical pneumoperitoneum cases. These CT findings were indicative of acute bowel disease and gastrointestinal perforation [22,23]. Fluid collection was observed in a few cases, and the estimated volume of fluid collection was small. Pneumatosis intestinalis was simultaneously observed in most nonsurgical pneumoperitoneum cases. From these results, we demonstrated that the absence of CT findings indicative of peritonitis, little fluid collection, if any, and the simultaneous presence of pneumatosis intestinalis were the radiological characteristics of nonsurgical pneumoperitoneum cases. It was noteworthy that there were no differences in the maximum diameter of intraperitoneal free air between the grades of pneumatosis intestinalis. Therefore, it is crucial to consider nonsurgical pneumoperitoneum when pneumoperitoneum cases exhibit simultaneous pneumatosis intestinalis, even if the extraluminal free air is massive and the pneumatosis intestinalis is minimal.

A 1992 study by Hoover et al [24] indicated that meticulous study of medical history, complete physical examinations, laboratory data with radiographic studies, and frequent reevaluation of these findings are necessary for the accurate diagnosis of nonsurgical pneumoperitoneum. Although their recommendations remain relevant, we should elaborate on the findings characteristic to nonsurgical pneumoperitoneum to make an accurate diagnosis and minimize unnecessary surgery. In this study, we demonstrated some CT findings often observed in nonsurgical pneumoperitoneum cases. CT images should be carefully evaluated using lung window settings, if some clinical findings to suspect nonsurgical pneumoperitoneum are present.

Conclusion

Nonsurgical pneumoperitoneum detected using computed tomography were common. The most common cause of free air was pneumatosis intestinalis, which may lead to ruptures more readily in elderly patients. Well-maintained general and local conditions and normal laboratory data were the clinical characteristics. The absence of CT findings indicative of peritonitis, little fluid collection, if any, and the presence of pneumatosis intestinalis were the radiological characteristics.

Abbreviations

CT: computed tomography

Declarations

- Ethics approval and consent to participate

This retrospective study was approved by the Fujimi-Kogen Medical Center Ethics Committee (Approval No. 54).

- Consent for publication

Not applicable

- Availability of data and material

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

- Competing interests

The authors declare that they have no competing interests.

- Funding

All authors have no funding to declare.

- Authors' contributions

WA and TM analyzed and interpreted the clinical and radiological data. WA and YY were major contributors in writing the manuscript. JI, HS and KK analyzed medical records in detail. All authors read and approved the final manuscript."

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- Authors' information (optional)

