2022

MRI Guided NeuroBlate Laser Ablations

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Introduction

- Magnetic resonance imaging (MRI) utilizes the alignment of hydrogen atoms either in the X,Y, or Z axis in the body creating a chemical effect. An MRI scanner does not contain ionizing radiation, but utilizes a strong magnetic field to align these atoms. Radiofrequency signals are used to acquire cross-sectional images of the body in a sagittal, coronal, & axial view.
- MRI has the ability to finely distinguish fluid and tissue within the body ultimately leading to clear diagnoses. Contrast known as Gadolinium (Gadovist) is used to enhance area of interest.
- "MRI sequences almost always comprise T2-weighted, T2-FLAIR (fluid-attenuated inversion recovery) and T1-weighted pre- and post-contrast sequences. T2-weighted and FLAIR images are most valuable for estimating macroscopic tumor boundaries: FLAIR increases the overall contrast between the tumor and normal brain tissue" (McNamara, Brandner, & Thrust, 2020, p. 31)

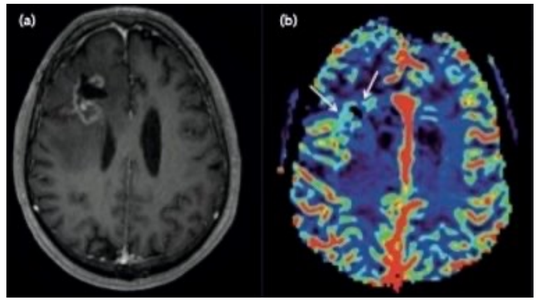

Fig 1. Perfusion MRI to see neovascular tumor (McNamara et al., 2020, p. 31)

Laser Interstitial Thermal Therapy (LITT)

- LITT therapy is a non-invasive procedure to treat several intracranial pathologies
- Ablation, or removal using heat from a laser "has superior precision and predictable volume of tissue ablation thus avoiding collateral damage ". Laser is applied to the region of tumor and kept within 50ºC and 80ºC for tumor necrosis, death.
- Tumors are cooled with a CO2-cooled side-firing probe or diffusion tip probe.
- LITT system comprises of a laser system, workstation, & MRI scanner. Two types of laser ablation systems include Visualase & NeuroBlate. (Salem et al., 2019, p. 2)

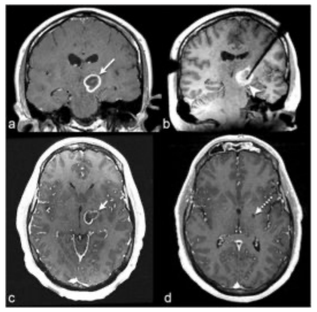

Fig 2. Patient with brain metastasis treated with LITT (Salem et al., 2019, p. 7)

Equipment for LITT

- Comprises of a laser light source, laser fibers, applicator, sheath & diffusion tip. Cooled tip is most commonly used for LITT, allowing the ablation to last longer and at higher temperatures.
- Workstation provides real time mapping during procedures to estimate tissue necrosis. NeuroBlate systems have a probe that determine baseline temperature of the brain while regulating CO2. (Salem et al., 2019, p. 3)

Fig 3. Depiction of optical fiber, ablation process, and pre-/ post-ablation MRI images in an axial plane demonstrating focal nature of damage zone (Drane, 2018, p. 2)

MRI Guided Laser Ablations

- Been available for several years and focused on cognitive outcome observed using MRI guided stereotactic laser ablation (SLA) systems. (Drane, 2018, p. 1)
- Patient is under general anesthesia and put into lateral, supine, or prone position depending on the location of tumor. A "burr hole" is made and filled with a stereotactic bolt for entry of laser probes.
- 3D T1- weighted fast spoiled gradient images are obtained to show full length of probe. T1 or T2 FLAIR images are taken for anatomical reference.
- Appearance of ablated lesion can be seen on MR images up to 3 months following the procedure. (Salem et al., 2019, p. 3)

