Objective

Product preoperatively to allow which direct stimulation therapy
(NaivePre™) can propagate through the maximum extent of an epileptic circuit through pathological white matter.

Methods & Results

1. MRI and DTI Sequences

A. SISCOM was used to locate the ictal onset zone.

B. Fractional Anisotropy (FA) was computed in interictal and post-ictal sequences. The results were subtracted. A threshold of 0.3 std dev from the mean was used to identify regions with significant changes in FA (see boxes).

2. SISCOM and spDTI (Visualize Epileptic Circuit)

A. SISCOM was used to locate the scalp-orientated zone.

B. Anatomical Information (FA) was computed in interictal and post-ictal sequences. The results were subtracted. A threshold of 0.3 std dev from the mean was used to identify regions with significant changes in FA (see boxes).

3. 3D Segmented Model

A. The SPGR MRI was used to create a 3D brain model.

B. Three segmented compartments were considered within this model: Grey matter, White matter and CSF.

4. Depth Lead Placement

A. A CAD electrode model that consisted of 4 conductive cylinders separated by insulators was placed in white matter near the white-grey matter interface, in regions identified by spDTI.

5. Simulate Electric Stimulation to Calculate the Electric Potential (EP) and E-Fields

The FEM mesh was used to compute a static EP when a bipolar stimulation of 4.3mA was applied in an isotropic conductive medium comprising 3 segmented compartments. Isotropic conductivities were assigned:

\[
\begin{align*}
\text{WM} &= 0.15 \, \text{S/m} \\
\text{GM} &= 0.06 \, \text{S/m} \\
\text{CSF} &= 1.79 \, \text{S/m}
\end{align*}
\]

6. Activation Function

The neural response to E-fields is related to the second derivative of the EP and to the axon direction.

\[
\nabla \text{EP} = \mathbf{E} = \mathbf{FDD} \cdot \hat{n}
\]

The first directional derivative (FDD) is equal to the scalar product of the gradient of EP and the axon direction.

\[
\nabla \text{EP} = \mathbf{FDD} = \nabla \text{EP} \cdot \hat{n}
\]

Bipolar stimulation in a sagittal slice of the temporal depth electrode showing the E-field lines exit an hyperpolarized or depolarized region.

7. 1. Effect of Axon Orientation in SDD

The red arrow represents the axon direction that was used to calculate the SDD in a segmented model to investigate the effect of axon orientation in the generation of regions of depolarization and hyperpolarization.

8. Identify Influenced Tracts (MCT Maps)

Regions of depolarization and hyperpolarization were used to identify influenced tracts using topography.

References


Funding Sources

RUMC (institutional) & Samsung-NeuroLogics Corp

Conclusions

This simulation demonstrated the potential of a new depth electrode planning software which combines the analytical model with a validated computer simulation tool for predicting "best-fit" field patterns. This software allows for the optimization of the activation function (A) and the treatment of an epileptic circuit by generating regions of depolarization and hyperpolarization in the brain tissue adjacent to the electrode.

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