

Melanosis Peritonei: A Rare Complication of Ionizing Radiation in Cross-Sectional Imaging

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Background	With the advancement of imaging techniques, CT scans are frequently the initial diagnostic modality utilized in the emergency department. Consequently, patients can be exposed to significant amounts of ionizing radiation. In this case report, we posit that repeated CT scans, associated with a substantial cumulative effective dose of ionizing radiation, contributed to a unique case of melanosis peritonei.
Summary	This report presents the unique case of a 42-year-old female diagnosed with melanosis peritonei following substantial exposure to ionizing radiation. This exposure resulted from a complex surgical course that began with the development of severe acute pancreatitis, progressed to chronic pancreatitis requiring a total pancreatectomy, and was further complicated by postoperative intra-abdominal fluid collections requiring image-guided drainage, recurrent incisional hernias, and chronic abdominal pain. Over 18 months, the patient presented multiple times to various emergency departments due to recurrent abdominal pain, resulting in a high cumulative dose of ionizing radiation, with 45 abdominal imaging studies obtained at our institution alone. Approximately 14 months after the index total pancreatectomy, she underwent incisional hernia repair, during which extensive melanosis peritonei was identified. Typically, this rare phenomenon is associated with conditions such as ovarian malignancies, colorectal adenocarcinoma, and melanoma. However, we suspect this is the first reported case of primary melanosis peritonei, likely resulting from excessive doses of ionizing radiation.
Conclusion	Since the development of spiral CT scanners, they have become an efficient tool for the diagnosis of various nonspecific symptoms, including abdominal pain. Ionizing radiation is known to induce cellular damage, and excessive use is suspected to have contributed to this case of melanosis peritonei. This case advocates for judicious use of imaging modalities and further investigation into the harmful effects and potential primary malignancies caused by ionizing radiation exposure.
Key Words	melanosis peritonei; small bowel mesentery; ionizing radiation; obstruction; complications; delayed complications

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Case Description

In this report, we present a patient who developed melanosis peritonei over an 18-month period, which we believe is secondary to repeated imaging studies. We were afforded the unique opportunity to identify this manifestation intraoperatively and observe its development through multiple surgical procedures. Without the identification of a previously known etiology, this is the first documented case of primary melanosis peritonei and is speculated to be secondary to the cumulative amount of ionizing radiation she received through numerous imaging studies.

A 42-year-old female with a past medical history significant for gastroesophageal reflux disease, chronic back pain secondary to disc herniation, epilepsy, daily tobacco use, and morbid obesity (status post-Roux-en-Y gastric bypass [RYGB] 10 years prior) presented with epigastric abdominal pain. Pertinent surgical history included tubal ligation and repair of an unspecified ventral hernia many years prior. Following an extensive workup, she was diagnosed with acute idiopathic pancreatitis. Although she initially improved with conservative management, she developed chronic pancreatitis with more than six acute-on-chronic episodes occurring over the next 12 months, resulting in chronic abdominal pain. Imaging findings progressed from heterogeneous pancreatic head enlargement, edema, and thickening of the adjacent duodenal wall, to the development of multiple small pseudocysts with other adjacent multiloculated fluid collections and dilation of the common bile duct, suggestive of partial biliary obstruction. Endoscopic retrograde cholangiopancreatography (ERCP) was attempted but unsuccessful given her post-RYGB anatomy. Image-guided biopsies were obtained and were consistent with chronic pancreatitis on two separate occasions. Further neoplastic workup was unremarkable.

Approximately one year after the initial episode of pancreatitis, the patient was diagnosed with infected necrotizing pancreatitis and concurrent ascending cholangitis. She underwent operative intervention with total pancreatectomy, splenectomy, cholecystectomy, duodenectomy with choledochojejunostomy reconstruction, and gastric remnant resection. The patient's postoperative course was complicated by the development of an incisional hernia and intra-abdominal fluid collections, requiring multiple image-guided drainages. Unfortunately, her chronic abdominal pain persisted, and she frequently returned to the emergency department, which led to multiple diagnostic CT scans and subsequent image-guided drain insertions/manipulations.

Approximately six months after the index operation, she underwent elective exploratory laparotomy with abdominal washout and primary repair of her incisional hernia, given her persistent fluid collections. Notably, the visceral and parietal peritoneum appeared normal at this time. Fourteen months after the index operation, she again underwent operative exploration. A small bowel resection and right hemicolectomy were performed due to ischemia in the setting of bowel obstruction from internal herniation and adhesive disease. It was during this operation that the parietal and visceral peritoneum were noted to exhibit diffuse black speckled pigmentation, consistent with melanosis peritonei (Figure 1). No known causes of this manifestation were identified intraoperatively, and pathological examination of biopsies confirmed the diagnosis. Postoperative workup was also unrevealing for an anatomic etiology.

Figure 1. Intraoperative Finding of Melanosis Peritonei. Published with Permission



Unfortunately, her chronic abdominal pain persisted with recurrent presentations to various emergency departments, and additional CT imaging studies were obtained. The results were grossly negative, and no further etiology of her abdominal pain or causes of melanosis peritonei were discovered.

The patient was eventually lost to follow-up five years after the index operation and has since died due to unknown causes.

