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## Case Report

## Asymptomatic sigmoid diverticulum perforation-induced subcutaneous, mediastinal, and retroperitoneal emphysema: A case report and literature review

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## ABSTRACT

**Background:** Mediastinal and subcutaneous emphysema usually result from spontaneous rupture of the alveolar wall. We present an educational case of subcutaneous, mediastinal, and retroperitoneal emphysema discovered during a routine medical check-up resulting from an asymptomatic perforation of the sigmoid diverticulum.

**Case presentation:** A 66-year-old man presented to our hospital for his health check-up. A chest X-ray revealed mediastinal emphysema during a physical examination. The patient had no subjective symptoms, fever, or hemodynamic instability. Physical examination revealed a snow grip sensation in the anterior neck but no abdominal tenderness. Blood tests showed an elevated inflammatory response, and a plain chest computed tomography scan revealed subcutaneous emphysema around the neck, as well as mediastinal and retroperitoneal emphysema. The patient was then admitted to the hospital and the patient was treated conservatively. On Day 7 post-admission, the emphysema was mildly relieved. However, on Day 10, the patient developed intestinal obstruction caused by barium. Colonoscopy revealed sigmoid colon perforation. On Day 11, partial resection of the sigmoid colon via laparotomy and colostomy (Hartmann operation) was performed. Postoperative pathology revealed a perforation of the sigmoid colon, which was confirmed to be induced by diverticulitis, as multiple diverticula were simultaneously found in the sigmoid colon.

**Conclusions:** Even in the absence of abdominal symptoms, retroperitoneal emphysema may develop due to perforation of the sigmoid colon. Therefore, if retroperitoneal emphysema is

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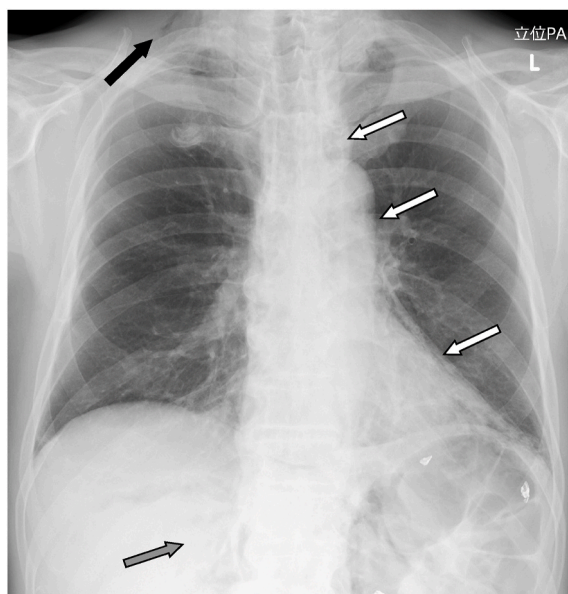
combined with mediastinal emphysema, evaluation, including abdominal CT, should be performed to identify the cause of emphysema.

## 1. Background

Mediastinal emphysema refers to air retention in the mediastinum; this condition is classified into idiopathic mediastinal emphysema (occurs spontaneously with no known cause) or secondary mediastinal emphysema (caused by trauma and/or pathological conditions). Most cases of idiopathic mediastinal emphysema resolve spontaneously and are associated with a good prognosis [1]. In contrast, secondary mediastinal emphysema is more severe and owing to the underlying disease, it is associated with complications and poor prognosis [2]. In the present report, we describe a rare case of asymptomatic perforation of the sigmoid diverticulum that resulted in subcutaneous, mediastinal, and retroperitoneal emphysema.

