

## Case Report

# Altitude Associated Colonic Perforation

Juan C. Mira, Martin D. Rosenthal and R. Stephen Smith\*

Department of Surgery University of Florida College of Medicine; Gainesville, Florida, USA

## Abstract

With increasing altitude, changes in barometric pressure can compromise incarcerated loops of bowel by limiting perfusion or provoking perforation by increasing intraluminal pressure. A 46 year old woman developed severe vomiting and abdominal pain while on vacation in Puerto Rico provoking her early return home. She clinically deteriorated in flight prompting her hospitalization upon arrival but was discharged without a clear diagnosis. The patient again deteriorated after discharge. On readmission, a large left hydropneumothorax with fecal matter and gas return upon thoracostomy tube placement was found. A posterolateral thoracotomy revealed an acute diaphragmatic hernia, a stool saturated pleural cavity and two small colonic perforations without necrosis. The patient underwent a transverse colectomy with end colostomy and had an uncomplicated postoperative course. Acute diaphragmatic hernia, colonic incarceration and in flight changes in barometric pressure are the suspected cause of this patient's presentation. To our knowledge, this is the first reported case of altitude associated colonic perforation following diaphragmatic herniation.

**Keywords:** Acute Diaphragmatic Hernia, Incarcerated Hernia, Colectomy, Hydropneumothorax, Boyle's Law, LaPlace's Law

## Introduction

Gas expands as altitude increases secondary to changes in barometric pressure. In the 17th century, Robert Boyle proved that pressure and volume are inversely proportional at constant temperature. When pressure decreases (as it does with increasing altitude), volume increases. Additionally, LaPlace's Law states that tension in the wall of a cylinder is directly proportional to the cylinder's radius and the pressure across the wall. Thus, the site of largest radius (volume) requires the least pressure to distend, thereby increasing wall tension.

In the circumstance that gas becomes trapped within bowel and rapid increase in altitude occurs, as it does during flying, the bowel can become compromised via two means: compromised blood flow or by exceeding the critical bursting pressure of the bowel resulting in perforation. It is well established that perforation of the colon can occur when cecal diameter exceeds 12cm [1]. Additionally, change in barometric pressure as the cause of a hollow viscus perforation has been previously reported in the literature [2]. Herein, we present the first reported case of altitude associated colonic perforation.

## Case Report

A 46 year old woman traveled to Puerto Rico where she suffered severe episodes of nausea and emesis shortly after dinner on the night of her arrival. She described heavy retching, chills, fevers, and subsequent abdominal pain and diarrhea. The following day she flew by commercial airline back to the continental United States to seek medical attention as her abdominal pain failed to improve despite resolution of her vomiting and diarrhea. In flight, she clinically deteriorated initially with increasing symptoms (left upper quadrant pain and left sided chest pain). This discomfort briefly subsided as the aircraft reached cruising altitude at which time the patient reported feeling a "popping sensation" in her left chest.

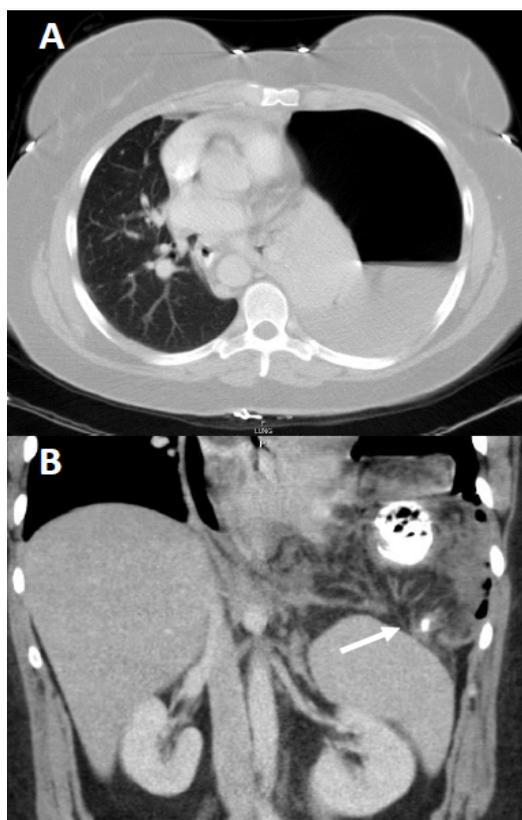
Upon arrival to Florida, the patient was hospitalized for three days. Per patient report, she underwent Computed Tomography (CT) without contrast showing a left diaphragmatic hernia upon arrival to the Emergency Room. She was admitted for observation given Per-Orem (PO) intolerance, fevers and chills. The following day, an upper endoscopy was performed which was negative and repeat CT chest with oral contrast showed only a small left pleural effusion. On the third day, after tolerating a PO challenge, the patient was discharge home off antibiotics.

The patient attempted to continue her daily activities but her clinical condition deteriorated after discharge. She presented to another hospital the day after discharge (day four after arrival from Puerto Rico) where her CT scan showed a large left tension hydropneumothorax and a large diaphragmatic hernia (Figure 1). Upon placement of a left tube thoracostomy, there was the immediate efflux of air and feces. The patient was transferred to the University of Florida Health hospital for further management. A CT scan was repeated confirming the presence of a diaphragmatic hernia with colon in the thoracic cavity and a thoracostomy tube above the diaphragm. Pre-procedural outside imaging was reviewed in further detail and revealed extravasation of oral contrast *prior* to chest tube insertion (Figure 2).

