

VARIOUS ROUTES OF AIR SPREAD FOLLOWING IATROGENIC COLORECTAL PERFORATIONS – A SINGLE-CENTER CASE SERIES WITH LITERATURE REVIEW

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Abstract

Over the last decade endoscopic colorectal interventions have been increasingly used to treat polyps and laterally-spreading tumors. Perforations are the most feared complications of both diagnostic and therapeutic endoscopy, and timely recognition and adequate treatment are of paramount importance for successful outcomes. A rare manifestation of iatrogenic retroperitoneal perforation is air propagation through the retroperitoneal space into the mediastinum, pleura, or subcutaneous tissue. In such cases, precise diagnosis and treatment may be challenging. The purpose of this study is to demonstrate a case series of nine patients who underwent colonoscopy and developed radiological signs of retroperitoneal air spreading to distant body compartments. In addition, the pathophysiology, diagnostics and treatment of such clinical scenarios are discussed.

INTRODUCTION

The use of diagnostic and therapeutic colonoscopy is increasing as a result of technological advances which allow more invasive resections of malignant polyps and other focal colorectal mucosal pathologies. Although colonoscopy is generally regarded as a safe method, complications such as bleeding and perforation may happen. Endoscopic resections of mucosal or submucosal lesions have inevitably led to an increased rate of complications, especially rectal wall perforation, which is seen in around 5% of therapeutic colonoscopies (1). Perforations in the colon and upper rectum typically lead to pneumoperitoneum and signs of acute abdomen. However, lower rectal retroperitoneal perforations have a less prominent clinical presentation, as they cause inflammation in the retroperitoneal space, which may be associated with air spreading through different extraperitoneal spaces, including the mediastinal pleura and subcutaneous tissues of various body parts

(2). Therefore, the diagnosis of colorectal perforation is sometimes difficult owing to the non-specific clinical presentation and confusing radiological findings. In some cases abdominal X-rays may suggest air in the retroperitoneal space, but this method is much more sensitive for intraperitoneal air (pneumoperitoneum). A more sensitive diagnostic method is computed tomography (CT) with intravenous contrast that may show air bubbles and purulent collections in the area around the suspected perforation, or air bubbles in distant areas such as the mediastinum and subcutaneous tissue of the head and neck (3).

In this study, we demonstrate a single-institution case series of patients with iatrogenic colorectal perforation who developed some of these unusual radiological and clinical scenarios. In addition, we discuss the diagnostics, treatment and possible mechanisms of air dissection through different anatomical planes.

METHODS

We performed a retrospective single-center analysis at the Department of Surgery of the University Hospital Center Zagreb, for the period between January and August 2023, using the Hospital Information System. Data were collected for all patients who had diagnostic or interventional endoscopy and suspected hollow organ perforation with radiological signs of pneumoretroperitoneum. Patients who had other causes (traumatic or surgical) of perforation were excluded, as well as patients who had pneumoperitoneum without the presence of air in the retroperitoneal space. Each case was described with highlights on the presentation, radiological findings and treatment modality. A summary of all cases was presented in figures and tables. The article was approved by the Ethical Committee of the University Hospital Center Zagreb.

RESULTS

Case 1

A 26-year-old female with a history of Crohn's disease, perianal fistulizing disease, and a right hemicolectomy with primary anastomosis underwent regular colonoscopy with manual anal dilatation due to fibrosis of the anal canal opening. The colonoscopy showed a moderately active granulomatous inflammation of the colon. At the end of the procedure, a suspicious rectal perforation was noted and the patient complained of intensive anal pain. A CT scan showed extensive pneumoperitoneum and pneumoretroperitoneum more prominent on the right side of the hemiabdomen, along with an area of free fluid around the sigmoid colon. The rectosigmoid wall was thickened. Urgent surgery was indicated, and revealed a thickened sigmoid and rectal wall, but no signs of abscess or intraperitoneal perforation. Bipolar sigmoidostomy was done for stool derivation, and a pelvic drain was placed. The patient recovered unevenly and was discharged on postoperative day 9. Stoma reversal surgery was performed 21 months later.