Discussion

Melanosis peritonei is a rare finding, with fewer than 20 cases documented in current scientific literature. The condition is defined by the presence of diffuse darkening of the peritoneum due to melanin deposition from melanocyte proliferation.¹ While the exact etiology and pathophysiology of melanosis peritonei is unknown, it has been identified secondarily in patients with certain malignancies. These include ovarian malignancies (e.g., dermoid cysts, teratomas, serous and mucinous cystadenomas), colorectal adenocarcinoma, and metastatic melanoma.²⁻⁵ It has also been previously associated with Peutz-Jeghers syndrome.¹

It is well-established that high doses of radiation have harmful effects on the human body.⁶ This has been demonstrated throughout history following catastrophic events such as the atomic bomb detonations of 1945 and the Chernobyl nuclear power plant explosion of 1986. For reference, the Chernobyl disaster exposed plant workers and first responders to 800-1600 millisieverts (mSv) of radiation. Consequently, many developed acute radiation sickness from the immediate damage to cells, tissues, and organs, which ultimately led to death in many cases over the following months. The development of acute radiation sickness has also been well-described in cancer patients receiving high-dose radiotherapy treatments. Furthermore, cancers such as leukemia, breast, colon, bladder, lung, esophagus, ovarian, stomach, and multiple myeloma have been associated with accumulated exposures of 500 mSv.⁷ For comparison, acute exposure of a pregnant female to 500 mSv could potentially lead to miscarriage, major malformation in a developing fetus, or neonatal death.⁸

The effects of low-dose radiation are more difficult to delineate, as they occur at the molecular level, altering chemical bonds that may affect DNA, potentially allowing for the growth of neoplastic cells. Although one might extrapolate that low-dose radiation can have deleterious effects, its exact implication is difficult to quantify scientifically, given the undeterminable latency period between the initial exposure and its identifiable consequence.⁶ This latency period and the microscopic nature of these biophysical changes make establishing a firm link between neoplastic formation and radiation doses below 100 mSv very difficult; in fact, no such definitive data exists.⁷ The Health Physics Society (HPS) recommends against receiving doses greater than 50 mSv in one year or a lifetime dose greater than 100 mSv above the dose received from natural sources, known as background radiation.⁹

According to the Health Physics Society¹⁰ and the U.S. Environmental Protection Agency (EPA),¹¹ the average yearly dose of radiation for U.S. inhabitants is approximately 6.2 mSv per year. Approximately half of this value can be attributed to background radiation from radioactive atmospheric elements (radon, uranium, thorium, etc.), cosmic radiation, and a small fraction from human activities, such as consumer and industrial functions. The other estimated half of the average U.S. inhabitant's radiation dose is attributed to medical procedures and their associated imaging studies, with computed tomography being the largest contributor.^{10,11} Despite improving technology and an overall decrease in radiation doses per scan, collective radiation dosing continues to increase due to the expanding utilization of CT imaging and nuclear medicine. On average, U.S. inhabitants were exposed to more than 7 times as much ionizing radiation from medical procedures in 2006 than was the case in the 1980s.¹⁰

At the time of our patient's frequent imaging studies, it was estimated that the effective dose (ED) of ionizing radiation for each abdominal CT scan was 10 mSv. Similarly, the ED for each pelvic CT scan was 10 mSv, and the ED for each abdominal X-ray was 0.7 mSv.^{10,11} Though the amount of imaging studies she received at other hospitals through her various presentations is unknown, her imaging is well-documented at our institution and indicates that the patient's abdomen and pelvis were subjected to an extensive amount of radiation. Over the 18-month period spanning the index operation and the operation at which melanosis peritonei was diagnosed, 33 abdominal/pelvic CT scans and 12 abdominal X-rays were obtained at our institution alone. According to the online EPA Radiation Dose Calculator,¹² this is estimated to be approximately 670 mSv of radiation, without including the radiation accrued at outside facilities. This is equivalent to 216 years of background radiation and is 72 times greater than the radiation dose received by the average U.S. inhabitant over the same time period, exceeding the yearly safe dose by a multiple of 4.5. Furthermore, these calculations do not include any preoperative imaging studies or studies received at other facilities. Though our patient received this 670 mSv dose over an 18-month period rather than instantaneously, it is likely that it produced detrimental effects. We believe this patient's cumulative radiation dose led to the development of melanosis peritonei and could have also been a contributing factor to her chronic abdominal pain.

Conclusion

Chronic abdominal pain, particularly in the setting of a complicated surgical course, is not an uncommon occurrence. It often leads to hospital admissions, and imaging studies are used as a diagnostic aid to avoid overlooking acute pathology. This paper presents a unique case of the rare entity, melanosis peritonei. While definitive causality cannot be established in this case, we propose that the significant amount of ionizing radiation that the patient received throughout the evaluation and management of her chronic abdominal pain was the probable cause of her melanosis peritonei. Currently, there are no established guidelines or algorithms for the utilization of imaging studies in patients presenting with these nonspecific symptoms.⁶

Lessons Learned

It is our opinion that imaging studies utilizing ionizing radiation, particularly repeat CT scans, for patients with established and well-documented chronic idiopathic abdominal pain, should be performed far more judiciously. These studies should be employed only after physical examination and other clinical data have raised concern for an acute process. In the modern era of medicine, with readily accessible imaging capabilities, administrative policies, patient satisfaction surveys, patient expectations of imaging, and other confounding variables, patients will be exposed to more imaging studies than previously observed. This presents an opportunity for research to identify a possible connection between extensive radiation exposure and the development of melanosis peritonei, various cancers, and potentially other pathologies.

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