Not applicable

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Figures

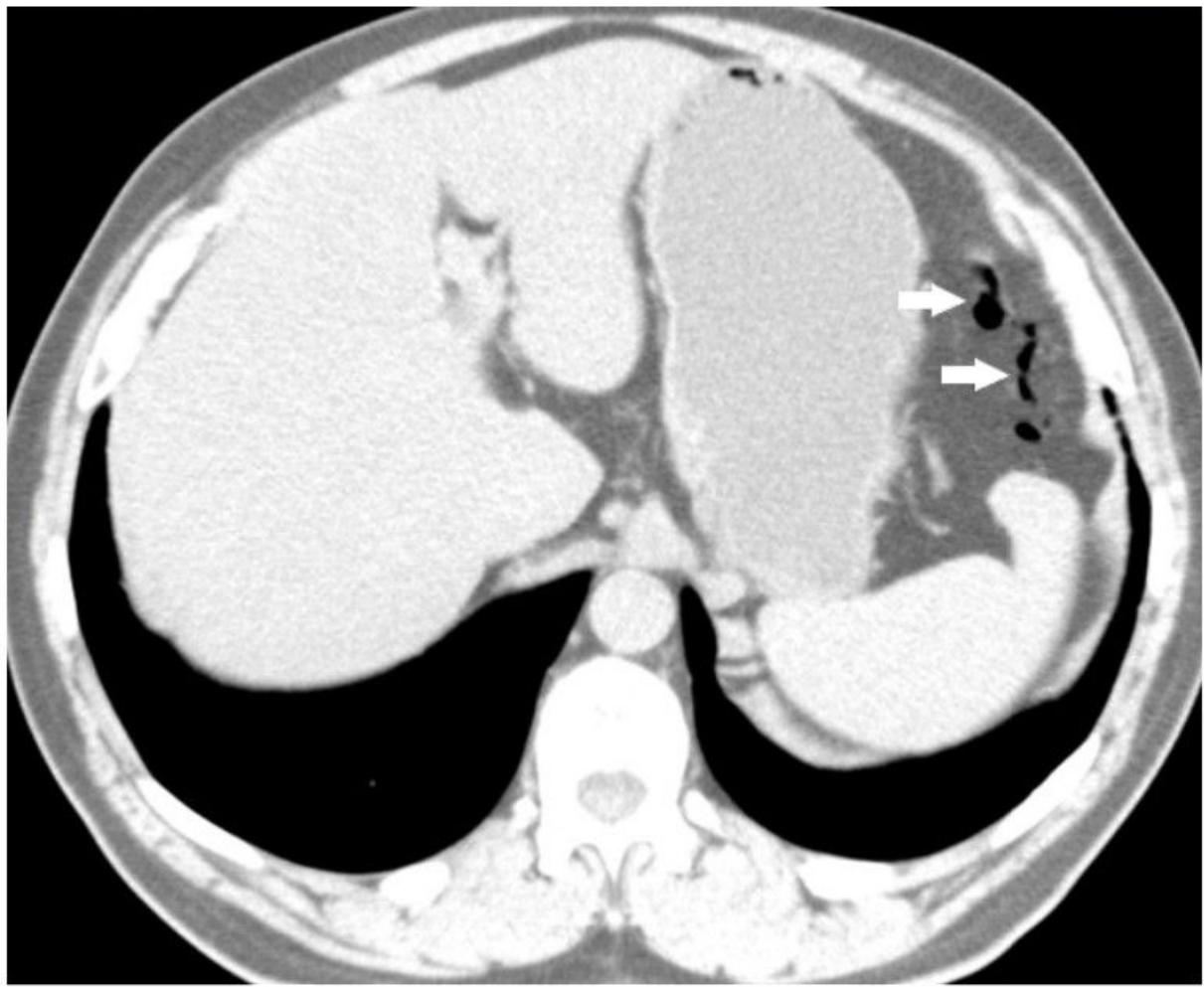


Figure 1

Intramesenteric free air. Intramesenteric free air (white arrows) was shown in left upper abdomen. This air was not continuous with intestinal wall.