Case 2

An 83-year-old male with a history of right hemicolectomy underwent regular colonoscopy with polypectomy in the descending colon. Immediate post-procedural recovery was uneventful and the patient was discharged on the same day. Five days later he presented to the emergency room (ER) with abdominal pain, bloating and signs of subcutaneous emphysema. An abdominal CT scan revealed pneumoperitoneum,

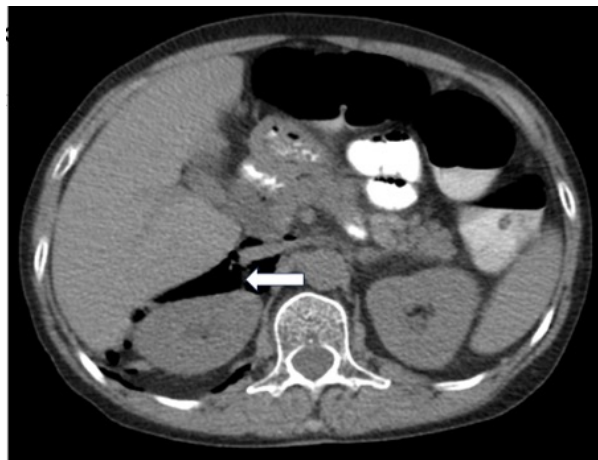


Figure 1. *Computed tomography scan of patient 2 showing pneumoretroperitoneum around right perirenal space (white arrow)*

pneumoretroperitoneum, subcutaneous emphysema, and pneumothorax (Figure 1). Colon perforation was suspected and the patient was transferred for emergency surgery. A descending colon perforation and abscess were found. Left hemicolectomy and unipolar colostomy were performed. The patient was discharged on postoperative day 11 and no postoperative complications were noted.

Case 3

A 49-year-old male patient with a history of adrenal carcinoma with lung metastases and tubulovillous adenoma of the rectum underwent colonoscopy with an attempt of endoscopic mucosal resection. The adenoma was partially resected (25 %) and the patient developed mild abdominal pain two hours after the procedure. A CT scan confirmed a small pneumoretroperitoneum. The patient did not develop severe abdominal pain, tenderness, or swelling of the abdomen. Conservative treatment with antibiotics and restriction of food intake showed good results; the patient recovered well and was discharged from hospital six days after the procedure.

Case 4

A 63-year-old female patient with a history of chronic obstructive pulmonary disease and positive fecal occult blood test had a screening colonoscopy. Endoscopic mucosal resection of a lateral spreading tumor in the ascending colon was done. Abdominal X-ray was performed routinely two hours after the colonoscopy, revealing pneumoperitoneum and pneumoretroperitoneum.

The patient was transferred to the operating room. Intraoperatively, a perforation and localized peritonitis at the level of the mid-ascending colon was found. Right hemicolectomy was performed with formation of an ileostomy. The patient was discharged on postoperative day 6. Stoma reversal surgery was performed five months later.

Case 5

A 67-year-old male patient was evaluated due to persisting anemia, weight loss, and elevated tumor markers. Colonoscopy showed a tumor located 85 cm from the anocutaneous line. A biopsy was taken and the patient

was discharged home. Five days later he was readmitted to the hospital due to abdominal pain. An urgent abdominal CT scan confirmed a tumor of the transverse colon and revealed pneumoperitoneum, subcutaneous emphysema, and pneumomediastinum (Figure 2). The patient was transferred to the operating room and a tumor of the transverse colon with gastric infiltration, cecal perforation, and diffuse peritonitis were found. Partial gastrectomy and right hemicolectomy were performed with formation of an ileostomy and mucous fistula. The patient recovered uneventfully and was discharged on postoperative day 10. Stoma reversal surgery was performed 13 months later.

