Morphologic and Perfusion Imaging of Tarantulas

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Introduction

Tarantulas (*Eurypelma californicum*) are robust and, when being cooled, are easy to handle and do not require anesthesia. Furthermore, the structure of the tarantula's morphology is clear and non-complex, making them a well suited subject for the evaluation of new investigative MR techniques.

The aim of this study was to evaluate the feasibility of *in vivo* MRI of tarantulas using readily available MRI equipment, such as a 1.5 Tesla whole body MRI system, to obtain morphological and perfusion information.

Materials and Methods

We studied three tarantulas (i.e. *Eurypelma californicum*), which were cooled in order to slow down the hemolymph (blood equivalent) circulation and to prevent a defense reaction during handling. The spiders have an anterior body part (prosoma) and posterior body part (opisthosoma), which are connected by a narrow stalk (peduncle). Leg movement is achieved by basal located muscles and hydraulic systems (hemolyphatic pressure), which require a temporary constriction of the peduncle.

All MRI examinations were performed using a whole-body 1.5 T scanner (Magnetom Vision Experimental, Siemens, Erlangen, Germany), equipped with prototype gradients (50-58 mT/m, 160 mT/m/ms), using a small loop coil. Morphologic images were acquired with a spin echo sequence (FOV: 50 mm, RFOV: 5/8, matrix: 256 x 160, resolution: 0.20 mm) T1-weighted (TR: 640 ms, TE: 14 ms, BW: 89 Hz/Px, slice thickness: 1 mm) as well as T2-weighted (TR: 7000 ms, TE: 45 ms, BW: 78 Hz/Px, slice thickness: 2 mm). Sets of three to thirteen slices were acquired in different orientations, before as well as after contrast media (CM) injection.

The sequence used for dynamic imaging was a T1-weighted rapid spoiled gradient echo sequence (SR-TurboFLASH, FOV: 70 mm, RFOV: 5/8, matrix: 256 x 160 interpolated to 512 x 320, slice thickness: 3 mm, TR: 11 ms, TE: 4.2 ms, TI: 600 ms, FA: 15°, resolution: 0.27 mm). 128 images per slice were acquired over a period of 5-6 minutes during and after contrast media injection for three image slices. Contrast media (0.2 ml Gd-DTPA, Magnevist, Schering Berlin, diluted with saline at a ratio of 1:4) was injected manually via an indwelling venous catheter into the opisthosoma dorsal at the posterior end.

From the dynamic image series signal intensity time curves (STC) were extracted on a pixel-by-pixel basis and a pharmacokinetic two-compartment model [1] was fitted to the STCs using a nonlinear least square algorithm [2]. The model parameters *A* (correlated with extracellular space), *k21* (correlated with vessel permeability/surface), and *t0* (start time of signal increase) determined, as well as the descriptive parameter *TTP* (time-to-peak). These were depicted in color-coded parameter maps.

Results and Discussion

In the morphologic MR images internal organs were be well delineated, as demonstrated in the example of a sagital image (*Fig. 1*) showing mainly the posterior body part. The position and size of these organs agreed well with published schematic diagrammes of the spider's anatomy [3]. The pharmacokinetic analysis was capable of showing the regional distribution of volume available for contrast media and distribution velocity, which were in excellent agreement with expectations (e.g. high distribution rate in the prosoma).

Fig. 1: Morphologic sagital image (t1-w, post-CM) of the posterior body part.

Aside from the tissue perfusion characteristics, transient variations of hemolymph circulation were visualized, as can be seen in the examples of *t0* parameter maps in *Fig. 2* (with and without hemolymph restriction). Stress, here due to the injection, caused the tarantula to move into a defense position, which requires the hydraulic systems. From the comparison of parameter values in prosoma and opisthosoma it was evident that one tarantula had been measured in a *'relaxed'* state, i.e. the peduncle was not constricted, and another tarantula in a *'stressed'* state, i.e. with peduncle constriction (compare *Fig. 2* left and right parameter map accordingly).

During unrestricted hemolymph circulation the contrast media reached the anterior body part (prosoma) at approximately 0.7 – 1.5 minutes after injection (yellow to red in parameter map). Under stress, when the hemolymph circulation was restricted to the opisthosoma, the arrival of contrast media in the prosoma was delayed to approximately 1.7 – 2.5 minutes (magenta to blue in parameter map). As a consequence thereof, in almost the entire opisthosoma the signal increase due to CM was observed within the first minute. This hypothesis based on the *t0* data was further supported by the *TTP* maps. The preference of hemolymph supply to the prosoma during rest, as evident from the *t0* map, was shown for the first time.

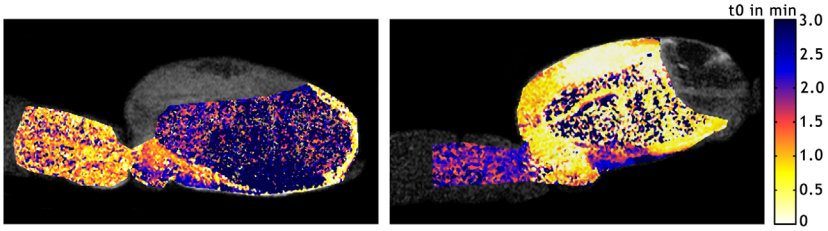

Fig. 2: Parameter maps of *t0* with normal circulation (left) and with hemolymph restriction due to stress (right). On the right the arrival of hemolymph in the anterior body part is delayed.

Conclusions

It was shown that with a standard 1.5 T MRI scanner it is possible to acquire morphologic images of a tarantula of sufficient resolution to depict the major organs, as well as dynamic image series of sufficient quality for pharmacokinetic analyses. This *in vivo* study provided novel physiological data that confirmed the function of the hemolymphatic system and the function of the peduncle, i.e. the temporary constriction of hemolymph supply to the prosoma. This investigation technique is therefore well suited for further studies of this kind, but may also aid in the preparation of high resolution experimental studies on special MR scanners, which are only available in a few locations.

References

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