

Nonsurgical Causes of Pneumoperitoneum

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The radiographic manifestation of free air in the peritoneal cavity suggests serious intra-abdominal disease and the need for urgent surgical management. Yet, about 10% of all cases of pneumoperitoneum are caused by physiologic processes that do not require surgical management. We retrospectively reviewed cases of nonsurgical causes of pneumoperitoneum at the 2 teaching hospitals of a university medical center between January 1990 and December 1995. Successful management by observation and supportive care without surgical intervention was defined as the diagnostic feature of nonperforation. Failure of a laparotomy to delineate a surgical cause or to result in a reparative procedure is congruent with a nonsurgical cause of pneumoperitoneum. During this period, 8 patients (6 men and 2 women; mean age, 61 years) were identified with nonsurgical causes of pneumoperitoneum. Two patients underwent negative laparotomy, and the other 6 were successfully managed nonoperatively and discharged from the hospital. In 6 patients, a cause of the pneumoperitoneum was identified. The causes may be grouped under the following categories: postoperatively retained air, thoracic, abdominal, gynecologic, and idiopathic. In our review of the literature, 61 of 139 reported cases underwent surgical treatment without evidence of perforated viscus. To avoid unnecessary surgical procedures, both primary medicine physicians and surgeons need to recognize nonsurgical causes of pneumoperitoneum. Conservative management is warranted in the absence of symptoms and signs of peritonitis.

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Pneumoperitoneum is a radiologic term denoting an abnormal collection of air in the peritoneal cavity. Radiographic evidence of free intraperitoneal air was linked to intra-abdominal disease in the early 1900s and continues to be a useful diagnostic tool for perforation of an intra-abdominal viscus.¹ About 85% of patients with a ruptured viscus will present with pneumoperitoneum, most often from a perforated gastric or duodenal ulcer, although perforated colon or small bowel may also present with pneumoperitoneum.²⁻⁴ When a new onset of pneumoperitoneum is present in a patient with fever, abdominal pain, leukocytosis, and signs of peritonitis, surgical management is indicated.

Pneumoperitoneum without evidence of visceral perforation has been reported in 5% to 14% of all occurrences.^{2,5,6} Often patients with this disorder undergo laparotomy without intraoperative evidence of visceral disease. Therefore, in atypical presentations or in patients with relevant historical evidence, nonsurgical causes of pneumoperitoneum should be considered. We reviewed cases of nonsurgical causes of pneumoperitoneum in inpatients at two major teaching hospitals of a university medical center from January 1990 to December 1995 and describe our clinical research to facilitate the examination of its clinical presentation, management, and outcome.

Report of Cases

Patient 1

The patient, a 65-year-old man, was admitted to the intensive care unit with pulmonary edema and respiratory failure requiring intubation. By hospital day 2, his chest radiograph and clinical course were consistent with the adult respiratory distress syndrome. High pressures were required to adequately ventilate the patient. Ventilatory management became normal by hospital day 26, and tracheostomy and gastrostomy were performed. On hospital day 39, pneumoperitoneum was noted on a chest radiograph. On physical examination, the patient's abdomen was slightly distended and nontender without peritoneal signs. Although not sufficient to exclude perforation, a radiographic examination with diatrizoate meglumine instilled through the gastrostomy tube failed to demonstrate extravasation. The patient was observed, and the amount of free air increased as bowel sounds were noted to decrease over the next 24 hours. A xenon lung perfusion scan demonstrated radioactive tracer beneath the right hemidiaphragm with the application of positive-pressure ventilation. The patient was conservatively managed and extubated one month later. The pneumoperitoneum increased over the course of a week