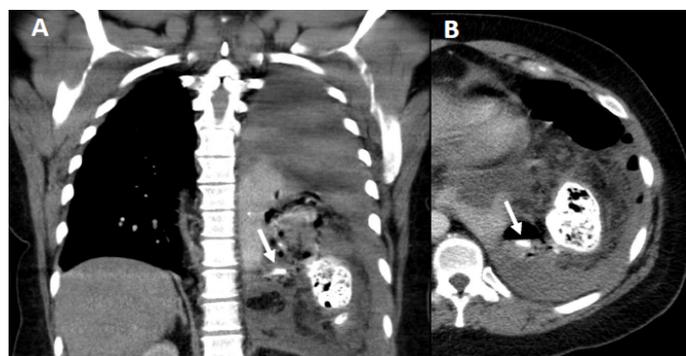
The patient was taken to the operating room where a left posterolateral thoracotomy was performed for source control and repair of the acute diaphragmatic hernia. The transverse colon was inspected revealing a colonic perforation but an otherwise viable segment of bowel. Resection of omentum and transverse colectomy were required. The two divided end of the transverse colon and remaining omentum were reduced through

\*Corresponding author: R Stephen Smith, Division of Acute Care Surgery, Department of Surgery, University of Florida College of Medicine, 1600 SW Archer Road, PO Box 100108, Gainesville, Florida USA, Tel: 352-273-5670; Fax: 352-265-0676; E-mail: steve.smith@surgery.ufl.edu

**Received:** November 23, 2017; **Accepted:** December 19, 2017; **Published:** December 21, 2017



**Figure 1:** CT images of (A) left hydropneumothorax and (B) diaphragmatic hernia (white arrow) from outside hospital prior to tube thoracostomy.



**Figure 2:** CT images showing extraluminal contrast (white arrows) prior to chest tube insertion. (A) Coronal plane. (B) Transverse plane.

the diaphragmatic hernia. The hernia was repaired primary and two chest tubes were placed. The patient was then placed supine and a laparotomy was performed to explore the abdomen. Due to ongoing vasopressor requirements, the patient was left in discontinuity and the abdomen was not closed. She was returned to the operating room the following day for colostomy and closure. Pathologic examination of the colon identified two areas of perforation with no evidence of necrosis. The post-operative course was uncomplicated and after return of bowel function, she was discharged.

## Discussion

This 46 year old woman had an unfortunate chain of events that led to her complicated clinical course. We conclude that

the following scenario led to her illness. The patient developed gastrointestinal upset from apparent gastroenteritis. Continued retching caused an acute tear in the diaphragm (there was no history or signs of chronic diaphragmatic herniation). Ongoing emesis, with increases in intra-abdominal pressure caused incarceration of the transverse colon, which can explain her significant left sided abdominal pain following the resolution of initial symptoms. The patient then returned to Florida on a commercial airline, in which cabins are pressurized to be equivalent to 6,000 to 8000 feet at cruising altitude. Of note, gas can expand up to 35% when ascending from sea level to 8000 feet [3]. As the patient ascended in the aircraft, the gas volume of the incarcerated colon increased, and as the gas was unable to escape from this incarcerated segment of bowel, it caused an acute perforation. Once the patient landed, she presented for evaluation by CT, which has sensitivity for identifying acute diaphragmatic rupture ranging from 56% to 87% [4]. Additionally, while the sensitivity of CT for identifying gastrointestinal perforation is high 80-100% [5], we believe that this perforation was missed acutely in her initial admission CT. The patient improved initially and was discharged. Once the patient presented to another institution, she had developed a tension hydropneumothorax due to an uncontained perforation above her diaphragm and resumption of oral intake.

This is the first reported case of altitude induced colonic perforation where both Boyle's and La Place's Laws produced this unfortunate situation. Assuming that the aircraft cabin was pressurized to 8000 ft, decrease in pressure at that altitude caused the colonic gas to expand in accordance with Boyle's Law. The gas in the incarcerated hernia expanded increasing wall tension to cause perforation due to mechanisms explained by La Place's Law.

## References

1. Vanek VW, Al-Salti M (1986) Acute pseudo-obstruction of the colon (Ogilvie's syndrome). An analysis of 400 cases. *Diseases of the colon and rectum* 29: 203-210. [PubMed]
2. Kenfack R, Debaize S, Sztern B, et al. (2007) Perforation of a hiatal hernia after a high altitude flight. *Rev Med Liege* 62: 144-146. [PubMed]
3. Hinninghofen H, Enck P (2006) Passenger well-being in airplanes. *Auton Neurosci* 129: 80-85. [PubMed]
4. Desir A, Ghaye B (2012) CT of blunt diaphragmatic rupture. *32: 477-498.*
5. Solis CV, Chang Y, De Moya MA, et al. (2014) Free air on plain film: Do we need a computed tomography too? *J Emerg Trauma Shock* 7: 3-8. [PubMed]

**Copyright:** ©2017 Mira JC. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.