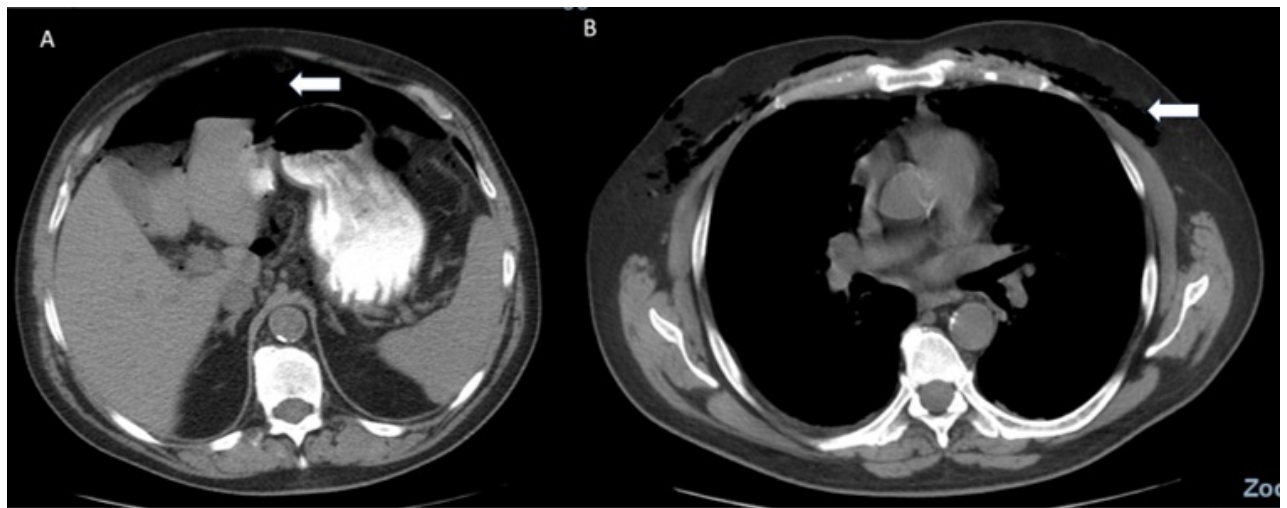


Figure 2. Computed tomography scan in patient 5 showing a) pneumoperitoneum; b) subcutaneous emphysema (white arrows)

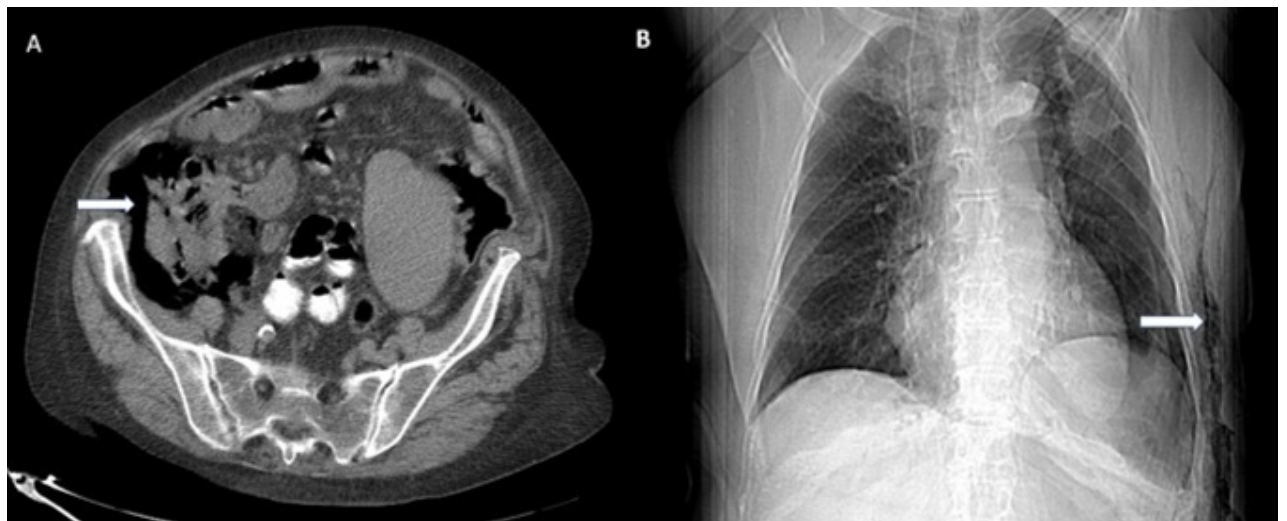


Figure 3. Computed tomography scan in patient 6 showing a) extensive pneumoretroperitoneum on the right side; b) subcutaneous emphysema on the left thoracic side (white arrows)

Case 6

A 72-year-old female patient with a history of angina pectoris had colonoscopic polypectomy in the area of the hepatic flexure. She was readmitted to the ER later in the same day due to fever and abdominal pain. Abdominal and thoracic CT revealed pneumoperitoneum, pneumoretroperitoneum, pneumothorax, and pneumomediastinum (Figure 3). The patient was transferred to the operating room, and surgery revealed a perforation defect of the hepatic flexure with diffuse peritonitis. Right hemicolectomy was performed with formation of an ileostomy and mucous fistula. The patient recovered well and was discharged on postoperative day 11. Stoma reversal surgery was performed four months later.