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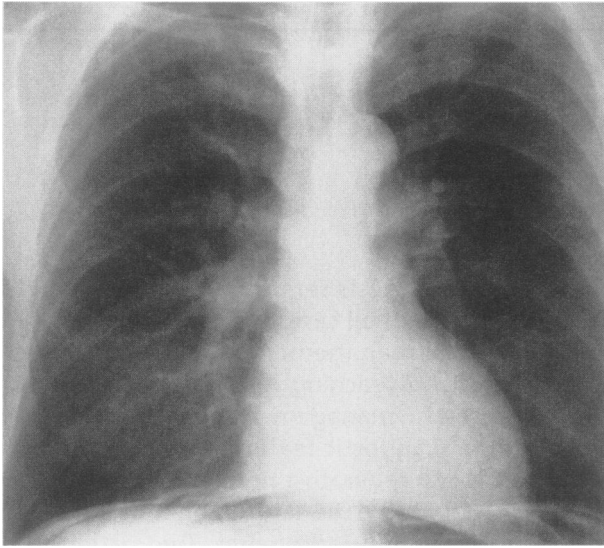


Figure 1.—Chest radiograph demonstrates free intraperitoneal air (Patient 4).

and then spontaneously resolved without the need to modulate ventilatory management or enteral feedings.

Patient 2

The patient, a 54-year-old man with a history of bipolar disorder and bullous emphysema, presented to the emergency department with intermittent, crampy, left upper abdominal quadrant pain. He did not have fever, chills, nausea, or vomiting and was afebrile with stable vital signs. No abdominal tenderness was present on physical examination. The leukocyte count was 12.5×10^9 /liter, with an increase in the number of immature cells. Radiographs of the abdomen and chest revealed pneumoperitoneum. Computed tomography of the abdomen confirmed the presence of pneumoperitoneum and revealed an incidental renal mass but no cause for the free air. He was admitted to the hospital for observation. The following day, the leukocyte count returned to normal, the patient was advanced to a regular diet, and he was discharged on day 4 of his hospital stay. He reported a similar event 20 years ago that led to an exploratory laparotomy that elicited no abnormalities.

Patient 3

The patient, a 74-year-old man with a history of adrenal insufficiency who was admitted to the hospital for hypoxic encephalopathy, was noted to have free air under the right diaphragm following a cardiac arrest complicated by esophageal intubation. He was afebrile. On examination, he had a grossly distended abdomen with decreased bowel sounds and a suggestion of tenderness obscured by the encephalopathy. His leukocyte count was $10.9 \leq 10^9$ /liter. An exploratory laparotomy was performed that demonstrated no evidence of perforation. The patient succumbed to progressive respiratory failure and died one month after admission.

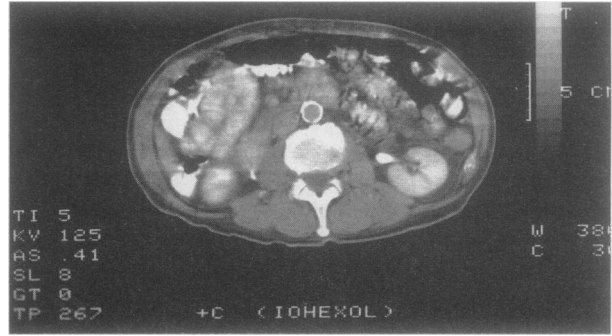


Figure 2.—Computed tomography of the abdomen confirms pneumoperitoneum and demonstrates pneumatosis cystoides intestinalis and air in the portal vein (Patient 4).

Patient 4

The patient, a 70-year-old man with a history of ichthyosis vulgaris, presented with diffuse abdominal pain for the previous few weeks, increasing acutely, and occurring with anorexia the day before consultation. His medical history was relevant for radical prostatectomy and 35 Gy of radiation therapy for stage C adenocarcinoma of the prostate eight months previously. Computed tomography of the abdomen six months before this presentation demonstrated no metastatic disease, although sigmoid diverticula were noted. He was afebrile, and an abdominal examination revealed no tenderness or peritoneal signs. His leukocyte count was within normal limits, but his chest and abdominal radiographs revealed free air under the diaphragm (Figure 1). Although not sufficient to exclude perforation, a limited upper gastrointestinal study with diatrizoate revealed no extravasation. Computed tomography of the abdomen revealed air in the wall of the left colon and free air in the porta hepatis and portal vein (Figure 2). The patient was conservatively managed and advanced slowly to a regular diet. He was discharged on day 4 of his hospital stay.

