Magnetic Resonance Microscopy of Blood Digestion in Ixodes scapularis

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Introduction

Ixodes scapularis are found in the eastern and upper midwestern parts of the United States and are known vectors of several diseases including Lyme disease. As Lyme disease continues to spread, improving the available control measures becomes more urgent and developing new techniques to probe a tick's blood digestion is an important step towards that goal. A better understanding of blood digestion could lead to developing new acaricides that inhibit digestion or reduce the number of eggs produced. Because magnetic resonance microscopy (MRM) is non-invasive and does not involve harmful doses of radiation or chemicals, it is a promising technique for serial investigations of *in vivo* blood digestion. When feeding on a host, *I. scapularis* ingests up to 100 times its unfed bodyweight in blood. Once completely fed, or engorged, the tick drops off its host and spends up to a month digesting its blood meal. To date, there are no methods to directly investigate blood digestion *in vivo*; however, our use of MRM to study respiration and circulation in an insect (1) suggested that blood digestion could be monitored. Here we report the promising results of the first MRM experiments to examine blood digestion in ticks.

Materials and Methods

Several *I. scapularis* nymphs were generously donated by Dr. Thomas Mathers (University of Rhode Island). They were fed on guinea pigs for several days before being removed for MR imaging experiments. The nymphs described in this abstract were almost fully engorged when removed. The nymphs were stored at room temperature in the dark for the duration of the studies. MRM experiments were performed using a Bruker 500 MHz instrument operating at a magnetic field of 11.7 T with resonance frequencies of 500.15 MHz (^{1}H). Images were obtained using a commercial Bruker probe fitted with a 5 mm solenoid coil. T1W images were acquired using a standard spin echo sequence (α=90°, TE=15ms, TR=500ms). The images had a field of view (FOV) = 3mm x 3mm, matrix = 64 x 64 (yielding a 47µm in-plane resolution), and slice thickness = 250µm.

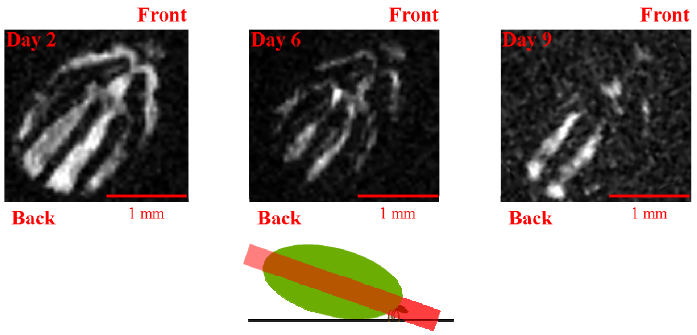

Figure 1. Serial T1-weighed images obtain for the same nymph tick. The location of the coronal slice was midway between the top and bottom of the tick as shown in the bottom cartoon. The front of the tick points towards the upper-right and the back of the tick points towards the lower-left. Left: Image obtained two days after the tick finished feeding. The image was obtained in ten minutes. Middle: Image obtained six days after the tick finished feeding. The image was obtained in ten minutes. Right: Image obtained nine days after the tick finished feeding. The image was obtained in forty minutes.

Results & Discussion

Figure 1 shows serial T1-weighted (T1W) images of an almost fully-engorged nymph tick (*I. scapularis*). As shown in the left image, two days after the tick finished feeding the entire digestive system appears bright, and is the major organ observable in the image. Six days after feeding, the digestive system is still visible, but is less intense. Nine days after feeding, only a portion of the rear digestive system is observable in the T1W image. These images demonstrate the feasibility of using MRM to investigate blood digestion in ticks; additional investigation is required to understand the source of these intensity changes.

Our hypothesis is that the digestion of the hemoglobin is the primary cause of the intensity changes show in Figure 1. During blood feeding, ticks ingest large amounts of iron-containing hemoglobin. Hemoglobin is a major protein in blood and iron is known to alter the intensities in MRM images. ***In conclusion***, these results are the first to show the potential of using MRM to monitor blood digestion in ticks. By using an *in vitro* feeding system (2), we will try to identify the causes of these changes as well as determine the effect of infection and acaricides on feeding and engorged ticks using MRM.

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References

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