Case 7

A 72-year-old male patient with positive fecal occult blood test had multiple regular screening colonoscopies. He underwent endoscopic removal of a rectal polyp 2 cm from the anocutaneous line and was discharged home the day after the procedure. Four days later, he was readmitted to hospital due to abdominal pain and fever. A CT scan was performed confirming extensive pneumoretroperitoneum (Figure 4). The patient was transferred to the operating room and surgery revealed a perforation defect with abscess on the dorsal rectal wall. Abscess drainage and bipolar sigmoid colostomy were performed. The patient recovered well and was discharged on postoperative day 15. Three months later he was readmitted to hospital due to a rectal fistula and abscess formation. Abscess drainage and a Hartmann procedure were done. Stoma reversal surgery was performed four months later.



Figure 4. Air bubbles in the pararectal space (white arrow)

Case 8

A 58-year-old female patient with a history of hemorrhoidal disease underwent regular colonoscopy. At the end of the procedure an iatrogenic perforation 15 cm from the anocutaneous line was immediately recognized and clipped. A CT scan was preformed and it confirmed extensive pneumoperitoneum and pneumoretroperitoneum with bilateral pneumothorax and pneumomediastinum (Figure 5), and the patient was transferred to the operating room. Urgent surgery was performed, revealing a sigmoid perforation. A Hartmann procedure was performed. The patient recovered uneventfully and was discharged on postoperative day 5. Stoma reversal surgery was performed nine months later.



Figure 5. Computed tomography scan in patient 8 showing extensive pneumoretroperitoneum (white arrows)

Case 9

An 81-year-old female patient underwent diagnostic colonoscopy and was discharged on the same day. Two days later, she presented to the ER with abdominal pain, diarrhea, and fever. The patient had been on corticosteroid therapy due to chronic myelomonocytic leukemia that was discovered two years previously. Abdominal and chest X-rays revealed pneumoperitoneum and pneumoretroperitoneum, followed by a CT scan which confirmed extensive pneumoperitoneum and pneumoretroperitoneum including signs of chronic cholecystitis. The patient was transferred to the operating room and underwent urgent surgery which showed a perforation of the ascending colon. Right colectomy with bipolar ileostomy, cholecystectomy, and appendectomy were performed. The patient had a prolonged hospital stay due to wound infection, and 27 days after the surgery

she developed acute renal failure followed by cardiac arrest 42 days after the initial surgery.

DISCUSSION

Our study presents a collection of nine cases of pneumoretroperitoneum associated with colorectal perforation. Given the rarity of this complication, our results are very valuable for clinicians who are involved in the treatment of these patients, especially for gastroenterologists, surgeons, and radiologists. In the literature case reports on this topic were predominant; only two reviews were available, but those described only pneumothorax or subcutaneous emphysema after colorectal endoscopy (5, 6). Other causes of pneumoretroperi-

toneum such as hemorrhoidectomy or diverticulosis were also described, but these were not associated with endoscopic interventions (7). The variability of signs and symptoms as well as the period from intervention to disease presentation contribute to the great challenges in diagnostics and treatment presented by this clinical scenario. The frequently subtle but progressive disease course may lead to serious septic complications. Therefore, timely recognition of colorectal perforation and adequate treatment are of paramount importance for a favorable prognosis. It is also important to emphasize that CO₂ insufflation during laparoscopic procedures is purposely used to create a pneumoperitoneum with the aim to allow space for surgical manipulation inside the abdominal cavity. However, such procedures may also result in pneumoretroperitoneum or subcutaneous emphysema (in case of an accidental

Demographic and clinical data of the nine presented cases are shown in Tables 1 and 2.