Patient 5

The patient, a 72-year-old woman with a history of scleroderma and secondary feeding difficulties, presented with abdominal pain, bloating, decreased appetite, and four days of constipation. She had coffee-ground emesis the morning of admission. She was afebrile with stable vital signs. On physical examination, she had decreased bowel sounds with tympany and tenderness in the left lower quadrant without peritoneal signs. A large amount of free air was present on a radiograph of the abdomen. Guaiac examination of a stool specimen and nasogastric lavage was negative for frank or occult bleeding, and the leukocyte count was 6.6×10^9 /liter. The patient was managed medically with a regimen of omeprazole and remained clinically stable for the following two days, with resolving pneumoperitoneum. She was fed, and abdominal pain with bloating developed. Ultrasonography and computed tomography

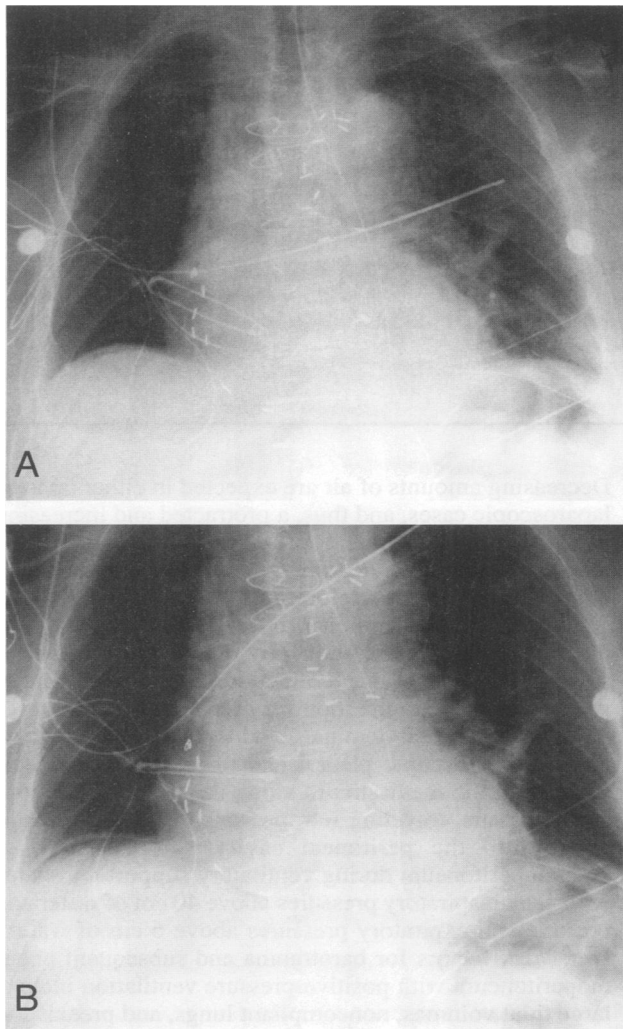


Figure 3.—Serial chest radiographs before (A) and after (B) nasogastric air insufflation of 600 ml, without a demonstrable increase in pneumoperitoneum (Patient 7).

of the abdomen and pelvis revealed multiple loops of fluid-filled bowel. A left pneumothorax subsequently developed, although a thoracostomy tube was not required. The pain and bloating resolved with the restriction of enteral feeding, and she was discharged on day 10 of her hospital stay on a regimen of parenteral nutrition and supplemental oxygen.

Patient 6

The patient, a 62-year-old man, presented one day following endoscopic polypectomy with increasing abdominal pain and pneumoperitoneum on abdominal radiograph. His temperature was 38.2°C, and he had otherwise normal vital signs. Physical examination of the abdomen revealed diffuse tenderness with localization of pain to the left side. The leukocyte count was 11.1×10^9 /liter. He was admitted to the hospital, and a

regimen of broad-spectrum intravenous antibiotics and intravenous hydration was started. He improved clinically over the next few days and was discharged on oral antibiotic therapy on day 5 of the hospital stay.

