Abdominal CT Scan Findings of Decompression Sickness: A Case Report

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Radiology Case. 2018 Oct; 12(10):17-23 :: DOI: 10.3941/jrcr.v12i10.3425

ABSTRACT

This case report depicts the radiologic findings of a 51-year-old male presenting with Decompression Sickness. Decompression Sickness is diagnosed clinically, therefore radiologic imaging of this disease entity is limited. Our patient's history includes a scuba dive to depth of 110 feet with a descending time of 24 minutes and an ascending time of 8 minutes. The patient subsequently presented to the Emergency Room with symptoms of shortness of breath and abdominal pain. The abdominal pain prompted physicians to explore further, and hence computed tomography (CT) imaging of the abdomen and pelvis was performed. This case report demonstrates a striking and unique gas pattern in both the systemic and portal venous system of our patient and provides an excellent example of the imaging findings of Decompression Sickness in the literature.

CASE REPORT

CASE REPORT

A 51- year old male presented to the Emergency Room with shortness of breath and abdominal pain. The patient stated he was diving to a depth of 110 feet over a span of 24 minutes and ascended for 8 minutes. When he got back on the boat he began to experience tingling in his extremities and abdominal pain. When he presented to the hospital, multiple areas of cyanotic marbling were seen on his chest, arms, and abdomen. His initial vitals in the emergency department were as follows: temperature of 97.6 degrees Fahrenheit, heart rate of 89 beats per minutes, respiratory rate of 20 breaths per minutes, blood pressure of 126/71 mmHG, and an oxygen saturation of 99%.

An electrocardiogram was performed which showed a rate of 98 beats per minutes, with normal sinus rhythm, and no ST-changes. Pertinent laboratory analysis revealed a red blood cell count of 5.95 X10^6/uL (normal 5-10 X10^6/uL), hemoglobin of 18.8 g/dL (normal 8-15 g/dL), hematocrit of 53.8% (normal 24-46%), and white blood cell count of 19.56X10^3 uL (normal 4-12 X10^3) (with a percentage of neutrophils and lymphocytes in the differential blood count of 81.8% and 15.4%, respectively).

Imaging studies were ordered and included a chest X-ray due to the patient’s shortness of breath as well as a computer tomography (CT) of the abdomen and pelvis. Chest X-ray revealed a normal examination. The images of the abdomen and pelvis gathered from our patient demonstrated a unique gas patterns in the systemic and portal venous system. Systemic gas was present in multiple veins including the common femoral veins, mesenteric veins and veins in the subcutaneous fat. Also, portal system gas could be appreciated and seen within the liver

Repeat vitals were done after approximately 2 hours in the emergency room revealed a heart rate of 73 beats per minute, respiratory rate of 23 breaths per minute, systolic blood pressure of 59 mmHg and a diastolic blood pressure of 42 mmHg. The patient was immediately started on intravenous hydration with a prompt response in blood pressure. He was then transferred to the hyperbaric oxygen treatment facility. The patient improved clinically and was later discharged. He was lost to further follow-up.

DISCUSSION

Etiology and Demographics:

Decompression Sickness occurs in divers as a consequence of inadequate depressurization when resurfacing. During a descent, a diver breathes air under increased pressure causing the body's tissue to become saturated with increased quantities of oxygen and nitrogen [1]. As a diver returns to the surface, the total gas tensions in these tissues can exceed the pressure in the environment which leads to release of nitrogen gas into the bloodstream. These gas bubbles can affect numerous parts of the human body and alter organ function by blocking blood vessels which results in rupturing tissues, as well as activating the clotting cascade to recruit proinflammatory cytokines. The extent and location of these gas bubble determines the clinical presentation [1].

