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Case Report

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Phrygian Cap Appearance of a Mouse Gallbladder on Magnetic Resonance Imaging

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Abstract

We used live-animal magnetic resonance imaging (MRI) to examine the gallbladders of male mice. These healthy mice were fasted overnight before the study and anesthetized in an animal chamber, with a gas mixture of oxygen and isoflurane for small animal MRI. In the course of these live-animal MRI studies, we observed a Phrygian cap appearance to the gallbladder of one healthy-appearing 6-week-old male mouse, similar to that of the human gallbladder described in many reports. After euthanasia for measurement of bile content, this mouse's gallbladder appeared anatomically normal. To our knowledge, this is the first report of a Phrygian cap appearance of the murine gallbladder.

Keywords

Mouse; Gallbladder; Phrygian cap; Small animal MRI

Introduction

Little is known regarding the radiological appearance of the rodent gallbladder; mice have rarely been studied, and rats lack a gallbladder. In the course of developing a novel test to measure bile acid transport, we had occasion to perform magnetic resonance imaging (MRI) on a series of health mice. As reported herein, one of these mice had an unusual appearance to the gallbladder that has been designated a 'Phrygian cap', when seen in humans, and rarely in other mammalian species. To our knowledge, this is the first report of a Phrygian cap appearance of the murine gallbladder.

Case History

For a study of bile acid transport, we used live-animal magnetic resonance imaging (MRI), to examine the gallbladders of male C57BL/6 mice (20-28 g body weight), obtained from Jackson Labs, Bar Harbor, ME. Sixteen healthy mice, maintained on standard rodent chow (7012 Teklad LM-485 Mouse/Rat Sterilizable Diet; Harlan, Indianapolis, IN), were fasted overnight before the study.

In vivo imaging was performed on a Bruker Biospec 7.0 Tesla 30-cm horizontal bore scanner, using Paravision 5.0 software (Bruker Biospin MRI GmbH, Germany). A Bruker 30-mm $^{19}F/^{1}H$ dual-tuned surface coil was used to transmit and receive radiofrequency (RF) signals at 300.28 MHz for ^{1}H and 282.55 MHz for ^{19}F nuclei. Mice were anesthetized in an animal chamber, with a gas mixture of O_2 (1 L/min) and isoflurane (3%; IsoFlo, Abbott Laboratories, North Chicago, IL). Animals were then placed supine in a Bruker animal bed, and the RF coil was positioned and fixed with surgical tape in the region of interest on the animal body. The animal bed was moved to the center of the magnet, and the isoflurane level was changed to 1.5%, and maintained at this level for the remainder of the experiment. An MR-compatible small-animal monitoring and gating system (SA Instruments, Inc., New York, NY) was used to monitor animal respiration rate and body temperature. Mouse body temperature was maintained at 36-37°C using a warm water circulator.

Three-slice (axial, mid-sagittal, and coronal) scout rapid acquisition with fast low angle shot MR imaging (FLASH) was used to localize the volume of interest. High resolution proton density-weighted anatomic images were acquired using rapid acquisition, with relaxation enhancement (RARE) sequence in the axial view, with repetition time=1847 or 2631 ms, echo time=11 ms, RARE factor=8, field of view=6×6 mm^2, slice thickness=1 mm, matrix size=400×400, in-plane resolution=0.15×0.15 mm^2, number of slices=12 or 24, and number of averages=8. Total acquisition time was not more than 18 min.

In the course of these live-animal MRI studies, we observed a Phrygian cap appearance to the gallbladder of one healthy-appearing 14-week-old male mouse, similar to that of the human gallbladder described in many reports (Figure 1A).

The mouse had an uneventful course, and recovered from isoflurane anesthesia without difficulty. On the same day, for measurement of bile acids, the gallbladder was dissected and examined using a dissecting lens. At surgery, the gross anatomical external and internal appearance of the gallbladder was entirely normal (Figure 1B), and not different from those of other mice in this study. These radiological and anatomical findings are entirely consistent with the Phrygian cap appearance of the gallbladder reported in humans.

Discussion

The term 'Phrygian cap' derives from headgear worn in Phrygia,

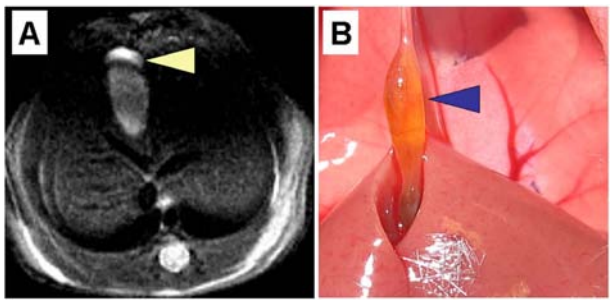

Figure 1: Magnetic resonance imaging of mouse gallbladder. **A.** Magnetic resonance imaging of the gallbladder revealed a Phrygian cap appearance (arrowhead). **B.** Post-imaging dissection of the mouse revealed a normal gallbladder without septae (arrowhead).

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an ancient land in the area that is now Turkey. Its capital, Gordium, was located not far from the Turkish capital of Ankara. Circa 695 BC, after invasion by Indo-European nomads, Phrygia ceased to exist as a kingdom. The Phrygian cap was not unique to ancient inhabitants of this land; it was worn by Iranian tribes, Cappadocians, Scythians, and other inhabitants of central Asia. Later, this cap, worn by freed slaves in Rome to announce their status, became associated with liberty; it was last worn by the sans-culottes during the French Revolution ('le bonnet rouge'). It is perhaps, best known today as the cap worn by cartoon Smurfs.

The Phrygian cap appearance to the gallbladder has been reported in up to 6% of human gallbladders imaged by oral and intravenous cholecystography, B-mode ultrasound, computerized tomography of the abdomen and magnetic resonance imaging [1-5]. Septated gallbladders, a form of congenital malformation, are associated with pathology [6]. Nonetheless, although once thought to represent a transverse congenital septum in the gallbladder fundus associated with gallbladder pathology, including calculi, torsion, diverticulosis, adenomyosis, duplication, tumor, and others, this appearance is now recognized as simple anatomical folding of the fundus, without clinical significance [1,4,7-11].

In non-humans, the Phrygian cap appearance has been reported in rhesus monkey and cat gallbladders [12,13]. To our knowledge, ours represents the first report of gallbladder imaging with a Phrygian cap appearance in a mouse. As in humans, this is likely is of no clinical significance; gallbladder dissection in our mouse revealed a normal mucosal appearance without septae. Based on these findings, we believe that, as in humans, the Phrygian cap appearance to the mouse gallbladder should be considered a normal anatomical variant that is not indicative of gallbladder pathology.

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Conflicts of Interest

The authors report no conflicts.

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