Patient 7

A 75-year-old man with a history of peptic ulcer disease was noted on postoperative day 2 of a coronary artery bypass graft to have pneumoperitoneum on routine chest roentgenogram. The patient was afebrile and reported mild abdominal tenderness. Bowel sounds were decreased, and mild to moderate epigastric tenderness was noted on examination. The leukocyte count was 23.8×10^9 /liter. Air was instilled through a nasogastric tube without increase in the amount of free air noted on radiographs (Figure 3). Esophagogastroduodenoscopy revealed multiple erosive ulcers in his stomach, a hiatal hernia, and Barrett's esophagitis. He was conservatively managed and discharged after advancing to a regular diet.

Patient 8

The patient, a 17-year-old woman with a history of Raynaud's phenomenon, presented with midsternal chest pain radiating to the back of five days' duration and severe epigastric pain the day before admission. She was afebrile with stable vital signs, and abdominal examination revealed normal bowel sounds with slight distension, diffuse tenderness, and involuntary guarding. A chest roentgenogram revealed free intraperitoneal air with massive gastric distension and small bowel dilation. The leukocyte count was normal. An exploratory laparotomy was performed that showed no evidence of visceral perforation. She improved clinically and was discharged on day 5 of the hospital stay.

Discussion

Pneumoperitoneum usually denotes a perforation of an intra-abdominal viscus, but in about 10% of patients, a nonsurgical source is responsible for free air in the peritoneum and the radiographic findings. Surgical intervention is often performed in these patients that fails to demonstrate disease or result in a reparative procedure. In our review of the literature, 61 (44%) of 139 patients with reported nonsurgical pneumoperitoneum went to surgery without evidence of a perforated viscus.

In this retrospective series, eight patients with nonsurgical pneumoperitoneum were identified. Two patients underwent laparotomy that elicited no abnormalities, and the remaining six were successfully managed nonoperatively and discharged from the hospital (Table 1). The major etiologic mechanisms may be grouped under the following categories: postoperatively retained air, thoracic, abdominal, gynecologic, and idiopathic (Table 2).

Free intra-abdominal air following an abdominal surgical procedure is a common and expected occurrence. Pneumoperitoneum may be recognized on roentgenography for as long as four weeks following an intra-abdominal procedure, although complete resorption

TABLE 1.—Patient Characteristics and Cause of Pneumoperitoneum*

Patient	Age, y	Sex	Association(s)	Cause	Category
1	65	M	ARDS, high airway pressures	IPPV	Thoracic
2	54	M	Bullous emphysema	Rupture of blebs	Thoracic
3	74	M	CPR, esophageal intubation	CPR	Thoracic
4	70	M	Diverticulosis, irradiation to pelvis	PCI	Abdominal
5	72	F	Scleroderma	PCI versus CVD	Abdominal
6	62	M	Colonoscopy and polypectomy	Postpolypectomy syndrome	Abdominal
7	75	M	Peptic ulcer disease, CABG	?Subclinical perforation	Idiopathic
8	17	F	Raynaud's phenomenon, bowel dilation	?Subclinical perforation	Idiopathic

*ARDS = adult respiratory distress syndrome, CABG = coronary artery bypass grafting, CPR = cardiopulmonary resuscitation, CVD = collagen vascular disease, IPPV = intermittent positive-pressure ventilation, PCI = pneumatosis cystoides intestinalis

usually occurs within the first week.⁷ Following laparoscopic procedures, nearly 50% of patients will have air within the peritoneal cavity detected radiographically.⁸

Decreasing amounts of air are expected in either open or laparoscopic cases, and thus, a protracted and increasing pneumoperitoneum in the presence of abdominal pain may indicate a complication of a perforated viscus and the need for surgical exploration.