## 2. Case presentation

A 66-year-old Japanese man with a smoking history of over 30 pack-years presented to our hospital without any symptoms for his health check-up. A chest X-ray revealed mediastinal emphysema (Fig. 1). Eighteen months prior, owing to a positive fecal occult blood test, a colonoscopy was performed on the patient (who had used over-the-counter laxatives to relieve constipation) and post-inflammatory induced stenosis was noted in the sigmoid colon. A diverticulum was found in the sigmoid colon. The stenosis was believed to be a result of diverticulitis; however, the patient remained asymptomatic and was placed under observation. The patient had no subjective symptoms, the body temperature was 36.3 °C, SpO<sub>2</sub> was 97 %, blood pressure was 140/86 mmHg, and pulse was noted to be 92/min. Physical examination revealed a snow grip sensation in the anterior neck, but no chest pain or tenderness. Blood tests showed a mild elevation of hepatic enzymes, with aspartate aminotransferase (AST), 43 IU/ml; alanine aminotransferase (ALT), 66 IU/ml; elevated inflammatory response; C-reactive protein CRP 17.1 g/dL, and WBC 16,290/ $\mu$ L. A simple computed tomography (CT) scan of the chest revealed subcutaneous (of the neck), mediastinal, and retroperitoneal emphysema, with no evidence of free air (Fig. 2). One week prior to admission, the patient had fallen from a stepladder and bruised his back, and traumatic emphysema was suspected; however, a chest CT scan of the chest showed no tracheal or esophageal tears. A high inflammatory response was determined as the cause of a back abscess, and the patient was referred to our department for wound cleaning. The patient was hospitalized and treated with sulbactam/ampicillin. Thereafter, blood culture test showed no bacteria, on Day 7 of hospitalization, the patient did not have a fever, emphysema was relieved, and antibacterial drug administration was terminated after confirming a decreasing trend in the inflammatory response. By Day 8 of hospitalization, the patient was able to eat all his meals and had no abdominal pain or other subjective symptoms, and a small number of stools with barium used for physical examination the day before hospitalization was seen. However, on Day 10 of hospitalization, abdominal distention and nausea appeared. A plain CT scan of the trunk revealed that the barium was retained from the descending colon to the sigmoid colon, and that the colon and small intestine at the oral side of the barium were dilated with fluid retention. This indicated the development of intestinal obstruction caused by solidified barium.

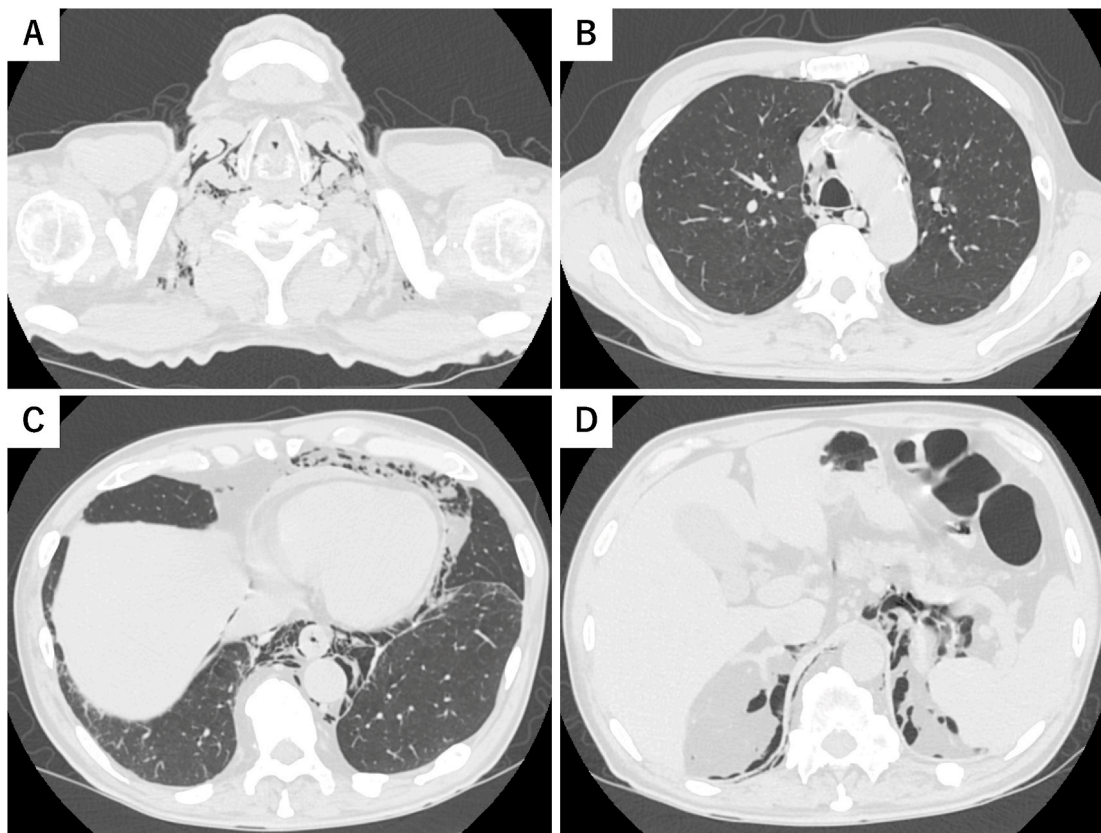


**Fig. 1.** Chest X-ray showed subcutaneous emphysema (black arrow) and mediastinal emphysema (white arrows) and retroperitoneal emphysema (grey arrow).

