Annotated Bibliography

Biospace. (2020). *Monteris Announces FDA Clearance of Neuroblate Fusion-S Software*. Retrieved from https://www.biospace.com/article/releases/monteris-announces-fda-clearance-of-neuroblate-fusion-s-software/

I. This article discusses how Monteris Medical Incorporated announced on July 14th, 2020, that it has received FDA clearance of its Neuroblate Fusion-S Software and the latest innovation has now been used in over 200 cases. This software provides visualization for neurosurgeons to ablate brain tissue and tumors. It provides a highly intuitive and detailed visual representation of critical anatomical detail which allows for neurosurgeons to view brain structures throughout the procedure much easier. The safety features within the Fusion-S Software includes an unlimited number of temperatures pick points which can be set at any location to closely monitor the brain ablation process and avoid healthy structures of the brain. Procedure time can be reduced as well through fewer steps to increase workflow. This article also explains that unlike traditional surgery, Neuroblate uses a robotically controlled laser thermotherapy that directs an MRI-guided laser to destroy the lesion or abnormal tissue. A procedure done with this software does not require a large opening to be made in the skull. The surgeon will create a small hole in the skull. While the patient is in the MRI machine, the doctor will guide a probe through the hole. This precision will lessen the likelihood of harm to nearby healthy tissues. Compared to other treatments, Neuroblate is safe and cost-effective, allowing shorter hospital stays for patients, minimal pain, fewer complications, and short recovery. Approximately 3,000 procedures using this system have been performed at more than 80 hospitals in North America. This article also discusses where Monteris Medical came from and what it is about. It is a private company that develops and markets Laser Interstitial Thermal Therapy (LITT). The Neuroblate System is not used to treat any specific disease.

II. A strength of this article is that it provides images of 3D anatomical views and multiple screen configurations, which allows surgeons to see more of the procedure and execute it correctly. There is also an image with an example of what the temperature pick points look like as well as color display. A strength of this article is that it specifically states that the Neuroblate system is not used for any one specific disease. There are no signs and symptoms that would indicate this system being used, it is simply up to the doctor's judgement whether or not it should be used. A weakness of this article is that in the beginning of the article it says this system has been used in over 200 cases, but then at the end of the article, it says it has been used in over 3,000 cases, so I am unsure which one is true.

III. This article is useful for my poster project about Neuroblate Fusion because it shows that the Moneris system is not only used in the United States, but in Canada as well. This shows that other countries are updating their technology and are also trying to improve their patient care, giving them the best treatment possible.

Eldridge, L. (2020). *What Are the Options If Your Glioblastoma Recurs?* Verywell Health. https://www.verywellhealth.com/glioblastoma-recurrence-treatment-options-4784168.

I. This article discusses coping methods and treatment options for patients with recurrent glioblastoma. It includes treatment, clinical trials, and life expectancy. Even when it appears that the tumor has been eliminated, the chance of recurrence is still high and most likely to occur in most cases. There are relatively few treatment options when these cancers come back. Several new treatments have been approved, but because they are so new, it can be difficult to navigate the information and get early results. Without treatment, the median survival rate for glioblastoma is only a few months. Even with treatment, survival is typically only around 1 year. The 5-year survival rate is roughly 5.0%. If a patient has surgery to remove the tumor along with chemotherapy or radiation therapy, the average survival is still only about 14 months. The numbers are slightly more optimistic in pediatrics, with a 5-year survival rate of 17%. The growth rate of glioblastoma exceeds that of any other cancer. In one study, the growth rate of untreated glioblastomas was 1.4% per day. The tumor doubled in size in about 49.6 days. In comparison, a breast tumor can double in size between 50 and 200 days. Glioblastomas spread along the white mater tracts of the brain. This can make it difficult to assess how much the tumor has actually spread. Parts of the brain can't just easily be removed to treat a tumor like other cancers. The growth of a glioblastoma is often driven by several abnormal genes in the cancer cells. Trying to block one pathway is ineffective in controlling the growth of the cancer. Scar tissue in the brain can often be difficult to differentiate from recurrence of the tumor. An MRI brain perfusion can help in making the distinction, but they are not available at all facilities. The blood-brain-barrier (BBB) is a tight knit network of capillaries that help prevent toxins from reaching the brain. Unfortunately, the BBB can make it almost impossible for drug treatments, such as chemotherapy, to reach the tumor if given intravenously. There are a few treatment options for people suffering with glioblastomas. As shown in the survival statistics, few of these treatments have led to long term survival. Some treatments do improve survival and quality of life. Repeat surgery has been linked to better overall survival and can help to alleviate symptoms caused by the tumor. For people with recurrent glioblastoma who receive a checkpoint inhibitor, a type of immunotherapy, prior to their surgery, a 2019 study done linked this combination to a improvement in survival. In the study, 35 patients were treated with the immunotherapy drug, Keytruda, right before surgery. The results showed that the patients who took Keytruda survived about 13.7 months. Those who didn't take it only survived about 7.5 months. The combination of surgery and taking Keytruda almost doubled the survival rate. Tumor treating fields, also known as Optune, were approved for treating recurrent glioblastoma in 2011. The treatment uses low-intensity, intermediate frequency, alternating electric fields to interfere with cell division in cancer cells. The treatment, fortunately, has very little effect on normal, healthy brain cells. Optune was initially approved because it has fewer side effects than other treatments that offered similar improvements in survival. Optune has been found to have a benefit on survival as well. Tumor treating fields doubled one-year and two-year survival with recurrent glioblastoma with few side effects. Unfortunately, not everyone with recurrent glioblastomas are always made aware of this option. With Optune, small transducers are applied to the scalp and attached to a battery pack. The device must be worn most of the time to be effective, usually about 18 hours a day. Tumor treating fields may be used for tumors in the upper part of the brain, but not for