Clinical & Imaging Findings:

Symptoms of decompression sickness are variable [1]. Approximately 75% of patients with decompression sickness will develop symptoms within one hour. There are prodromal manifestations of the disease which include malaise, fatigue, a sense of foreboding, anorexia and headache. Type 1 Decompression Sickness involves mild insults to the musculoskeletal system, integumentary system, and lymphatic system. Localized joint pain is the most common symptom in the disease. Pruritus and localized erythema evolving into mottled areas of cyanosis, as seen with our patient, are skin manifestations likely due to vasospasm of venous drainage. Type 2 decompression sickness is more severe and often results in life-threatening neurologic symptoms [1].

One complication of Type 1 decompression sickness occurs when nitrogen gas accumulates in the lungs during ascent. The gas becomes trapped in alveoli due to breath holding or underlying obstructive lung disease, which raises alveolar pressure and eventually causes alveolar rupture. This allows gas to enter the arterial system, resulting in an arterial gas embolism. This is the second most common cause of death among scuba divers (asphyxiation being number one) [2]. Symptoms of an arterial gas embolism typically overlap those seen in asphyxiation or pneumothorax, and therefore an initial chest radiograph is often obtained to help delineate the diagnosis. A subsequent CT scan of the chest is recommended in patients with possible pulmonary barotrauma, not only to detect gas within the pulmonary arterial circulation, but also to determine if there is any pre-existing pulmonary disease as well as to assess future fitness to dive [3].

Another complication of Type 1 decompression sickness occurs when nitrogen gas bubbles precipitate in bone marrow. This can obstruct osseous venous flow resulting in bone infarction, known as dysbaric osteonecrosis. This commonly occurs in the humeral head, followed by the femur and proximal tibia [4]. Currently, plain film radiographs remain the first-line modality for making the diagnosis, which shows crescentic subchondral sclerosis in a periarticular distribution. However, these findings are relatively insensitive and plain film radiographs often fail to show the extent of disease in the initial stages. Therefore, screening plain films of the shoulders are recommended in all patients with hyperbaric exposure up to 12 months after the initial insult. If radiographic findings of dysbaric osteonecrosis are seen, it often has direct implications for future fitness to dive [5]. Other imaging modalities, including ultrasound and nuclear medicine scans, have also shown tremendous diagnostic utility, although their role in imaging remains poorly defined [5].

Nitrogen gas bubbles can also cause infarction in the central nervous system, as seen in Type 2 decompression sickness, manifesting as stroke-like symptoms. The white matter in the brain and spinal cord are preferentially affected due to their high myelin content. Magnetic Resonance Imaging (MRI) has the highest sensitivity for detecting these neurologic derangements, revealing restricted diffusion and gas foci within affected white matter tracts [6].

Our patient's imaging demonstrated portal venous gas as well as gas in multiple veins including the common femoral veins, mesenteric veins, and veins in the subcutaneous fat. The radiographic criterion for portal venous gas is a branching area of low attenuation that extends to 2 centimeters within the liver capsule [7]. The peripheral gas distribution is related to the direction of blood flow in the liver [8]. Gas in the mesenteric veins appears as branched or tubular areas of decreased attenuation in the mesenteric border of the bowel. Mesenteric vein gas should not be confused with pneumoperitoneum [7]. The most apparent feature of our patient's imaging is the hepatic portal venous gas. Most literature of hepatic portal venous gas focuses on other causes, including mesenteric vascular pathology, closed-loop bowel obstruction, intra-abdominal infections, and iatrogenic causes.

Treatment & Prognosis:

Treatment of Decompression Sickness is focused on oxygen administration and hyperbaric treatment. The administration of oxygen was shown to be beneficial prior to hyperbaric oxygen treatment in a recent study. These results influenced the Divers Alert Network into placing oxygen at dive locations, in particular those areas that had a long transport time to the nearest hyperbaric chambers [9]. Our patient was treated successfully with hyperbaric oxygen chamber therapy.

