Mach band sign: an optical illusion

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The chest radiograph of a 63-year-old woman who was found unresponsive was concerning for pneumopericardium, but lacked the other corroborative features suggestive of pneumopericardium. None of the follow-up chest radiographs showed evidence of air around the heart. The radiolucent shadow that mimicked pneumopericardium in this case was due to an artifact known as Mach band sign, an illusion created by lateral inhibition in the light receptors in the retina.

Physicians rely on radiographs and computed tomography for diagnosis. However, they must realize that radiographs provide shadows of objects, and several artifacts arising from our visual perception can mimic pathologic lesions. This case report illustrates the importance of recognizing one of the most common and important illusions, the Mach band effect.

CASE DESCRIPTION

A 63-year-old woman was found unresponsive by her husband. She was intubated on the scene by paramedics and transferred to the intensive care unit. The chest radiograph showed opacities in the mid and lower zones of the right lung (*Figure*). A linear hypodensity at the lateral margin of the right atrium was suspicious for pneumopericardium. No radiolucent line was visible on the left side of the heart or around the great vessels. The patient was treated with broad-spectrum antibiotics for possible aspiration pneumonia. She later improved and was extubated. No chest radiographs during her subsequent hospital course showed pneumopericardium. The radiolucent shadow seen lateral to the right atrium was due to the Mach band sign.

DISCUSSION

While interpreting chest radiographs, we believe that we are seeing true shadows of structures in the chest. However, several artifacts can arise due to our visual perception, which can lead to errors in diagnosis. One of them is the Mach band effect. This optical illusion is named after Ernst Mach, a physicist who described the sign in 1865. It occurs due to spatial high-boost filtering by the human visual system on

the image captured by the light receptors in the retina, where a phenomenon called lateral inhibition occurs (1). This is an edge enhancement method to facilitate the detection of edges of an object. It is more prominent with objects that have a curved border than in those with an angled border. The eye enhances the edges of the object by making the edge of a dark object lighter and the edge of a lighter object darker. This phenomenon can cause a physician to see a dark shadow when in fact there is none. This effect created the translucency at the cardiac borders mimicking a pneumopericardium in our case (2). Mach band sign can also simulate pneumothorax or fractures. Alternatively, the knowledge of this phenomenon might lead a radiologist to misinterpret a true shadow as a Mach band effect and ignore it.

In patients with pneumomediastinum, usually several other findings substantiate the presence of air in the mediastinum. The “continuous diaphragm sign” is due to air tracking on the inferior surface of the heart, giving the appearance of the diaphragm as a continuous line below the heart. Radiolucencies may be seen surrounding great vessels due to the air tracking alongside them. Moreover, a bright white line (of parietal pericardium) bordering the free margin of the radiolucent shadow of air is also seen in true cases of pneumopericardium. These findings were not present in our patient. Apart from the phenomenon of optical illusion, the presence of radiolucent lung between the cardiac border and the descending branch of the right pulmonary artery is also believed to be responsible for this appearance.

A similar illusion, again caused by lateral inhibition in the retina, is the background contrast effect (3). The radiographic density of an image gets altered in comparison with its surrounding structures. This is similar to the Mach band effect, but it covers a larger area than the Mach effect, which creates only a narrow bandlike effect. Cornsweet illusion is a similar optical illusion, where an object of uniform intensity might

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Figure. (a) Chest radiograph showing opacities in the right lower zone and a radiolucent shadow bordering the right atrial silhouette. **(b)** Magnified view of the cardiac silhouette showing a curvilinear radiolucent shadow bordering the right atrium.

appear to have different intensities if separated by a line. This effect is similar to the background contrast effect, in that large areas can be affected, but unlike the Mach effect, here the region adjacent to lighter structures will appear lighter and the region near darker areas will appear darker.

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