tumors in the back of the brain. In roughly 15% of patients, the tumor might appear to worsen before responding positively to the tumor treating fields. Immunotherapy is also a treatment option. Immunotherapy is a type of treatment that uses the immune system to treat cancer. There are, however, many different types of immunotherapy with a few options offering hope in treating recurrent glioblastoma. Re-treating with radiation may sometimes be helpful in improving both survival and quality of life with recurrent glioblastoma. Stereotactic body radiotherapy (SBRT) is a type of high-dose radiation delivered to a small area of tissue and may offer benefit with less radiation exposure. Chemotherapy may be used for recurrent glioblastoma. When chemotherapy has been previously used, either different drugs or higher doses of the previous drugs are often used. There are several factors that affect the life expectancy and prognosis of glioblastomas. They include age, performance status, tumor volume, location of the tumor, treatments used, amount of tumor that can be surgically removed, and timing of recurrence. Even with all of these factors, it is important to remember that every patient and every tumor is different. No cases are going to be exactly the same. Trying to cope with an aggressive cancer like glioblastoma can be lonely. Support is essential and patients have found support groups to be very helpful. Many people prefer an online support community for glioblastomas because it is not as common as other tumors.

II. A strength of this article is that it gives a lot of information on every treatment option for someone suffering with glioblastoma. This is a very informative article where someone recently diagnosed with glioblastoma can read and educate themselves on all of their options. It gives examples of some case studies that show how effective or ineffective each treatment can be. It also lists all the common signs and symptoms someone with a glioblastoma may be experiencing. One weakness of this article is that it never lists Neuroblate Fusion or laser therapy as an option anywhere. It is never discussed, which is a downside because that is what my project is mainly about. But, this article gave great information about the primary pathology of my poster.

III. This article is useful for my poster project because it discussed signs and symptoms of glioblastoma, treatment options, and life expectancy of this disease.

Montemurro, N., Anania, Y., Cagnazzo, F., & Perrini, P. (2020). *Survival Outcomes in Patients with Recurrent Glioblastoma Treated with Laser Interstitial Thermal Therapy (LITT): A Systematic Review*. [Clinical Neurology and Neurosurgery] 195, 1-5. Elsevier. doi:https://doi.org/10.1016/j.clineuro.2020.105942

I. This article discusses the outcomes of survival of patients with glioblastomas who undergo laser interstitial thermal therapy (LITT). Glioblastoma is the most common primary brain tumor in adults. Over the last 40 years of researching this disease, scientists and doctors still find the survival rate of patients with glioblastoma to be poor. The current treatment for glioblastoma is a gross total resection (GTR) followed by radiotherapy. LITT became a new minimally invasive treatment option for patients. LITT is a thermocoagulative therapy for cancer treatment that uses