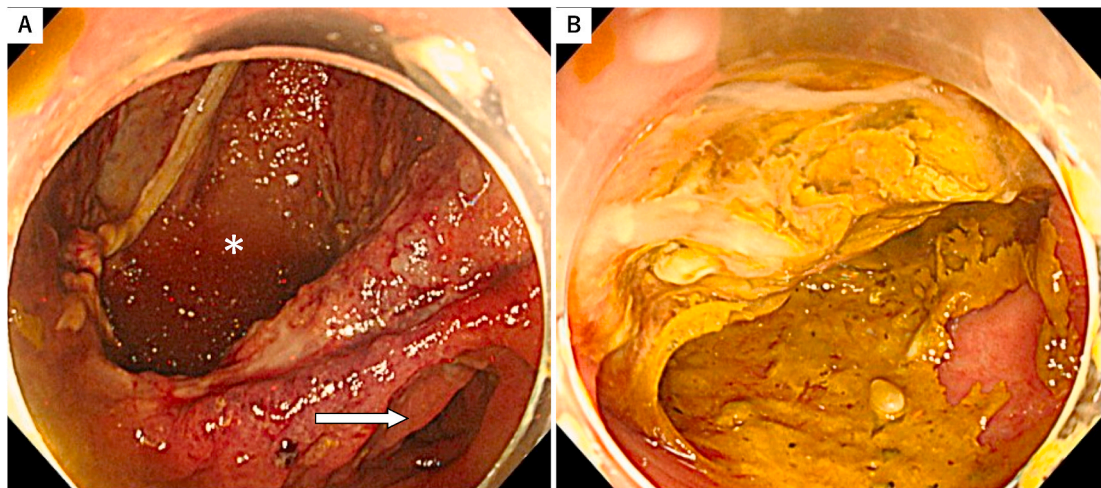
Colonoscopy revealed a coarse mucosal lumen in the sigmoid colon thought to be a fistula (pseudo lumen) and a normal mucosal lumen with stenosis (Fig. 3). Barium was stagnant on the mouth side of the narrowing of the lumen of the normal mucosa of the sigmoid colon. The lumen of the rough mucosa of the sigmoid colon was easily hemorrhagic, fatty tissue was present, and the lumen was a blind end; perforation of the sigmoid colon was suspected. Therefore, the patient was immediately transferred to the Department of Surgery. On Day 11 of hospitalization, the patient underwent laparotomy. At the time of laparotomy, there was only ascites and no stool in the abdominal cavity. The large meshes, small intestine, sigmoid colon, and rectum in the pelvis from the root of the inferior colonic artery were strongly adherent. When the adhesions of the large mesenchyme and small intestine were detached, a large amount of fecal discharge was observed from within the mesentery; the perforated area on the mesenteric side of the sigmoid colon was identified. There was an intestinal injury at the adhesion between the sigmoid colon and the bladder, and the patient was resected from its mouth side to the anal side of the perforation (Hartmann method), and a colostomy was created. Gross examination of the operative specimen revealed multiple diverticula in the sigmoid colon and a 3 cm perforation on the mesenteric side (Fig. 4). Postoperative pathology showed inflammatory cell infiltration around the perforation but no malignancies or granulomas. At the perforation site, a void was observed in the mesenteric fatty tissue, suggesting a perforation on the intestinal membrane side. Multiple diverticula in the sigmoid colon suggested perforation due to diverticulitis. The emphysema did not recur thereafter (Fig. 4), and the patient was discharged on postoperative Day 46.

