Appendix 1

Summary of the cases

Case 1: Chilaiditi

Learning Objectives

- Describe the process of gut development and why specific parts are retroperitoneal or intraperitoneal.
- Describe how the abdomen can be subdivided into quadrants and regions.
- Distinguish portions of the colon and contiguous structures.
- Demonstrate abdominal surface projections of the colon.
- Explain the key causes of abdominal pain and related characteristics, location, organs.
- List commonly used imaging methods for abdominal pain.

Introduction and Patient Background

Subject

79-year-old Caucasian female

History & Chief Complaint

- Chief Complaint: Abdominal discomfort
- She presented with a moderate abdominal discomfort, anorexia, distention and nausea.

Exam

The physical examination revealed a soft abdomen with mild tenderness in the upper right quadrant, yet no rebound was revealed.

Since acute cholecystitis is the most common reason of the abdominal pain encountered in the emergency department and the patient complaints suggested choledochal related diseases, abdominal ultrasonography was performed. No pathology was found in the gallbladder and other abdominal structures via ultrasonography. On the direct abdominal radiography, a lucent appearance compatible with the air filling in the right subdiaphragmatic area was observed. This appearance was suggesting pneumoperitoneum. MRI was performed for the differential diagnosis of diaphragmatic hernia, perforated peptic ulcer, bowel obstruction, volvulus, ischemic bowel, appendicitis, and diverticulitis.

Note: While MRI is not typically the first-line imaging modality for evaluating abdominal conditions in living patients, CT is more commonly used, we are using MRIs in these cases because they are the imaging data available from our body donor program.

Questions

Please recall or search:

1. Which organs are located in the right upper quadrant?
2. What is rebound?

Anatomical Correlation

Anatomical correlation

-Please review the 3D model demonstrating the abdominal regions and recall the major organs located in each region.

Radiology Findings

An abdominopelvic MR examination confirmed the interposition of a segment of large bowel between the liver and the right hemidiaphragm consistent with ‘Chilaiditi sign’. Since the patient presented with symptoms, a diagnosis of Chilaiditi syndrome was made. Further information on Chilaiditi sign and syndrome is provided in the supplemental material.

- Please interpret the patient's MRI scans using your XR devices.
- Review the photogrammetric and segmented 3D models on your XR devices, and compare them with the corresponding radiographic images to identify and match anatomical structures.

Case 2: Mobile Cecum

Learning Objectives

-Recall the process of bowel rotation during embryogenesis.
-Describe the anatomical relationship between the cecum and the peritoneum.
-Identify the major organs located in each of the four abdominal quadrants.
-Demonstrate the surface anatomy and landmarks corresponding to the cecum.
-List common causes of recurrent abdominal pain.

Introduction and Patient Background

Subject

87-year-old Filipino male

History & Chief Complaint

- Chief Complaint: Recurrent abdominal distension, right lower quadrant pain and chronic constipation
- Patients medical history did not present remarkable episodes, except for a chronic recurrence of current symptoms. No previous surgery was reported.

Exam

He was nontoxic appearing with normal vital signs. Abdomen was soft with right lower quadrant tenderness to palpation. Enlarged liver noted. Remainder of the examination was normal. Laboratory investigations did not reveal obvious abnormality. On plain X-ray Chilaiditi sign was observed. MRI was performed for the differential diagnosis.

Note: Given the patient's age and chronic symptoms, a colonoscopy should also be considered to exclude underlying colonic pathology.

Note: While MRI is not typically the first-line imaging modality for evaluating abdominal conditions in living patients, CT is more commonly used, we are using MRIs in these cases because they are the imaging data available from our body donor program.

Questions

Please recall or search:

1. What are the basic components of abdominal examination?
2. What are the organs located in the right lower quadrant?

Anatomical Correlation

Anatomical correlation

-Please watch this video on the topography of the colon.

Radiology Findings

An abdominopelvic MR examination demonstrated a mobilized cecum in the right upper quadrant. Also mild dilation of the infra renal abdominal aorta with a small aneurysm and a large liver cyst that enveloped almost the entire left lobe was observed. Although simple liver cysts are usually benign, they can cause pain or discomfort. Patient was diagnosed with Mobile Cecum Syndrome. Further information on Mobile Cecum is provided in the supplemental material.

- Please interpret the patient's MRI scans using your XR devices.
- Review the photogrammetric and segmented 3D models on your XR devices, and compare them with the corresponding radiographic images to identify and match anatomical structures.

CASE 1

Chilaiditi Sign/ Syndrome

Etiology

•The exact cause of Chilaiditi syndrome is unknown. However, the condition occurs with greater frequency in individuals with chronic lung disease, scarring of the liver (cirrhosis), and accumulation of fluid within the abdominal cavity (ascites).

•Other risk factors include decreased liver volume, obesity, paralysis of the motor nerve to the diaphragm (phrenic nerve palsy), and, in some cases, it can be congenital.