Spontaneous pneumoperitoneum from an intrathoracic route is the most frequently reported cause in non-surgical peritoneal air collections.^{3-5,9,10} Intermittent positive-pressure ventilation may lead to air being introduced into the abdominal cavity by direct passage through microscopic pleural and diaphragmatic defects or through the mediastinum along the perivascular connective tissue, traveling retroperitoneally, and then rupturing into the peritoneal cavity.^{9,11,12} The risk of pneumoperitoneum during ventilatory support correlates with peak inspiratory pressures above 40 cm of water and positive end-expiratory pressures above 6 cm of water.⁴ Other risk factors for barotrauma and subsequent pneumoperitoneum with positive-pressure ventilation include large tidal volumes, noncompliant lungs, and preexisting pulmonary disease, most notably obstructive airway disease and the adult respiratory distress syndrome.^{9,13} In patients receiving ventilatory support who have a new onset of pneumoperitoneum, the presence of air itself may cause pain and peritoneal irritation, although generally of less severity than in visceral perforation.^{14,15} The report of patient 1 illustrates the thoracic route for non-surgical pneumoperitoneum and the use of a xenon lung scan for demonstrating extravasation of radioactive tracer beneath the diaphragm with positive-pressure ventilation. Other causes of pneumoperitoneum by the thoracic route include asthma,¹⁶ spontaneous rupture of pulmonary blebs (Patient 2),¹⁷ pulmonary tuberculosis,¹⁸ and blunt trauma.

Iatrogenic causes of pneumoperitoneum that share the mechanism of increased tracheal pressure include insufflation during bronchoscopy and mouth-to-mouth resuscitation.^{13,19-21} Cardiopulmonary resuscitation may result in abdominal free air due to the combination of increased airway pressure and the application of blunt force to the chest.¹⁹⁻²¹ A rare phenomenon of tension pneumoperitoneum has been described as a complication of

TABLE 2.—Causes of Pneumoperitoneum

Category	Mechanism
Postoperative	Retained air from open laparotomy Retained air from laparoscopy
Thoracic	Intermittent positive-pressure ventilation Barotrauma Increased intrathoracic pressure—cough, retching Valsalva maneuver Asthma Bronchoscopy Cardiopulmonary resuscitation and mouth-to-mouth ventilation Adenotonsillectomy Pulmonary tuberculosis Blunt trauma Bronchopulmonary fistula Spontaneous rupture of pulmonary blebs
Abdominal	Pneumatosis cystoides intestinalis Endoscopic procedures Postpolypectomy syndrome Peritoneal dialysis Collagen vascular disease Pneumocholecystitis Jejunal and sigmoid diverticulosis Distended hollow viscus Subclinical perforated viscus
Gynecologic	Vaginal insufflation Knee-chest exercises Pelvic inflammatory disease Coitus Gynecologic examination procedures Vaginal douching
Idiopathic	

positive-pressure ventilation and cardiopulmonary resuscitation that, without urgent decompression, rapidly progresses to hemodynamic collapse.^{22,23} As in Patient 3, a lowered threshold for surgery based on the inability to perform a reliable physical examination may lead to a high “negative laparotomy” rate in these patients.

The most common abdominal cause of nonsurgical pneumoperitoneum is pneumatosis cystoides intestinalis, also referred to as cystic lymphomatosis or enteromesenteric emphysema.^{9,24–26} Pneumatosis cystoides intestinalis is characterized by multiple intramural gas-filled cysts that may be throughout the gastrointestinal tract but are most commonly found at the terminal ileum.^{27,28} The condition is generally benign and asymptomatic, although nonspecific complaints such as vomiting, diffuse abdominal pain, diarrhea, abdominal distension, and tenesmus are seen in less than 15% of patients.^{27,28} Pneumatosis cystoides intestinalis is generally found in conjunction with other primary disease processes, including chronic obstructive pulmonary disease and inflammatory bowel disease. As Macklin demonstrated, any thoracic disease that might introduce air into the mediastinal route could lead to pneumatosis cystoides intestinalis.¹¹ When the cysts rupture, a pneumoperitoneum may be produced with a spectrum of symptoms ranging from asymptomatic to acute abdominal pain. The condition generally resolves spontaneously but may be indolent and recurrent. Treatment with hyperbaric oxygen and antibiotics has demonstrated some efficacy in reducing long-term symptoms from this disease. In the short term, as in Patient 4, conservative and watchful management is generally sufficient.²⁵