### 3. Discussion

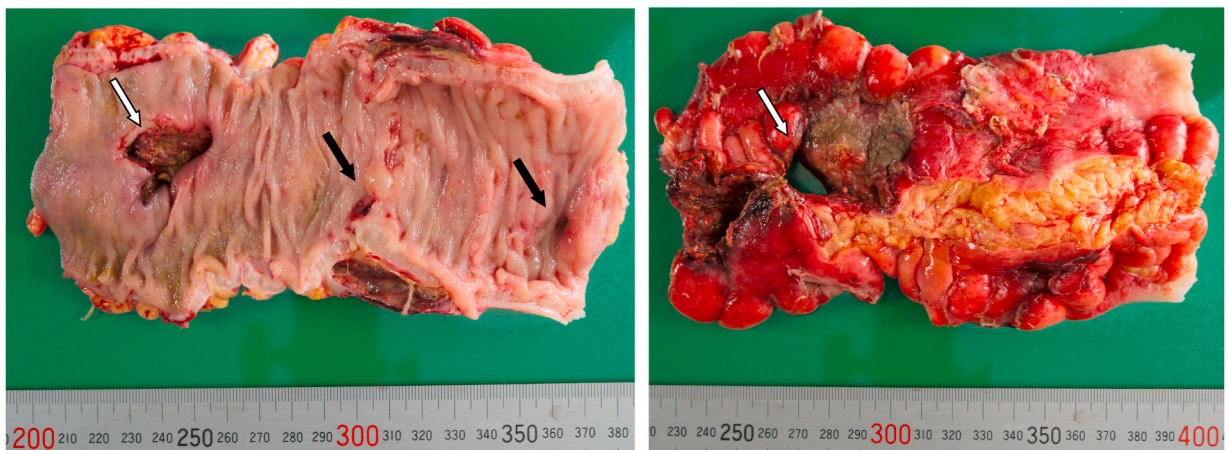
Because the space between the cervical subcutaneous tissue, mediastinum, and retroperitoneum is anatomically continuous [3], this patient was initially suspected to have developed mediastinal and retroperitoneal emphysema in the chest following injury from a fall. Traumatic mediastinal emphysema has been reported to occur in approximately 10 % of the cases of blunt chest trauma [4]. The mechanisms of occurrence include injury to the trachea and esophagus and the Macklin effect, in which leaked air reaches the mediastinum due to the rupture of alveoli caused by increased intra-alveolar pressure [5]. However, in the present case, imaging findings showed no tracheal or esophageal injury, pneumothorax, or multiple air accumulations in the pulmonary interstitium; suggestive of the Macklin effect. In addition to trauma, mediastinal emphysema can be of medical origin, such as bronchial asthma, upper airway inflammation, or soft tissue fragility due to a malnutritional condition such as anorexia nervosa; however, in this case, mediastinal emphysema was not of medical origin. Idiopathic mediastinal emphysema is characterized by a lack of an elevated



**Fig. 2.** A Chest simple CT (Computed Tomography) showed subcutaneous emphysema of the neck. B-C Chest simple CT showed mediastinal emphysema. D The lower margin of the chest simple CT showed retroperitoneal emphysema with no evidence of free air.



**Fig. 3.** **A** Colonoscopy revealed a coarse mucosal lumen in the sigmoid colon thought to be a fistula (pseudo lumen) (\*) and a normal mucosal lumen with stenosis (arrow). The lumen of the rough mucosa of the sigmoid colon was easily hemorrhagic, fatty tissue was present, and the lumen was a blind end; perforation of the sigmoid colon was suspected. **B** Barium was stagnant on the mouth side of the narrowing of the lumen of the normal mucosa of the sigmoid colon.



**Fig. 4.** A gross examination of the operative specimen revealed multiple diverticula in the sigmoid colon and a 3 cm perforation on the mesenteric side (arrow).

inflammatory response, and patients with idiopathic mediastinal emphysema and an elevated inflammatory response should undergo examination for the identification of an infectious source, including mediastinitis. Although we suspected that the elevated inflammatory response was attributed to the back abscess on the first day in the present case, but the mildly elevated inflammatory response persisted even after completion of antimicrobial therapy. In addition, since the inflammatory response is elevated in intestinal perforation with systemic emphysema even in the absence of peritonitis [6,7], it was suggested that the elevated inflammatory

**Table 1**

Retroperitoneal emphysema as a rare complication of intrathoracic factor excluding trauma or medical origin reported in the English literature. NA, no available information.

Age	Sex	Cause	remarks	Presenting symptom	Treatment regime	Outcome	Reference no.
15	Female	anorexia nervosa	none	sore throat, retro sternal thoracic pain	none	survived	8
7	Female	Mycoplasma pneumoniae pneumonia	none	fever, respiratory difficulties	antibiotics, steroid	survived	9
38	Female	anorexia nervosa	mental retardation	difficult to move	antibiotics	survived	10

response was not only due to a back abscess but also to intestinal perforation. Retroperitoneal emphysema due to intrathoracic factors is extremely rare, with only three cases reported, except for trauma or medical origin (Table 1) [8–10]. In the present case, although the relationship of trauma and intestinal perforation could not be completely ruled out, bowel perforation was evident, and it was reasonable to conclude that the mediastinal emphysema was due to sigmoid diverticulitis.

