Aerospace Medicine Clinic

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You are the flight surgeon for a 39-yr-old active-duty male who presents for initial qualification examination for duties as a remotely piloted aircraft (RPA) pilot. He was previously qualified as an RPA sensor operator (SO) approximately 10 yr prior. During that RPA SO qualification exam, he had a chest X-ray (CXR) that was notable for cardiomegaly without any comment on the status of his diaphragm. At that time, he did not note any symptoms, including chest pain, shortness of breath, or abdominal pain. Further evaluation with an echocardiogram, while technically difficult due to poor acoustic windows, did not have any significant findings. Therefore, he was qualified to be an RPA SO, a job he performed without incident for the next 10 yr.

After 9 yr as an RPA SO, he applied to be an RPA pilot. A CXR obtained at that time was normal except for an elevated left hemidiaphragm felt by the radiologist to be nonpathological. To further characterize that defect, fluoroscopy was performed, which also showed an elevated left hemidiaphragm but no evidence of diaphragmatic dysfunction. His flight surgeon ascertained the abdominal symptoms from the past decade and attributed them to irritable bowel syndrome. He was advised on dietary changes, but this was not followed up, and his condition did not become symptomatic.

He ultimately did not complete his training for RPA pilot duties in the required amount of time, and his pilot medical examination lapsed. Therefore, he returned 2 yr after his initial RPA pilot examination for another initial qualification examination in anticipation of restarting the program. Due to a recent COVID-19 infection, he obtained a CXR prescribed by U.S. Air Force (USAF) protocols for that disease. This CXR continued to show an elevated left hemidiaphragm, but this time a CT scan of the chest was obtained to further characterize that finding. That scan showed a large left-sided diaphragmatic hernia containing multiple loops of small bowel, without incarceration or strangulation.

1. At what stage of life are most diaphragmatic hernias usually discovered?
   A. Perinatally.
   B. Within the first year of life.
   C. Between 1–17 yr old.
   D. After 18 yr old.

ANSWER/DISCUSSION

1. A. Most diaphragmatic hernias are discovered in the perinatal period. Anterior diaphragmatic hernia is defined as a protrusion of abdominal organs or omental fat into the thoracic cavity through a defect in the diaphragm.[7] In adults, atraumatic and noniatrogenic diaphragmatic hernias (excluding hiatal hernias) are a rare condition. While first described in the medical literature by its eponymous discoverer, Morgagni, in 1761,[9] anterior diaphragmatic hernias only represent about 1–6% of surgically treated hernias.[13] The vast majority of diaphragmatic hernias are congenital and are diagnosed perinatally followed by repair shortly after birth, but even these defects are rare, being found in only 1 in 3000 live births.[3]

Diaphragmatic hernias can be either posterior (Bochdalek) or anterior (Morgagni),[2] with the anterior type being more common in adults. While the exact prevalence in adults is unclear, studies in children show that anterior hernias are right sided (Morgagni) 90% of the time, bilateral (Morgagni-Larrey) in 8% of cases, with left-sided (Larrey) cases in the remaining 2%.[12] These hernias form due to a congenital fusion defect between the septum transversum of the diaphragm and the costal arches, leading to a retrosternal area of weakness in the diaphragm.[1,13] It is thought that the right side is more prone to hernia formation due to relative protection provided by the pericardium on the left diaphragm.[7]

You have the patient return to your clinic to discuss his radiology results and to obtain a more detailed history related to this newly discovered diaphragmatic hernia. When asked more specifically about chest and abdominal complaints, he notes that during the past 10 yr he has had recurrent dull, nonlocalizable abdominal pain that would resolve spontaneously.

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He also recalls that occasional reflux symptoms, especially after large meals, have been happening more frequently over the past several years. He has never discussed these issues with a physician and has not used any medications for these complaints.