Advantages: MRI Guided Laser Ablations

- Creates alternative treatment if pathology cannot be accessible by surgery. Potentially reduces pain since craniotomy, surgical opening of the skull & brain tissue will not been performed.
- LITT procedures can be used for other pathologies such as glioma, brain metastases, radiation necrosis, & epilepsy. Technique is "safe and effective" showing promising results. "In the past few years, stereotactic laser ablation (SLA; also known as laser interstitial thermal therapy) been employed to treat MTS in place of open procedures" (Sperling et al., 2020, p. 1184).
- Lesions within the central and peripheral zone will increase, but quickly decrease in size two weeks after ablation. (Salem et al., 2019, p. 5)
- Showed no signs of declining cognitive functions such as naming man-made objects and/or famous people post-surgery. (Drane, 2019, p. 2)

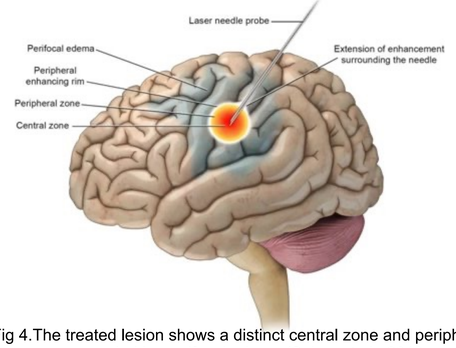

Fig 4.The treated lesion shows a distinct central zone and peripheral zone surrounded by perifocal edema (Salem et al., 2019, p. 4)

Blood-Brain (BBB)/Blood-Tumor Barrier (BTB)

- These barriers presents challenges in treating glioblastomas as they restrict most drugs. Standard of care drug blocked is Temozolomide.
- Experiment was conducted to demonstrate ability of LITT to improve permeability of drugs to treat glioblastomas, common malignant tumors that leads to epileptic & seizure episodes.
- Experiment was carried by injecting tumor cells into animals and left to grow for 7-10 days.
- Laser treatment undergone for 3 minutes for tissue temperature of 43° Celsius (109.4ºF).
- MRI was utilized to demonstrate necrosis, or tissue death.

- Fig 5. shows laser treated tumors demonstrating greater degree of permeability.

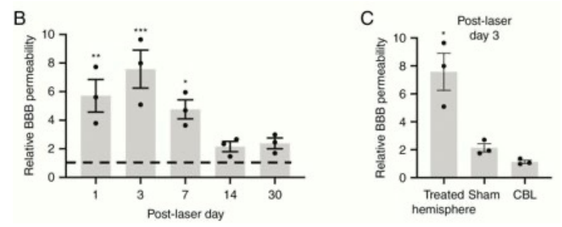

Fig 5. LITT demonstrating permeability of BBB/ BTB (Salehi et al., 2020, p. 5)

Indications and Contraindications

Indications:

- Recurring glioblastomas, such as tumors and necrosis that can be repaired invasively.

Contraindications:

- Patients having non- MRI compatible metal devices implanted, or could not be safely brought through scanner to apply laser probes
- Tumors close to spinal cord or blood vessels can present a greater risk for patients, "CSF spaces or a blood vessel close to the lesion can dissipate the heat away from the ablated lesion due to a heat sink effect. Although this effect can lead to incomplete ablation, it can also act as an insulator protecting a nearby vital structure from the thermal injury generated at the ablation zone." (Salem et al., 2019, p. 2)

Conclusion

- MRI guided Neuroblate laser ablations is a non-invasive alternative from open resection surgery.
- Post procedural outcomes such as diminished tumors & cognitive functions are more successful with LITT.
- Requires adequate communication from multiple parties such as MRI technologists, neurological surgeons, & companies that comprise laser systems. Ablated lesion can be seen on an MRI scanner, while the laser systems such as Visualase & NeuroBlate can see temperature of surrounding tissue.
- Workstation is able to pick up coordinates of glioblastoma to help guide neurological surgeons in ablating, or heating process. Patient would need to follow up with continuous brain scans to monitor size of lesion.

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