Table 1. Demographic, clinical and treatment characteristics of reported cases with iatrogenic colorectal perforation (N = 9)

	Age	Sex	Colonoscopy indication	Endoscopic intervention	Time to presentation	Symptoms	Radiological findings
Case 1	26	F	Anal stenosis and Crohn's disease	Colonoscopy with manual anal dilatation	Immediate recognition	Perianal and anal pain	CT scan: PP, PR, localized fluid around sigmoid colon
Case 2	83	M	Regular follow-up	EMR of rectal and transversal polyp	5 days	Abdominal pain, nasal speech, swallowing difficulties, clogged ear	Chest and abdominal X-rays: PP, PR, SE, PM
Case 3	49	M	Polypectomy in rectum	ESR of rectal polyp	2 hours	Abdominal pain	CT scan: PR
Case 4	63	F	Lateral spreading tumor	EMR	24 hours	Acute abdomen	Chest and abdominal X-rays: PP, PR
Case 5	67	M	Anemia and weight loss	Tumor biopsy	5 days	Neck swelling	CT scan: PP, PR, PM, SE
Case 6	72	F	Diagnostic colonoscopy	Polypectomy at hepatic flexure with clipping of defect	1 day	Acute abdomen	CT scan: PR, PP, PT, PM, SE
Case 7	72	M	Lateral spreading tumor	ESR rectum	4 days	Fever and abdominal pain	CT scan: PR
Case 8	58	F	Diagnostic colonoscopy	Clipping of the defect	Immediate recognition	Rectal bleeding	CT scan: PP, PR, PP, PM
Case 9	82	F	Diagnostic colonoscopy	-	2 days	Acute abdomen	Chest and abdominal X-rays: PP, PR

F – female; M – male; PR – pneumoretroperitoneum; PP – pneuperitoneum; PM – pneumomediastinum; PT – pneumothorax; SE – subcutaneous emphysema; EMR – endoscopic mucosal resection; ESR – endoscopic submucosal resection

Table 2. Management and outcomes of reported cases with iatrogenic colorectal perforation (N = 9)

	Management	Intraoperative findings	Type of surgery	Outcome	Hospital stay (days)	Inflammatory markers at presentation
Case 1	Surgical	Thickened sigmoid and rectal wall	Sigmoidostomy	Discharged, no complications	9	L 4 CRP 50
Case 2	Surgical	Descending colon perforation and abscess	Left hemicolectomy and unipolar ileostomy	Discharged, no complications	11	L 16 CRP 218
Case 3	Conservative	-		Discharged, no complications	6	L 11 CRP 275
Case 4	Surgery	Ascending colon perforation and localized peritonitis	Right hemicolectomy and unipolar ileostomy	Discharged, recovered from postoperative pneumonia	6	L 10 CRP 200
Case 5	Surgery	Tumor of transverse colon with gastric infiltration, cecal perforation and diffuse peritonitis	Right hemicolectomy and unipolar ileostomy, partial gastrectomy	Discharged, minor wound infection	8	L 11, CRP 220
Case 6	Surgery	Perforation defect of hepatic flexure with peritonitis	Left hemicolectomy with ileostomy	Discharged, no complications	11	L 46 CRP 250
Case 7	Surgery	Perforation defect on dorsal rectal wall with abscess	Bipolar sigmoidostomy	Discharged, percutaneously drained pelvic abscess	15	L22 CRP 310
Case 8	Surgery	Sigmoid perforation	Hartmann procedure	Discharged, no complications	5	L 11 CRP 107
Case 9	Surgery	Perforation of ascending colon	Right hemicolectomy and unipolar ileostomy	Death, cardiac arrest	42	L14 CRP 197

L – leukocyte count; CRP – C-reactive protein

puncture of the subcutaneous or retroperitoneal space during needle insufflation). Moreover, laparoscopy may even cause pneumothorax, which happens when gas escapes into the pleural cavity through diaphragmatic defects or during pleural damage. This complication is predominantly seen in upper gastrointestinal laparoscopic procedures such as the Nissen fundoplication or proximal gastrectomy. In these cases, pneumothorax has been described as a complication in up to 2 % of patients, while in thoracoscopic procedures the rate is much higher. Pneumoperitoneum is usually present and radiologically detectable even up to five days after lapa-

roscopy, while subcutaneous emphysema may persist even longer (up to 3 – 4 weeks) (8). Therefore, it may be challenging to distinguish these benign postoperative findings from serious complications such as hollow organ perforation or gas-forming infections. To avoid unnecessary surgical exploration, clinicians should meticulously evaluate each patient's clinical condition.