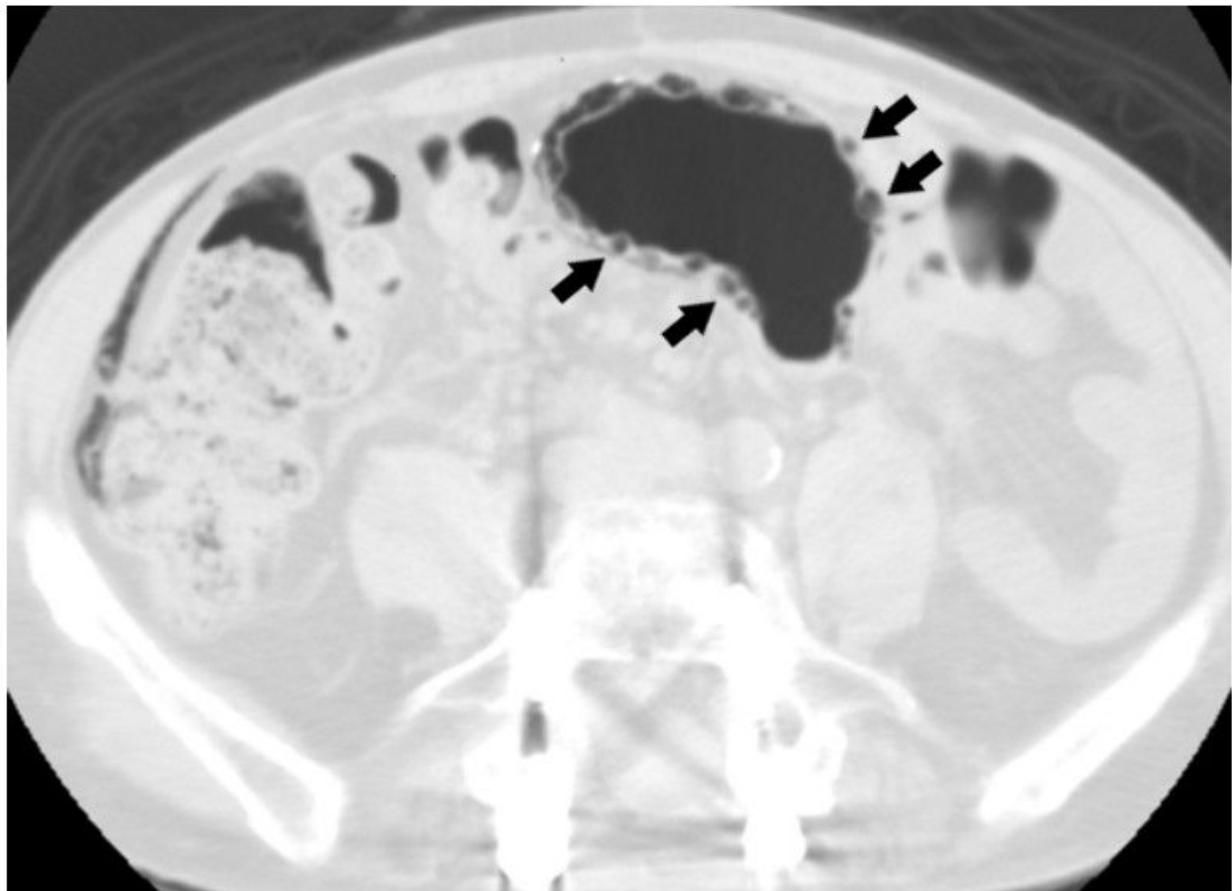


Figure 2

Bubbly pneumatosis intestinalis. Bubbly air (black arrows) in sigmoid colon was observed.



Figure 3

Linear and circular pneumatosis intestinalis. Linear and circular air (black arrows) in small intestine was observed.