Differential Diagnosis:

The differential diagnosis for radiographic findings seen in Decompression Sickness includes a wide variety of other entities that result in portal venous gas. Generally, a finding of

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portal venous gas suggests bowel wall ischemia until proven otherwise. Portal venous gas can be seen on ultrasound, abdominal X-Ray, and CT. Ultrasound shows hyperechoic moving foci in the lumen of the portal vein, commonly with posterior "dirty" shadowing. Abdominal X-ray demonstrates foci of decreased attenuation in the periphery of the liver. CT findings include tubular areas of decreased attenuation in the periphery of the liver. If the patient's history (e.g. recent intra-abdominal surgery) and physical exam (e.g. lack of peritonitic signs) are not consistent with this diagnosis, alternative causes should be considered. Other causes of portal venous gas can be characterized into the following categories: bowel wall abnormalities, bowel obstruction, intra-abdominal infection, and iatrogenic [10]. Of note, it is important to be able to distinguish portal venous gas from pneumobilia, which refers to air in the biliary tree. While portal venous gas is seen as branching gas at the *peripher*y of the liver, pneumobilia tends to result in more *central*-predominant intrahepatic gas [11].

Bowel ischemia

Impairment in normal vascular supply to the small or large bowel can eventually lead to transmural necrosis of the bowel wall. This can result in bacterial overgrowth within the bowel wall with subsequent release of gas, a by-product of bacterial metabolism. The finding of gas locules within the bowel wall is known as pneumatosis intestinalis [12]. The gas eventually dissipates via the mesenteric and portal venous system, reaching their final destination in the portal venous branches at the periphery of the liver [13]. The classic presenting symptoms is abdominal pain that is "out of proportion to physical examination". In addition to pneumatosis intestinalis and portal venous gas, contrast-enhanced CT may also reveal a lack of bowel wall enhancement within ischemic loops of bowel [10].

Bowel overdistension

Distension of the bowel wall can also result in portal venous gas. Overdistension of the bowel can lead to progressive wall ischemia that produces pneumatosis intestinalis and eventually portal venous gas, much in the same manner as previously described. This is often seen in the setting of a closed-loop bowel obstruction or severe metabolic ileus [14]. However, this can also be appreciated in the setting of barotrauma, as in the discussed case, as well as acute gastric dilation [15].

Infection

Complicated intra-abdominal infections is another cause of portal venous gas. This often occurs in severe cases of diverticulitis, cholecystitis, appendicitis, hemorrhagic pancreatitis, or untreated abdominopelvic abscesses [14].

Iatrogenic

A radiologic finding of portal venous gas does not necessarily indicate a severe underlying intra-abdominal pathology. In patients without signs or symptoms of an acute abdomen, iatrogenic causes of portal venous gas must be considered. Recent intra-abdominal surgical/endoscopic procedures can result in gas entering the portal venous system.

Drug related

Additionally, patients on certain chemotherapy medications or glucocorticoids have been found to incidentally have portal venous gas [14].

TEACHING POINT

Decompression sickness is primarily diagnosed clinically and does not usually prompt radiographic imaging. The purpose of this report is to show computed tomography images of the abdomen and pelvis in a patient with decompression sickness as there are few published cases in the literature to our knowledge.