Colorectal perforation is most commonly seen after therapeutic interventions, particularly endoscopic submucosal and endoscopic mucosal resection, but it may also occur as a result of barotrauma or thermal

injury, or during simple diagnostic colonoscopy if the camera punctures the colonic wall (2, 4, 9). There are several risk factors for iatrogenic colorectal perforations, the most important being increased age, low body mass index, low plasma albumin level, and underlying colon pathology (8). Technological and technical advances in colorectal endoscopy have resulted in an increased number of more invasive focal lesion excision. On the one hand, this enables many patients to avoid more aggressive surgical resection, but on the other, it inevitably leads to an increased risk of colorectal perforation as a result of deeper mucosal or submucosal dissections. Thus, a high level of critical thinking and endoscopic experience is required when evaluating the indications for polypectomy, especially in large, lateral spreading, or malignant polyps.

Most commonly the perforation is seen in the sigmoid colon, due to its curved anatomy and the fact that it is a common site of colonic pathologies such as diverticulosis or polyps. Following the perforation, the insufflated air may escape through the defect and reach different abdominal and extra-abdominal spaces, depending on the site and type of perforation. Thus, if the perforation occurs in the transverse or sigmoid colon, which are completely intraperitoneal, the air will in most cases accumulate intraperitoneally and cause pneumoperitoneum with typical radiological signs. As the ascending and descending colon are located partially retroperitoneally, perforations may cause both pneumoperitoneum and pneumoretroperitoneum. Lastly, perforations in the rectum below the peritoneal reflections inevitably lead to accumulation of air retroperitoneally, while pneumoperitoneum may occur secondary to air propagation or progression of the perforation size. Once in the retroperitoneum, the ectopic gas may pass into other body compartments through distinct anatomical and fascial planes (2, 9-15).

The peritoneum is a two-layer serous membrane which encases and covers the abdominopelvic wall and viscera (2, 7, 16). The colon consists of four regions: the retroperitoneal ascending and descending part partially covered by the peritoneum, and the intraperitoneal transverse and sigmoid portions completely covered by the peritoneum and suspended by a double layer of peritoneum (mesocolon). In rectal perforations, as well as in cases of posterior colonic wall perforation, the gas migrates into the retroperitoneal space directly. Moreover, it is possible that the gas migrates into the retroperitoneal space through the intact colonic wall and further through the mesocolon (9).

In four out of our nine patients, signs of gas in the thoracic cavity were developed – four of them had pneumomediastinum, three developed signs of subcutaneous emphysema, and two developed pneumothorax. During embryonic development, the chest and abdomen originate from a single celomic cavity lined by a serous membrane. Later in development, that serous membrane evolves into the peritoneal membrane and pleura, both of which present the border between the cavities (abdominal and thoracic) and the retroperitoneal and subpleural (mediastinal) space. Isolation of the thoracic and abdominal cavities develops around the 7th week of gestation. The esophageal diaphragmatic hiatus (Th10 level) admits the esophagus and vagal trunks to transverse between the thorax and abdomen, and can serve as a potential pathway of spread of free air between the mediastinum and retroperitoneum (2, 18, 19).

The diaphragmatic hiatus of the aorta (Th12 level) is another possible pathway of spread of free air between these two subserosal spaces, as well as the inferior vena cava, whose wall is firmly attached to the margin of the diaphragmatic foramen (Th8 level), thus allowing air to pass next to it. Furthermore, the foramina of Morgagni are two defects in the retrosternal region through which internal thoracic vessels pass; in the presence of pneumoperitoneum, a tear in their peritoneal lining can occur, allowing the passage of gas cranially towards the mediastinum. The lumbocostal triangle is a weak spot in the diaphragm which may act as a possible transphrenic pathway for gas migration (20).

Beside these diaphragmatic hiatuses and defects that present a communication between the subperitoneal and subpleural spaces, certain procedures like cardiopulmonary resuscitation or chest drain insertions (pneumothorax decompression) also present a greater risk for the development of pneumomediastinum in case of colonic perforation.

Two of our patients developed pneumothorax. After the passage of gas from the retroperitoneum into the mediastinum via the diaphragmatic hiatuses or unrecognized diaphragmatic defects, a rupture in the mediastinal pleura can occur which causes decompression of air in the pleural space and pneumothorax.