Cases of atypical pneumatosis cystoides intestinalis or an as-yet-undefined process of the gastrointestinal tract are reported in collagen vascular diseases such as scleroderma, systemic lupus erythematosus, and mixed connective tissue disorder.^{25,26,29} As in Patient 5 of our series, it is difficult to clearly establish the presence of pneumatosis cystoides intestinalis in all patients, but with a relevant etiologic condition, attempted conservative management is appropriate in the absence of peritonitis. However, cases of pneumatosis cystoides intestinalis in immunosuppressed patients that evolved rapidly into enteric infection, bowel ischemia, and death have been reported.^{25,30} Caution is also warranted in infants, in whom pneumatosis cystoides intestinalis is mimicked by necrotizing enterocolitis.²⁴

Air insufflation, forceful manipulation, and excessive electrocautery in endoscopy have also been linked to the development of pneumoperitoneum.^{31,32} Microperforations may allow air to escape under high pressures without extravasation of intestinal contents. Pneumoperitoneum may be detectable in as many as 0.1% of endoscopic procedures, and although pneumoperitoneum was initially thought to be an indication for laparotomy, conservative management is generally warranted in the absence of peritoneal signs.^{32,33}

Rare causes following the abdominal route include pneumocholecystitis,³⁴ jejunal and sigmoid diverticulosis,^{35,36} and fecal impaction or distended hollow vis-

cus.^{16,37} It is proposed that air can leak under pressure from thinned, intact bowel wall without demonstrable or clinically substantial perforation.

A phenomenon labeled postpolypectomy syndrome has been described in transmural burns of the colon following polypectomy and may rarely be associated with pneumoperitoneum.^{38,39} Patients with the syndrome generally present with fever, abdominal pain, and localized peritoneal signs following endoscopy. Conservative management by hospital admission, the cessation of oral intake, intravenous antibiotic therapy, and hydration has been reported. Patient 6 had a typical presentation of postpolypectomy syndrome, and this case provides an example of successful management by observation and appropriate antibiotic therapy. Failure to improve or worsening of symptoms require a laparotomy.

It has been proposed in idiopathic pneumoperitoneum, especially in the presence of a “negative laparotomy,” that a subclinical microperforated hollow viscus may have been present.^{5,35,40} For a nonsurgical pneumoperitoneum to develop by this mechanism and resolve with conservative management, the leak must be small enough to permit the escape of gas without the evolution of bowel contents, and it must occur in a patient whose resistance to infection is intact. As in Patients 7 and 8 of our series, pneumoperitoneum may have evolved from subclinical perforation or be due to other factors that remained enigmatic.

Gynecologic causes, although rare compared with the previously described causes, illustrate another mechanism whereby air can pass upward (through the fallopian tubes) into the peritoneum. Specific examples include vaginal insufflation by orogenital sex,⁴¹ vaginal douching,⁴² postpartum knee-chest exercises,⁴³ the use of bulb aspiration in pelvic examinations,⁴⁴ pelvic inflammatory disease,⁴⁵ and coitus.⁴⁶

Conclusion

Most patients with nonsurgical pneumoperitoneum have historical clues or associated conditions that may indicate to the physician the possibility of this diagnosis. When abdominal pain and distension are minimal and peritoneal signs, fever, and leukocytosis are absent, nonsurgical causes of pneumoperitoneum should be considered.

Our recommendations are to remain alert for nonsurgical causes and, when such processes are considered, to attempt conservative management with supportive care and careful observation. Frequent reevaluation may preclude surgical intervention in all but the sickest patients to allow the clinical course to declare itself. Caution must be exercised in maintaining strict vigilance, especially in immunosuppressed patients, in whom signs of peritonitis may be occult and the course rapid and grave. By acquiring a working knowledge of the wide array of possible causes of pneumoperitoneum and their mechanisms, physicians can more successfully avoid resorting to unnecessary laparotomy and its associated morbidity.

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