Gastrointestinal perforation (descending duodenal leg, ascending colon, descending and sigmoid colon, and rectum), infective pancreatitis, and retroperitoneal infection are associated with retroperitoneal emphysema [11]. Colorectal retroperitoneal perforation affects individuals of all ages, and is caused by diverticulitis, cancer, colonic ischemia, toxic megacolon, ectopic perforation, and trauma [12]. Colorectal perforation presents with retroperitoneal and subcutaneous emphysema due to the pressure gradient between the gastrointestinal lumen, retroperitoneum, and subcutaneous tissue. The retroperitoneum is divided into anterior pararenal, perirenal, and posterior pararenal cavities, with the anterior pararenal cavity being continuous with the mesentery and the posterior pararenal cavity being continuous through the diaphragm to the mediastinum. Normal soft tissue intraluminal pressure is 5 mmH<sub>2</sub>O, whereas the intraluminal pressure in the gastrointestinal tract during peristalsis reaches 60 mmH<sub>2</sub>O [13]. If perforation occurs on the mesenteric side, this pressure gradient allows gas to migrate to the mediastinum and subcutis, as the sigmoid colon has a narrower lumen than other parts of the colon. A review of English-language literature revealed 30 cases of mediastinal emphysema caused by intra-abdominal factors excluding trauma and medical procedures, with 20 of these involving colonic perforation, as observed in the present case, with sigmoid diverticulitis as the most common causative disease (Table 2) [6,7,14–22]. Therefore, when retroperitoneal emphysema is present, abdominal CT, including that of the pelvic floor, should be considered. In the present case, inflammation of the sigmoid colon was noted, and inflammatory bowel disease and intestinal tuberculosis were included in the differential diagnoses. Finally, based on the pathological findings, the retroperitoneal perforation appeared to be caused by diverticulitis. The patient had previously been diagnosed with diverticulitis and sigmoid colon stenosis on colonoscopy, and it was thought that the stenosis caused stagnation of barium, resulting in intestinal obstruction.

Notably, retroperitoneal perforation may result in a lack of abdominal pain symptoms. Colorectal perforation commonly manifests as free perforation of the contralateral enterocolitis membrane, which is easy to diagnose at an early stage, owing to the appearance of free gas and signs of peritoneal irritation on abdominal CT. The high prevalence of perforations on the contralateral side of the intestinal membrane is because the straight arteries entering from the intestinal membrane do not interconnect, and the contralateral side of the intestinal membrane is most susceptible to the hemostatic shortage. In contrast, in cases of retroperitoneal perforation, the large bowel is perforated on the mesenteric side; therefore, the bowel contents are covered by the mesentery, which leads to poor peritonitis symptoms, and intra-abdominal gas and ascites effusion are less prominent on imaging findings [23]. Thus, there are scattered case reports of patients requiring several weeks to be diagnosed [6]. Clinicians should remember that abdominal symptoms may be less prominent in the elderly and in patients on steroids [6].

The appropriate treatment for colonic retroperitoneal perforations remains controversial. Colonic perforation after colon resection or colonoscopy may improve with conservative management, such as fasting and antibiotics if the abscess is localized, even if associated with mediastinal emphysema [24,25]. Surgical treatment is standard for intestinal perforation, except for those of medical origin or trauma [6], and appropriate surgical options, including colostomy, should be selected depending on the perforation site. Although deaths have been reported due to delayed diagnosis and lack of proper treatment [26], there have been no reported cases of mediastinitis requiring mediastinal drainage or other therapies after colonic retroperitoneal perforation. Therefore, mediastinal emphysema caused by the diffusion of intestinal gas due to pressure gradients may improve with treatment of the underlying disease alone. Mediastinal emphysema in this case also showed a preoperative tendency to decrease; however, because a large fistula had formed in the sigmoid colon, resection and Hartmann's operations were performed.

#### 4. Conclusions

Reading chest X-rays is a common task of the respiratory physician, who is likely to be the first to detect mediastinal emphysema. Asymptomatic intestinal perforation is extremely rare for mediastinal emphysema, but the disease should not be overlooked. The present case is highly educational, and respiratory physicians should be aware of it. Even in the absence of abdominal symptoms, if mediastinal emphysema is associated with retroperitoneal emphysema, considering the potential severity of the condition due to sigmoid perforation, efforts should be made, including abdominal CT, to adequately identify the cause of the emphysema.

