fMRI in patients with lumbar radiculopathy

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Introduction: fMRI studies have made significant contributions to the understanding of how the brain processes pain. However, most of the studies have involved either normal subjects subjected to painful stimuli during fMRI or patients with chronic pain subjected to nonpainful or painful stimuli. Studying patients with acute pain has been difficult because of the difficulty in altering the patients painful experience during fMRI and motion artifacts. Back pain with radiating leg pain (radiculopathy) resulting from a herniated lumbar disc is a common clinical pain syndrome. The severity of the pain can be altered by relatively simple maneuvers. These include elevating the painful leg (straight leg raising), dorsiflexion of the foot on the painful side, valsalva maneuver (holding one's breath) and tensing the muscles of the painful leg. The question remains whether the change in pain perception by the patient during these maneuvers can be imaged with fMRI and whether or not motion induced by these maneuvers will make the fMRI studies uninterpretable.
We elected to study patients with back pain and radiculopathy from a herniated disc at the L4-5 or L5-S1 levels using the above methods of attempting to alter the pain perception (Both levels cause a similar distribution of pain radiating down the back of the leg,) to determine if we could reliably obtain fMRI images when the patients pain scale rating changed during the maneuvers.

Methods

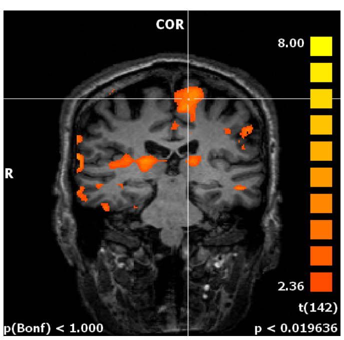
Lumbar radiculopathy patients were imaged in a 3T Siemens Allegra scanner using a single channel quadrature coil. The subjects signed a written consent form approved by the local IRB. A Block design was used for fMRI stimulus design. The blocks consisted of 20s task and 20s rest. Task included breathhold, dorsiflexion of right foot, muscle tensing of right foot, and right leg raise. A T2 *-weighted EPI sequence (TR/TE/FA = 2000ms/30ms/77°) was used to acquire whole brain volumes (32 slices) at a voxel dimension of 3.8x3.8x4. High resolution T1-weighted anatomical images were acquired with an MPrage sequence.

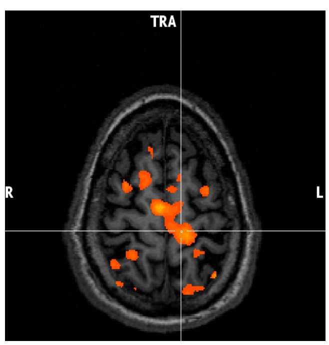
Analysis

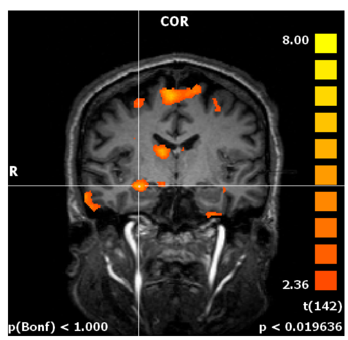
fMRI data were analyzed using Brainvoyager QX. The standard sequence of preprocessing steps were performed for the fMRI data, including slice scan time correction, high pass filtering and spatial smoothing. 3D head motion correction was performed to detect and correct for small head movements. Estimated translation and rotation parameters were inspected. The anatomical data was corrected for spatial intensity inhomogenities. The data was then resampled to 1 mm resolution and transformed into ACPC and Talairach standard space. The fMRI data was co-registered with the subject's 3D anatomical data and then normalized so that the analysis could be done in the talairach space. For each subject block data, a Brainvoyager protocol file was derived representing the onset and duration of the tasks for the different conditions. In order to account for hemodynamic delay and dispersion, each of the predictors was derived by convolution of an appropriate boxcar waveform with a doublegamma hemodynamic response function. Using hypothesis driven, voxelwise standard analyses (GLM), we tested for overall task related effects.

Results

Figure 1a, 1b, 1c and fig 2 summarize the main results of the hypothesis driven GLM analysis. Significant effect of pain from right leg raise was seen in the thalamus and the amygdala. Figure 1a and 1c show the activations in the thalamus and the amygdale regions respectively. Figure 1b shows the cerebral motor activation in the left motor cortex due to the right leg raise maneuver. Figure 2 shows no thalamus activity during the task which caused no pain.







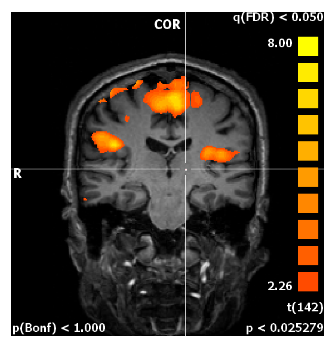


Fig 1a Thalamus activity during pain. Fig 1b motor activity during right leg raise. Fig 1c Amygdala activity during pain. Fig2 no thalamus activity

Discussion

After inspecting the motion files from the fMRI data, we determined that the maneuvers we used to induce differential pain in the block design did not create motion artefacts that prevented analyses and interpretation. Any motion that was present was easily corrected by motion correction algorithm in Brainvoyager. Thus, we are now confident that these maneuvers can be used in the block design for the fMRI experiments to study acute pain. In terms of data analysis, we observed cerebral activation in the thalamus and the amygdala during maneuvers that elicited pain. During no-pain maneuver there were no activations in those regions.

References

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