2. Adult patients with anterior diaphragmatic hernias most commonly present with which symptom?
   A. Cough and/or shortness of breath.
   B. Heartburn.
   C. Abdominal pain or pressure.
   D. Asymptomatic.

ANSWER/DISCUSSION

2. A. Most diaphragmatic hernias present with chronic cough and/or shortness of breath. Diagnosis is often incidental, with 28% of patients being asymptomatic; 38% exhibiting pulmonary symptoms such as dyspnea, cough, or shortness of breath; and 37% having vague symptoms of pain or pressure in the abdomen or chest.[6] However, given this rare condition, other studies have shown different distributions of these symptoms and presentations, some with only 10% being asymptomatic.[7] CT allows for accurate identification of diaphragmatic hernias, correctly diagnosing 70–83% of cases and allowing for surgical planning by characterizing the extent of involvement of abdominal contents.[10,14] MRI and upper gastrointestinal barium studies are also potential modalities, but they are much less commonly utilized.[7]

After discussing the diagnosis with the patient and reviewing the results of his imaging studies, you begin to discuss the next steps. He strongly desires to remain in the military and is adamant about his desire to pursue RPA pilot training. He is also concerned about this condition and wants to ensure it is adequately addressed.

3. After receiving a CT abdomen report for this RPA pilot applicant, what should be the next action for the diagnosing physician?
   A. Immediate referral to the emergency room due to risk of strangulation.
   B. Urgent surgical consult (within 1–2 wk).
   C. Routine surgical consult (1–2 mo).
   D. Watchful waiting by Primary Care Manager with follow-up in 6 mo.

ANSWER/DISCUSSION

3. C. General surgery should be routinely consulted. While these hernias do not represent a surgical emergency, they should be repaired promptly, with 58% of hernias containing parts of the colon[10] and 20% with signs of possible obstruction.[6] Currently, 56% of cases are managed via open surgical technique, but laparoscopic (transabdominal) and thoracoscopic (transthoracic) techniques are becoming more popular, encompassing 40% of cases.[7,8] Regardless of technique, the defect is surgically repaired by reducing the herniated contents and sac, followed by defect closure with sutures that are sometimes overlaid with surgical mesh reinforcement.[8,12] Pulmonary complications, including pleural effusion requiring drainage, represent the most common short-term surgical complications. Recurrence of the hernia is highly uncommon and, therefore, has yet to be statistically characterized.[12]

Given the rarity of this diagnosis, there is a paucity of long-term outcome data to inform clinical risk assessment.[7] The preponderance of literature for the long-term management of congenital diaphragmatic hernias concerns the pediatric population. However, this likely does not translate well to adult patients due to the substantially increased severity of congenital diaphragmatic hernias in the pediatric population with its requisite cardiopulmonary defects, developmental pathology, and gastrointestinal problems.[5] Despite this, we can surmise that with the majority of adult symptomatic patients endorsing pulmonary complaints,[6] monitoring of pulmonary function could be prudent in populations in high occupational risk settings or presenting with recurrent symptoms.

We are not aware of any cases of diaphragmatic hernia in aviators in the USAF, and this case may represent the first of its kind. Furthermore, there are no studies that characterize the prevalence of diaphragmatic defects in military populations. However, when examining the demographics of those typically diagnosed, this is not surprising. A review of 298 cases of anterior diaphragmatic hernias showed an average age of 53 yr old, with females representing 62% of cases.[6] Therefore, one would not expect this condition to be frequently identified in a military population that skews heavily male and younger than 30 yr old.

After discussing the results, our patient was initially referred to general surgery, but later referred to a cardiothoracic surgeon when he elected to undergo surgical repair. The repair of his Larrey diaphragmatic hernia was conducted via laparotomy and left thoracostomy. During the operation, the surgeon originally attempted to reduce the hernia solely through the abdominal cavity; however, he was unable to do so and therefore performed the thoracostomy to access the hernia from the superior aspect. The diaphragmatic defect was repaired, and a polytetrafluoroethylene mesh patch was applied.