#### CRediT authorship contribution statement

**Daichi Setoguchi:** Writing – review & editing, Writing – original draft, Visualization, Validation, Investigation, Data curation, Conceptualization. **Naoki Iwanaga:** Writing – review & editing, Writing – original draft, Supervision, Conceptualization. **Kotaro Nema:** Writing – review & editing, Investigation, Conceptualization. **Tomoya Hagiwara:** Writing – review & editing, Visualization, Investigation, Conceptualization. **Kotaro Hayashida:** Writing – review & editing, Visualization, Investigation, Conceptualization. **Koki Yamashita:** Writing – review & editing, Investigation, Data curation, Conceptualization. **Tatsuro Hirayama:** Writing – review & editing, Data curation, Conceptualization. **Masataka Yoshida:** Writing – review & editing, Data curation, Conceptualization. **Kazuaki Takeda:** Writing – review & editing, Data curation, Conceptualization. **Shotaro Ide:** Writing – review & editing, Data curation, Conceptualization. **Masato Tashiro:** Writing – review & editing, Data curation, Conceptualization. **Takahiro Takazono:** Writing – review & editing, Supervision, Data curation, Conceptualization. **Masachika Kitajima:** Writing – review & editing, Visualization, Investigation, Conceptualization. **Noriho Sakamoto:** Writing – review & editing, Supervision, Data curation, Conceptualization. **Koichi Izumikawa:** Writing – review & editing, Supervision, Data curation, Conceptualization. **Katsunori Yanagihara:** Writing –

**Table 2**

Retroperitoneal emphysema as a rare complication of intra-abdominal factor excluding trauma or medical origin reported in the English literature. \*, 20 cases of colon perforation were reported. NA, no available information. NOM, non-operative management.

Age	Sex	Causes	remarks	Presenting symptom	peritoneal irritation	time from onset (day)	site	Treatment	Outcome	Reference no.
41	Female	emphysematous pyelonephritis	diabetes mellitus	fever, slight shortness of breath	none	7	kidney	Urgent left total nephrectomy	survived	14
70	Female	diverticulitis	renal impairment	poor mobility, fever	none	NA	junction of the descending and sigmoid colon	NOM	died	15
71	Male	duodenal ulcer	none	chest pain, epigastric pain	NA	2	duodenum	Duodenectomy	survived	16
22	Female	acute appendicitis	none	fever, nausea, abdominal pain	none	12	appendix	right hemicolectomy	survived	17
71	Male	diverticulitis	lung cancer	abdominal pain, fatigue, fever, nausea	admit	2	descending colon	left hemicolectomy extending to the transverse colon, debridement	died	18
59	Female	retroperitoneal abscess	diabetes mellitus	malaise, poor appetite, vague epigastric pain, abdominal fullness, dyspnea	none	7	NA	Drainage	survived	19
* 19–90	11 Male/9 Female	13 diverticulitis/3 ulcerative colitis/1 colon cancer/1 renal cancer/1 stercoroma/1 NA	9 steroid and immunosuppressive agent	12 abdominal pain/2 chest pain et al.	15none/5 NA	1–30	12 sigmoid colon/3 descending colon/2 rectum/3 NA	9 Hartmann's procedure/4 colostomy/2 Subtotal colectomy/1 Segmental resection and anastomosis/4 NOM	17 survived/3 died	6
75	Male	diverticulitis	steroid, non-ST elevated myocardial infarction, asthma	abdominal bloating	none	NA	descending colon	Hartmann's procedure	survived	20
79	Female	diverticulitis	diabetes mellitus	abdominal pain, vomiting	none	NA	descending colon	Hartmann's procedure	died	7
74	Female	diverticulitis	diabetes mellitus	pelvic pain, chronic constipation, rectal bleeding	none	NA	rectosigmoid junction	Hartmann's procedure	survived	21
74	Female	sigmoid colon perforation	steroido, immunomodulator, COVID-19	abdominal pain	admit	NA	sigmoid colon	partial colectomy	NA	22
66	Male	diverticulitis	none	none	none	unknown	sigmoid colon	Hartmann's procedure	survived	Present case

review & editing, Supervision, Data curation, Conceptualization. **Keiji Inoue**: Writing – review & editing, Supervision, Investigation, Conceptualization. **Hiroshi Mukae**: Writing – review & editing, Supervision, Data curation, Conceptualization.