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FIGURES

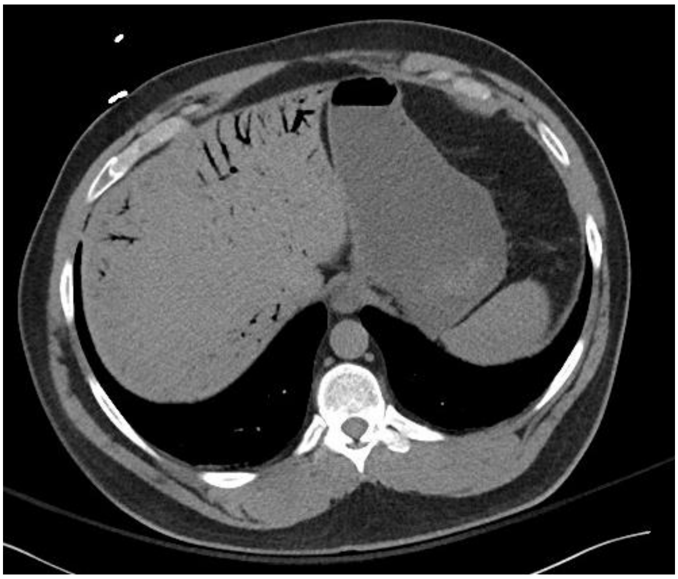

Figure 1: 51-year old male with Decompression Sickness.
Findings: Non-contrast CT axial image through the superior aspect of the liver demonstrating extensive peripherally-distributed intrahepatic gas representing portal venous gas.
Technique: Axial images were obtained from the diaphragm to the pubic symphysis without intravenous contrast (Siemens Sensation 16 CT scan with 98 eff. mAs, 140 kVp, and 5.0 mm slice thickness).

Figure 3 (right): 51-year old male with Decompression Sickness.
Findings: Non-contrast CT axial image at the level of the femoral heads demonstrates gas-fluid levels in the common femoral veins (arrows) and subcutaneous veins bilaterally (arrowheads). Technique: Axial images were obtained from the diaphragm to the pubic symphysis without intravenous contrast (Siemens Sensation 16 CT scan with 98 eff. mAs, 140 kVp, and 5.0 mm slice thickness).

Figure 2: 51-year old male with Decompression Sickness.
Findings: Non-contrast CT reformatted coronal image redemonstrating peripherally-distributed intrahepatic portal venous gas.
Technique: Coronal images were obtained from the level of diaphragm to the pubic symphysis without intravenous contrast (Siemens Sensation 16 CT scan with 98 eff. mAs, 140 kVp, and 5.0 mm slice thickness).

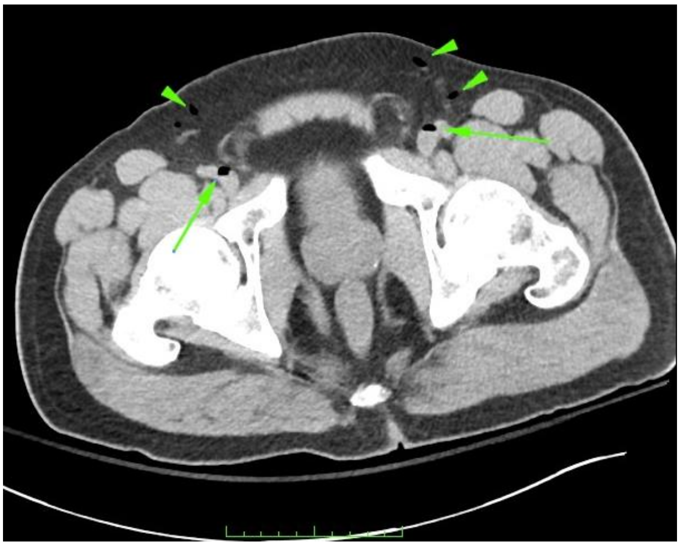

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Figure 4: 51-year old male with Decompression Sickness.
Findings: Non-contrast CT coronal reformatted image demonstrates gas in the bilateral common femoral veins and intrahepatic portal veins (arrows).
Technique: Coronal reformatted images were obtained from the diaphragm to the pubic symphysis without intravenous contrast (Siemens Sensation 16 CT scan with 98 eff. mAs, 140 kVp, and 5.0 mm slice thickness).