Epidemiology

•The global incidence of Chilaiditi sign is estimated to range from 0.025% to 0.28%, with a male-to-female ratio of approximately 4:1. It is also observed more frequently in older adults.

Terminology

Chilaiditi sign is a radiological finding characterized by the interposition of a segment of the colon between the liver and the diaphragm.

•Chilaiditi sign can be asymptomatic, but in some cases, it is associated with various clinical symptoms, particularly gastrointestinal issues, ranging from mild abdominal discomfort to severe conditions like acute bowel obstruction. When these symptoms are present, the condition is referred to as **Chilaiditi syndrome.**

Signs and Symptoms: recurrent abdominal pain, nausea, vomiting, constipation, indigestion, difficulty swallowing, and abdominal tenderness

Diagnosis: The diagnosis of Chilaiditi sign is based on specific radiologic criteria: the right hemidiaphragm must be clearly elevated above the liver by interposed bowel, the bowel should be air-filled to mimic pneumoperitoneum, and the superior margin of the liver must appear displaced below the level of the left hemidiaphragm.

Related Disorders

•Chilaiditi syndrome can be initially misdiagnosed as a diaphragmatic hernia or pneumoperitoneum (abnormal presence of gas or air within the abdominal cavity.

•Complications of Chilaiditi syndrome may include a volvulus of the cecum, splenic flexure, or transverse colon. Cecal perforation and, rarely, perforated subdiaphragmatic appendicitis can also occur as complications of Chilaiditi syndrome.

•Volvulus: when a portion of the intestine loops around itself and/or the mesentery that supports it

•Mobile cecum: an anatomic variant where the cecum is detached from the parietal peritoneal wall due to the failure of the cecum, terminal ileum, right colon, and mesentery to fuse to the parietal peritoneal wall. Can cause Chilaiditi's sign/syndrome.

Treatment

•Initial management of Chilaiditi syndrome should include bed rest, intravenous fluid therapy, bowel decompression, enemas, and laxatives. A repeat radiograph following bowel decompression may show disappearance of the air below the diaphragm.

•If a patient does not improve with initial conservative treatment, or if bowel obstruction persists or ischemia is suspected, surgical intervention becomes necessary. In recent years, surgery has also been increasingly used to manage chronic or intermittent abdominal pain. The choice of surgical procedure depends on the segment of colon involved: cecopexy is typically sufficient for uncomplicated cecal volvulus unless gangrene or perforation is present, in which case resection is required. For transverse colon volvulus, surgical resection is preferred, as colonoscopic reduction is not advised due to a high risk of gangrene (approximately 16%).

•It should be noted that intervention is not required for asymptomatic patients.

Contraindications of abdominal laparoscopic surgery: coagulopathy, disseminated abdominal cancer, pulmonary compliance, cardiovascular issues, intracranial disease

Postoperative complications: Intestinal perforation, bile leak, retroperitoneal hematoma, pancreatitis, postoperative air embolism.

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CASE 2

Mobile Cecum

Etiology

•Bowel development during embryogenesis is a complex process that begins in the 4-5th gestational week and occurs in three stages: herniation, return to the abdominal cavity, and fixation. Abnormalities in the rotation or fixation of the gastrointestinal tract are often linked to other developmental defects. When the cecum and ascending colon remain suspended by a mesentery without proper fixation, they can rotate freely, potentially leading to a range of symptoms known as "mobile cecum syndrome." However, this condition can also be asymptomatic, having been identified in 11.2% of autopsies. Another reason for the mobile cecum is long, floppy mesentery fixed to the retroperitoneum by a narrow base of origin.

Epidemiology

• Abnormal mobility of the cecum and ascending colon has been estimated to occur in 10–20 % of the population.

Terminology

Mobile cecum: Mobile cecum is defined as a failure of the cecum, terminal ileum, and right colon along with the mesentery to fuse to the posterior parietal peritoneal wall.

Signs and Symptoms: Although anatomic variations like a mobile cecum are relatively common, they sometimes cause recurrent right lower abdominal pain. When a mobile cecum does lead to volvulus, a rare occurrence, it can quickly progress to strangulation and gangrene, requiring emergency surgery if not diagnosed promptly.

Diagnosis: The most successful diagnosis tool for mobile cecum was found to be a computed tomography (CT).

Related Disorders

Cecal Volvulus: a rare condition that can result from a mobile cecum, where the cecum, detached from the abdominal wall, twists on itself

•Responsible for 1-1.5% of all intestinal obstructions, 11% of all volvulus-related intestinal obstructions, and its incidence is 2.8-7.1 cases per million annually.

•Can cause abdominal pain, abdominal bloating, abdominal distension, vomiting, constipation, and diarrhea

Treatment

•Goals of Treatment: Reduce abdominal pain, constipation, and eliminate movement of the cecum

•Laparoscopic cecopexy.

Cecopexy: treatment of the mobile cecum that involves a surgical operation to fix the cecum to the abdominal wall.

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