### Ethics approval and consent to participate

Ethical approval was not required for the publication of this manuscript.

### Consent for publication

The authors obtained written informed consent from the patient.

### Availability of data and materials

Data will be made available on request.

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### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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### References

- [1] K. Takada, S. Matsumoto, T. Hiramatsu, E. Kojima, H. Watanabe, M. Sizu, S. Okachi, K. Ninomiya, Management of spontaneous pneumomediastinum based on clinical experience of 25 cases, *Respir. Med.* 102 (2008) 1329–1334, <https://doi.org/10.1016/j.rmed.2008.03.023>.
- [2] M. Caceres, R.L. Braud, R. Maekawa, D.S. Weiman, H.E. Garrett Jr., Secondary pneumomediastinum: a retrospective comparative analysis, *Lung* 187 (2009) 341–346, <https://doi.org/10.1007/s00408-009-9164-4>.
- [3] R.J. Maunder, D.J. Pierson, L.D. Hudson, Subcutaneous and mediastinal emphysema. Pathophysiology, diagnosis, and management, *Arch. Intern. Med.* 144 (1984) 1447–1453.
- [4] M. Wintermark, P. Schnyder, The Macklin effect: a frequent etiology for pneumomediastinum in severe blunt chest trauma, *Chest* 120 (2001) 543–547, <https://doi.org/10.1378/chest.120.2.543>.
- [5] C.C. Macklin, Transport of air along sheaths of pulmonic blood vessels from alveoli to mediastinum clinical implications, *Arch Intern Med* 64 (1939) 913–926.
- [6] T. Muronoi, A. Kidani, E. Hira, K. Takeda, S. Kuramoto, K. Oka, Y. Shimojo, H. Watanabe, Mediastinal, retroperitoneal, and subcutaneous emphysema due to sigmoid colon penetration: a case report and literature review, *Int. J. Surg. Case Rep.* 55 (2019) 213–217, <https://doi.org/10.1016/j.ijscr.2019.02.003>.
- [7] R.R. Luo, J. Fu-Shan, C.C. Hsieh, Pneumoretroperitoneum, pneumoperitoneum, pneumomediastinum and pneumopericardium in an elderly woman with rupture of diverticulitis, *Asian J. Surg.* 46 (2023) 2225–2226, <https://doi.org/10.1016/j.asjsur.2022.11.114>.
- [8] A.I. Hatzitolios, M.L. Sion, A.D. Kounanis, E.N. Toulis, A. Dimitriadis, I. Ioannidis, G.N. Ziakas, Diffuse soft tissue emphysema as a complication of anorexia nervosa, *Postgrad. Med. J.* 73 (1997) 662–664, <https://doi.org/10.1136/pgmj.73.864.662>.
- [9] Y. Inamo, Y. Ishizuka, K. Hashimoto, M. Hasegawa, K. Saito, T. Kida, A. Nakamura, T. Ishikawa, T. Fuchigami, A 7-year-old girl with subcutaneous emphysema, pneumomediastinum, pneumothorax, and pneumoretroperitoneum caused by Mycoplasma pneumoniae pneumonia, *J. Infect. Chemother.* 18 (2012) 247–250, <https://doi.org/10.1007/s10156-011-0301-7>.
- [10] Y. Takano, H. Tanaka, M. Kawamo, J. Sasaki, M. Hayashi, Systemic emphysema accompanying marked undernutrition, *Acute Med Surg* 3 (2016) 143–146, <https://doi.org/10.1002/ams2.146>.
- [11] M.A. Meyers, Radiological features of the spread and localization of extraperitoneal gas and their relationship to its source. An anatomical approach, *Radiology* 111 (1974) 17–26, <https://doi.org/10.1148/111.1.17>.
- [12] G. Montori, G. Di Giovanni, Z. Mzoughi, C. Angot, S. Al Samman, L. Solaini, N. Cheynel, Pneumoretroperitoneum and pneumomediastinum revealing a left colon perforation, *Int. Surg.* 100 (2015) 984–988, <https://doi.org/10.9738/intsurg-d-14-00201.1>.
- [13] J.P. Quigley, D.A. Brody, A physiologic and clinical consideration of the pressures developed in the digestive tract, *Am. J. Med.* 13 (1952) 73–81, [https://doi.org/10.1016/0002-9343\(52\)90082-x](https://doi.org/10.1016/0002-9343(52)90082-x).
- [14] Y.C. Wang, J.M. Wang, Y.C. Chow, A.W. Chiu, S. Yang, Pneumomediastinum and subcutaneous emphysema as the manifestation of emphysematous pyelonephritis, *Int. J. Urol.* 11 (2004) 909–911, <https://doi.org/10.1111/j.1442-2042.2004.00919.x>.
- [15] L. Lentner, A. Firkin, R. House, Cervical surgical emphysema: rare presentation of a sigmoid colon retroperitoneal perforation with abscess rupture through the lumbar triangle of Petit, *Australas Radiol.* 51 Spec No. (2007) B140–B143, <https://doi.org/10.1111/j.1440-1673.2007.01854.x>.
- [16] C.M. Chao, C.C. Lai, Pneumomediastinum and pneumoretroperitoneum caused by perforated duodenal ulcer, *J. Emerg. Med.* 47 (2014) e147–e148, <https://doi.org/10.1016/j.jemermed.2014.06.062>.
- [17] C.S. Dalbem, T.F. Nunes, S. Machado Mda, S.M. Goldman, Pneumomediastinum and pneumoretroperitoneum: an extremely rare presentation of acute appendicitis, *BMJ Case Rep.* 2015 (2015), <https://doi.org/10.1136/bcr-2014-207255>.
- [18] P. Ruscelli, C. Renzi, A. Polistena, A. Sanguinetti, N. Avenia, G. Popivanov, R. Cirocchi, M. Lancia, S. Gioia, R. Tabola, Clinical signs of retroperitoneal abscess from colonic perforation: two case reports and literature review, *Medicine (Baltim.)* 97 (2018) e13176, <https://doi.org/10.1097/md.00000000000013176>.
- [19] C.Y. Su, C.H. Chen, Pneumomediastinum, pneumoperitoneum, and pneumoretroperitoneum caused by Escherichia coli retroperitoneal abscess in a diabetic patient, *Kaohsiung J. Med. Sci.* 35 (2019) 246–247, <https://doi.org/10.1002/kjm2.12047>.