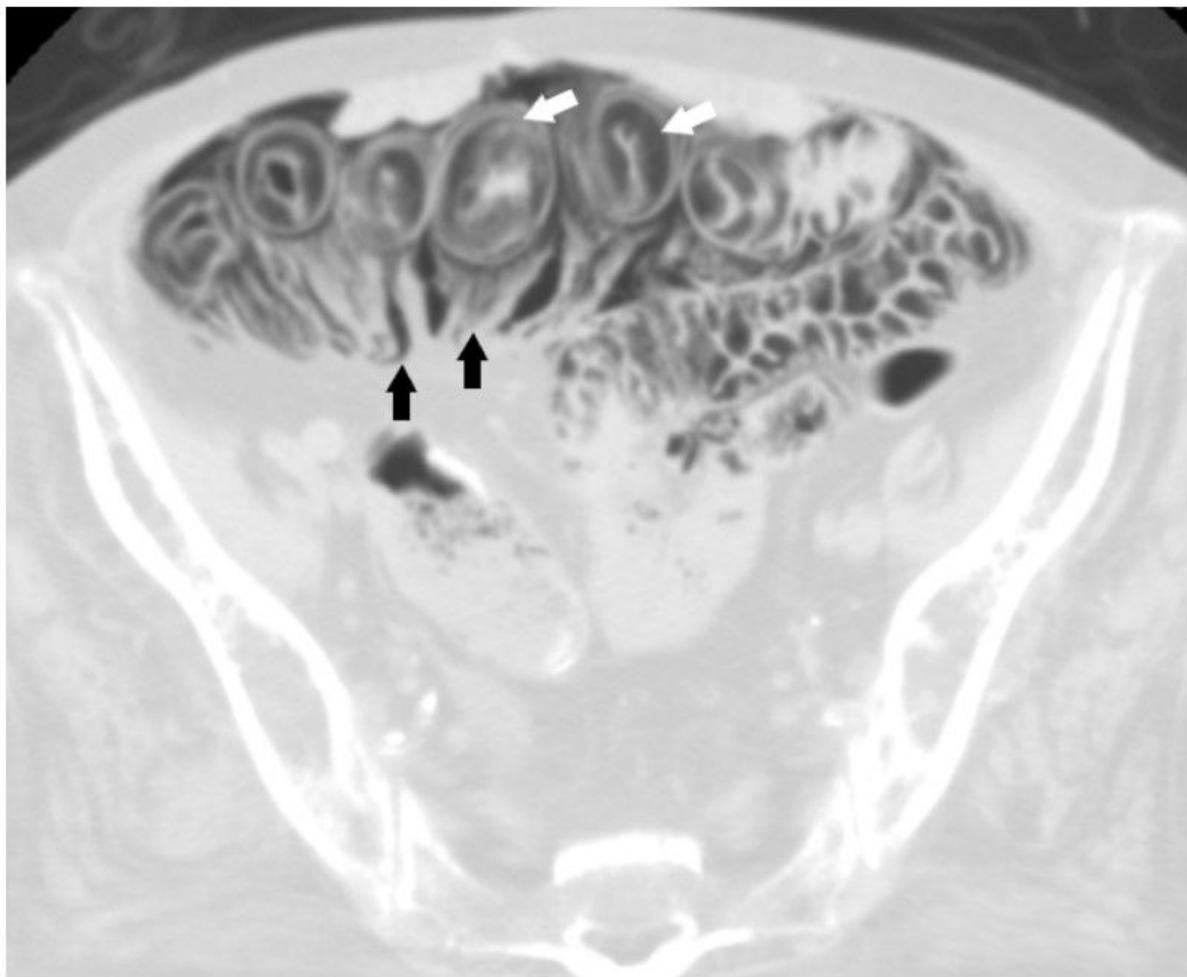


Figure 4

Pneumatisos intestinalis in the mesentery. Air in the small intestine (white arrows) and in the mesentery (black arrows) was shown.

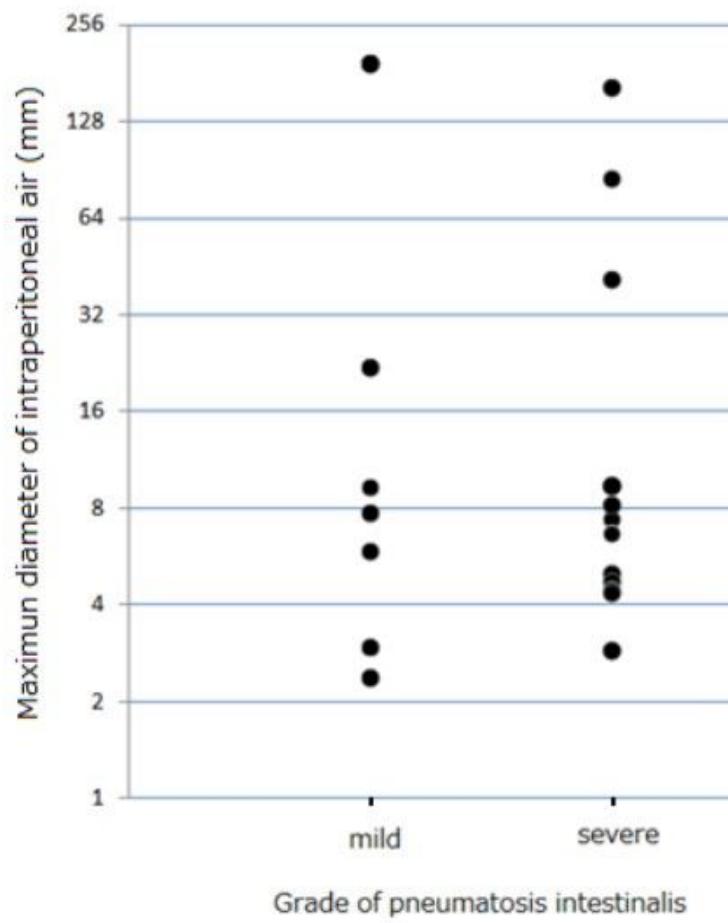


Figure 5

Comparison of maximum diameter of intraperitoneal free air between the grades of pneumatosis intestinalis. No significant differences in the maximum diameter of intraperitoneal free air were observed between the grades ($p=0.999$).

Supplementary Files

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