It has to be taken into consideration that every urgent surgery carries a higher risk of pneumothorax that can develop due to barotrauma during intubation and ventilation (4, 5, 22). Three of our patients also developed subcutaneous emphysema that manifested with

palpable crepitus in the neck, chest, and abdominal wall. Abdominal wall subcutaneous emphysema can occur if gas travels along the mesentery towards the abdominal wall (23). As there are no barriers between the subcutaneous tissues of the body, there is no barrier to gas migration from abdominal subcutaneous tissues cranially towards the subcutaneous tissue of the chest and neck (24, 25).

Regarding the treatment, a total of four of our patients had right hemicolectomy performed due to perforations in the cecum, hepatic flexure, ascending colon, and transverse colon. Right hemicolectomy with exteriorization of the ileal and colonic bowel ends was the most frequent urgent operation in our patients. One patient had left hemicolectomy performed due to the perforation site in the descending colon, and two patients had a Hartmann procedure due to the sigmoid and rectal site of perforation. One patient had bipolar sigmoidostomy performed although there was no evident site of perforation observed at operation. In only one patient conservative treatment was possible. He developed pneumoperitoneum and pneumoretroperitoneum shortly after partial endoscopic mucosal resection of a tubulovillous adenoma of the rectum, but no clinical signs of acute abdomen were present.

Therefore, treatment mainly depends on the site of perforation and the clinical signs. In the absence of septic complications and clinical deterioration, a conservative approach may be considered if there is no clear sign of perforation. However, in such cases hospitalization and careful monitoring are required. Recently, laparoscopy has evolved as both a diagnostic and therapeutic procedure in many abdominal surgical emergencies. Consequently, it may also have an important role in the treatment of iatrogenic colorectal perforations, including retroperitoneal perforations. During laparoscopy, the whole abdominal cavity can be explored, and free fluid such as blood, pus, or enteric content may be easily detected. In addition, the laparoscopic technique may be used for abdominal lavage and drain placement, as well as laparoscopic treatment of acute diverticulitis, especially in cases of small perforations with minimal pericolic inflammation. Taking all this into consideration, every effort should be invested to avoid unnecessary radical open surgical resection or colostomy. However, in cases of progressive septic complications or diffuse peritonitis, a timely surgical intervention is mandatory.

In our series, one patient (an 81-year-old female) had a prolonged hospital stay due to wound infection, and 27

days post operation she developed acute renal failure, followed by cardiac arrest 42 days after initial operation. All other patients that underwent urgent surgery had stoma reversal surgery performed in a period of 4 to 13 months after the initial operation.

CONCLUSION

Iatrogenic colorectal perforation presents a serious complication, and timely recognition and adequate treatment are of paramount importance for favorable outcomes. Clinicians should consider the atypical clinical and radiological presentation of such perforations, including detection of gas in distant abdominal compartments such as the pleural space or subcutaneous tissue. Retroperitoneal perforations are particularly challenging as they may cause slow but progressive septic complications. In such cases, prompt diagnostic and clinical evaluation is required in order to select the most appropriate treatment.

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SAŽETAK

RAZLIČITI PUTEVI ŠIRENJA ZRAKOM NAKON JATROGENIH KOLOREKTALNIH PERFORACIJA – NIZ SLUČAJEVA U JEDNOM SREDIŠTU, S PREGLEDOM LITERATURE

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Tijekom posljednjeg desetljeća kolorektalne endoskopske intervencije sve se više koriste za liječenje polipa i lateralno-širećih tumora. Perforacija je najozbiljnija komplikacija dijagnostičke ili terapijske endoskopije te su pravovremeno prepoznavanje i primjereno liječenje najvažniji za prognozu. Rijetko očitovanje retroperitonejske jatrogene perforacije kolona jest širenje zraka kroz retroperitonejski prostor u medijastinum, pleuru ili potkožno tkivo te u tim slučajevima precizna dijagnoza i liječenje mogu predstavljati velik izazov. Svrha ovog istraživanja jest pokazati niz od devet bolesnika koji su bili podvrgnuti kolonoskopiji i razvili radiološke znakove širenja zraka u retroperitoneum i na udaljene dijelove tijela. Članak opisuje i patofiziologiju, dijagnostiku i liječenje tih kliničkih scenarija.

Ključne riječi: jatrogena perforacija; retroperitoneum; pneumoperitoneum; pneumotoraks; kolonoskopija

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