- [20] K. Kono, K. Ito, Y. Sasajima, Y. Miyake, T. Sakamoto, Retroperitoneal perforation of the descending colon diverticulitis presenting with systemic emphysema, *Trauma Surg Acute Care Open* 5 (2020) e000606, <https://doi.org/10.1136/tsaco-2020-000606>.
- [21] H. Hafiani, N. Bouknani, E.M. Choukri, R.C. Saibari, A. Rami, Pneumoperitoneum, pneumoretroperitoneum and pneumomediastinum: rare complications of perforation peritonitis: a case report, *J. Med. Case Rep.* 18 (2024) 187, <https://doi.org/10.1186/s13256-024-04488-1>.
- [22] J. Shen, X. Shen, F. Zhao, J. Yao, Pneumomediastinum and pneumoretroperitoneum after COVID-19: concealed intestinal perforation, *BMC Infect. Dis.* 24 (2024) 801, <https://doi.org/10.1186/s12879-024-09720-3>.
- [23] B. Ravo, S.A. Khan, R. Ger, A. Mishrick, H.S. Soroff, Unusual extraperitoneal presentations of diverticulitis, *Am. J. Gastroenterol.* 80 (1985) 346–351.
- [24] R. Yamamoto, K. Yoshida, M. Ando, Y. Toyoda, A. Tanaka, K. Kato, R. Yamaguchi, Retroperitoneal and mediastinal emphysema after sigmoid colon resection, *Case Rep Gastroenterol* 17 (2023) 137–142, <https://doi.org/10.1159/000529282>.
- [25] H.C. Jung, H.J. Kim, S.B. Ji, J.H. Cho, J.H. Kwak, C.M. Lee, W.S. Kim, J.J. Kim, J.M. Lee, S.S. Lee, Pneumomediastinum Pneumoretroperitoneum, Subcutaneous emphysema after a rectal endoscopic mucosal resection, *Ann Coloproctol* 32 (2016) 234–238, <https://doi.org/10.3393/ac.2016.32.6.234>.
- [26] P.W. Choi, Pneumomediastinum caused by colonic diverticulitis perforation, *J. Korean Surg. Soc.* 80 (Suppl 1) (2011) S17–S20, <https://doi.org/10.4174/jkss.2011.80.Suppl1.S17>.