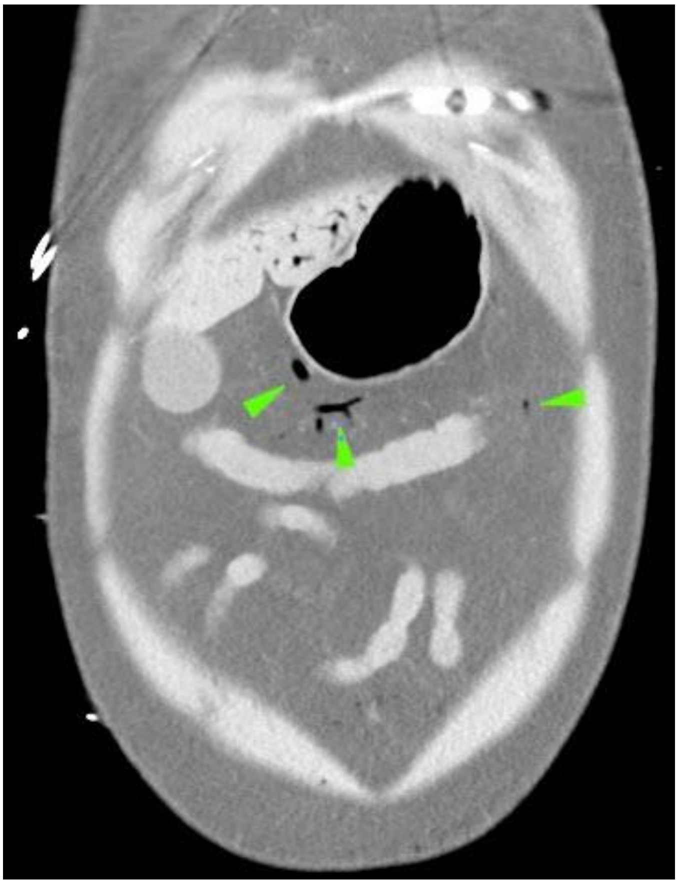
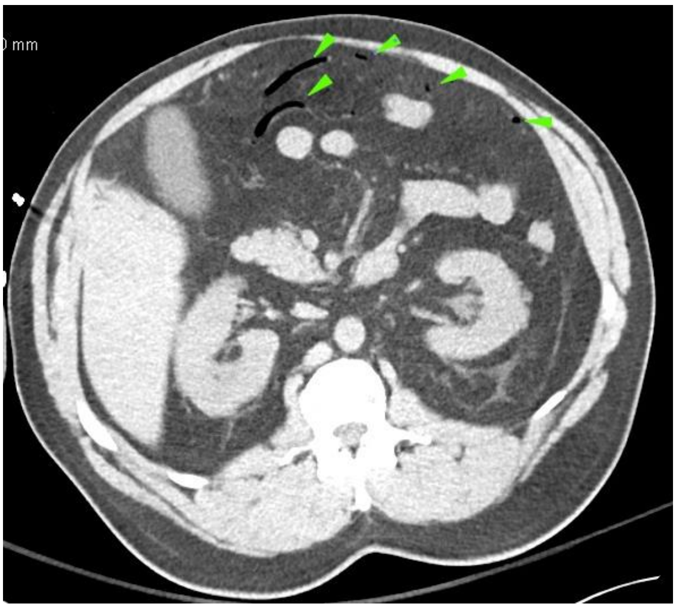


Figure 5: 51-year old male with Decompression Sickness.
Findings: Non-contrast CT coronal reformatted image through the anterior aspect of the abdomen demonstrates gas in the omental veins (arrowheads).
Technique: Coronal reformatted images were obtained from the diaphragm to the pubic symphysis without intravenous contrast (Siemens Sensation 16 CT scan with 98 eff. mAs, 140 kVp, and 5.0 mm slice thickness).

Figure 6 (right): 51- year old male with Decompression Sickness.
Findings: Non-contrast CT axial image of the abdomen through the level of the kidneys demonstrates gas in the omental veins (arrowheads).
Technique: Axial images were obtained from the diaphragm to the pubic symphysis without intravenous contrast (Siemens Sensation 16 CT scan with 98 eff. mAs, 140 kVp, and 5.0 mm slice thickness).