His postoperative course was most significantly complicated by a left pneumothorax, which resolved via thoracostomy tube placement. He also sustained mild acute kidney injury and a small bowel obstruction, both of which were resolved as of hospital discharge. He gradually recovered and resumed his previous level of exercise and running 2 mo postoperatively. Follow-up imaging demonstrated only a small fat-containing hernia and no persistent symptoms.

The patient returns to your flight medicine clinic 4 wk after being released from surgical follow-up. He states that his surgeon did not recommend any limitations and he should be able to do any job that he desires, including flying. He asks what the

next step will be in his medical clearance for RPA pilot training and states that he is also interested in pursuing a private pilot license.

4. If this aviator presented to a U.S. civilian aviation medical examiner (AME) requesting a Federal Aviation Administration (FAA) third class medical certificate, what would be the proper aeromedical disposition?
   A. Defer to the FAA regional flight surgeon.
   B. Issue an FAA third class medical certificate.
   C. Deny the application.
   D. Ask the airman to return at a later date for consideration.

ANSWER/DISCUSSION

4. A. The AME should defer to the FAA regional flight surgeon. The FAA AME guide does not make a direct reference to diaphragmatic hernias and their aeromedical disposition. However, the inguinal, ventral, or hiatal hernia section provides a useful construct for AME decision-making (with hiatal hernias being the most proximate analog). The guide states that only if hernias are symptomatic is deferral to an FAA decision required. However, under the diseases of the lung section, the AME guide also discusses thoracostomy, which this airman required to treat his condition. Therefore, despite the absence of hernia symptoms, the AME should defer the medical certificate to the FAA for a decision.[4]

All U.S. military aeromedical standards also lack specific aeromedical guidance on diaphragmatic hernias.[11,15,17] However, the Army, Navy, and Air Force all cite diaphragmatic hernias or defects as not meeting retention standards for general military service.[15,16,18] Therefore, all U.S. military branches would require a waiver for continued service and then would require a specific aeromedical waiver disposition on a case-by-case basis.

A lack of long-term outcome data makes an evidence-based aeromedical disposition difficult. The current surgical literature indicates that recurrence after surgical correction is exceedingly rare.[12] Therefore, we can surmise that the risk of sudden incapacitation would be extremely small. The risk of a subtle performance decrement over time is also difficult to estimate due to a lack of adult data. Given compression of thoracic structures, spirometry or cardiac functional testing could be considered to mitigate this long-term risk. Both of these studies are easy to obtain and interpret. Surgical complications are limited to the first 30 d after intervention.[12]

It would be reasonable to assume stability of the repair after departing the immediate postoperative period. Despite the lack of long-term data, it can be assumed that this patient poses a low aeromedical risk as an RPA pilot and that clearance for duty is a prudent course of action. Dispositioning this case would have been more difficult if he were applying for an aircrew position in high-performance aircraft. There are no studies evaluating the integrity of mesh repairs of diaphragmatic defects under $+G_z$ conditions, nor are there any studies that assess the ability to breathe under positive pressure conditions. Additionally, postoperative data note no case reports of adverse ventilatory mechanics after these procedures. However, it would be judicious to mitigate theoretical risk by limiting aeromedical clearance to non-high-performance aircraft only.

Because this patient is a military pilot applicant, he is referred to the USAF Aeromedical Consultation Service for evaluation. Repeat CT imaging did not demonstrate any substantial changes. He also underwent pulmonary-function testing, which revealed that all parameters were within normal limits. Therefore, he was granted a 2-yr aeromedical waiver for RPA pilot duties. He will be subsequently monitored via pulmonary function tests with emphasis on spirometric lung volumes and diffusing capacity for carbon monoxide.

After being granted his aeromedical waiver, he entered and successfully completed RPA pilot training. Since that time, he has had no medical complaints or complications of his surgery. He continues to meet USAF fitness standards and world-wide deployability.

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