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	Clinical History	Additional CT Findings	Comments
Bowel Wall Ischemia	• Severe abdominal pain out of proportion to examination findings • Poor response to analgesia	• Pneumatosis • Thickened and edematous bowel wall • Diminished bowel wall enhancement (although hyperenhancement in regions of reperfusion) • Mesenteric fat stranding • Ascites • +/- arterial/venous filling defect	• A diagnosis that MUST be initially excluded • Classified into acute or chronic categories • Can be secondary to mesenteric arterial occlusion, venous outflow occlusion, or generalized low flow states
Bowel Obstruction (usually closed-loop)	• Abdominal pain and distension with associated nausea/vomiting • Inability to tolerate oral intake	• Dilated proximal loops of bowel (> 3 cm for small bowel, > 6 cm for majority of large bowel) • Collapsed distal loops of bowel • Transition point (although often not visualized) • Stool and gas in the small bowel (small bowel feces sign) • Thickened and edematous bowel wall • Pneumatosis intestinalis • Lack of bowel wall enhancement	• Most commonly due to adhesions, external hernias, and abdominal neoplasms • Other causes include intussusception, Crohn's disease, and gallstones
Barotrauma	• History of exposure to significant changes in ambient air pressure (e.g. pressurized aircraft, scuba diver) • Mild symptoms including arthralgia, skin marbling, petechial hemorrhages, and lymphatic obstruction • More severe symptoms resulting in CNS dysfunction	• Mesenteric/subcutaneous vein gas • Pneumatosis intestinalis • Pulmonary artery gas embolism • Avascular necrosis (days to weeks following insult) • Dural venous plexus gas	
Complicated Intra-Abdominal Infection	• Symptoms including fevers, chills, abdominal pain, nausea/vomiting, and diarrhea • Patients often meet criteria for sepsis with peritonitic signs on physical exam	• Variable; dependent on site of infection	• Generally, in the setting of sepsis secondary to complicated diverticulitis, cholecystitis, appendicitis, or hemorrhagic pancreatitis
Iatrogenic	• History of recent intra-abdominal surgery/endoscopic procedure • Medication history (e.g. chemotherapies, glucocorticoids)	• Pneumatosis intestinalis	

Table 1: Differential diagnoses table for Portal Venous Gas.

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Etiology	Divers, caisson workers, pilots
Incidence	900 cases yearly
Gender ratio	Non-applicable
Age predilection	Non-applicable
Risk factors	Patients with patent foramen ovale are at risk for serious complications
Treatment	Hyperbaric oxygen chamber therapy, supplemental oxygen
Prognosis	Improvement with early treatment and/or resolution.
Findings on Imaging	On CT, unique intravascular gas patterns in the systemic and portal veins can be seen.

Table 2: Summary table for Decompression Sickness.

	Main Findings	**Associated Findings**
Ultrasound	• Hyperechoic moving foci in the lumen of the portal vein, commonly with posterior "dirty" shadowing	• Color Doppler reveals sharp spikes on both sides of baseline
Abdominal X-Ray	• Foci of decreased attenuation in the periphery of the liver • As opposed to CT imaging, substantial amounts of gas are required for detection	• Foci of decreased attenuation along the bowel wall, which often coalesce to appear as "bubbly" cystic collections (pneumatosis intestinalis) • Lucency beneath the diaphragm (suggesting pneumoperitoneum due to bowel wall rupture)
Computer Tomography (CT)	• Tubular areas of decreased attenuation in the periphery of the liver (most commonly in the left lobe) • *Findings must be distinguished from pneumobilia, which results central-predominant tubular areas of decreased attenuation	• Foci of decreased attenuation along the bowel wall, which often coalesce to appear as "bubbly" cystic collections (pneumatosis intestinalis) • Evidence of pneumoperitoneum • Lack of bowel wall enhancement within ischemic loops of bowel

Table 3: Radiologic Findings of Portal Venous Gas.

ABBREVIATIONS

CT = Computed tomography
MRI = Magnetic resonance imaging

KEYWORDS

Case Report; Decompression Sickness; portal vein gas; CT; abdominal gas

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