laser energy directly into the tumor, causing tissue damage and necrosis. The real-time feedback of the thermal dose delivery enables the neurosurgeon to precisely control the damage against the tumor. Two of the most common LITT systems that have been used in neurosurgery includes the Monteris Neuroblate System and the Medtronic Visualase Thermal Therapy System. Due to the aggressiveness of this tumor, recurrence is inevitable and cannot be avoided. Currently, there is no standard treatment for recurrent glioblastomas. A Pubmed and MEDLINE search performed to gather articles that are relevant to LITT for recurrent glioblastomas from 2000 to present day. The inclusion criteria included a case series reporting patients with recurrent GBM treated with LITT. The exclusion criteria included review articles, single case report, case series reporting only other intracranial lesions or newly diagnosed GBM treated with LITT, case series where it is not possible to extract data of recurrent GBM patients, case series on the same data set, and studies with insufficient data. The database originally found 71 articles, but only 39 articles were eligible for screening. Only 17 of the articles found met the criteria with a total of 203 patients with recurrent glioblastomas, who underwent 219 LITT procedures. In approximately 23.1% of patients, recurrent GBM was located in the midline of the brain. The morbidity rate was only 6.4% with an average hospital stay of 3 and a half days. The most common complications found were seizures, motor deficits, wound infection, transient hemiparesis, and hemorrhage. There were zero deaths reported related to the LITT procedures. There are several clinical studies that support the value of aggressive intervention for recurrent glioblastomas. More recent studies described the results of LITT as a direct treatment in patients with far progressed, newly diagnosed GBM and in patients with recurrent GBM that are not candidate for a second surgery. The average overall survival (OS) rate after the initial diagnosis was 14.7 months. The average OS after LITT treatment was 10.2 months. The data shows that there is a slight decrease in the OS after the second treatment. In this study, the average progression-free survival (PFS) after surgery in patients with recurrent GBM treated with LITT was slightly lower compared to other current studies on repeat surgery in GBM patients. This is most likely due to 23.1% of patients treated with LITT had lesions in deep structures such as the thalamus, basal ganglia, and midbrain. In these sections of the brain, GTR can be difficult and is typically not achieved during the first surgery. Advantages of LITT include minimal invasiveness and the possibility of treating deep lesions. The three major factors that need to be considered when LITT treatment is being planned are location, size, and shape of the tumor. Adverse lesions for LITT include hypervascular, diffuse neoplasms involving bilateral or multiple lobes, or extremely large tumors in which treatment wouldn't result in a full resection. Size is the most important criteria. Medical professionals suggest that the maximum target diameter should not be greater than 3 cm when using a single laser.

II. A strength I found in this article is that it gives examples of lesions that would be contraindicated for receiving LITT treatment. It is important to know that not all brain lesions or tumors can be treated with laser therapy. Another strength of this article is that it explains the importance of knowing the location, size, and shape of the lesion. If the lesion is in a difficult location and is surrounded by important anatomy, then the procedure is too risky for the patient and may cause them further damage. Size is the most significant criteria in the decision to use LITT. A weakness of this article is that it says that the two most common and commercially available LITT systems are Monteris Neuroblate and Medtronic Visualase Thermal Therapy, but

it doesn't specifically say which ones were used in the research articles that were found. Since my entire research project is based on the benefits of the Neuroblate Fusion, it would be beneficial to know if a majority of the LITT procedures were done on the Monteris system or not.

III. This article is useful for my poster project because it discusses how common it is for glioblastomas to become recurrent after undergoing a first surgery and how it is more successful after a second one with LITT. This article is also useful because it talks about the survival rates in patients being treated with LITT and how successful it is for them. This article includes the clinical advantages of LITT compared to other methods of treatment. This is also useful because it provides me with indications and contraindications for getting Neuroblate Fusion.

Monteris Medical. (2021). *A Minimally Invasive Procedure: Neuroblate Procedure*.

I. This website discusses how Neuroblate is a minimally invasive surgical tool that uses robotic control, laser technology, and real-time MRI thermometry. The plan and access section of this website explains how the Neuroblate system will be chosen. Prior to the start of the procedure, the neurosurgeon plans the surgical approach with their preferred stereotactic platform. Based on the intended location and size, they then choose either the Neuroblate directional probe or the diffusing tip probe. The next section is a patient transfer section. The patient's head needs to remain stabilized and is then transferred to the MRI department. As an alternative, an intra-operative MRI can be used. The third section that this website discusses is the procedure itself. The surgeon accurately places the probe and uses the system to deliver laser energy to the intended area with the tumor or lesion. Under MRI-guidance, the ablation is monitored throughout the procedure. If necessary, more than one trajectory can be made using a single laser probe. The fourth section on this website is the post-procedure. Neuroblate is a minimally invasive procedure and is generally tolerated very well by patients. Most patients tend to go home with only 1-2 stitches and the recovery time is short. Lastly, the website explains how Monteris provides neurosurgeons with the technology to be able to ablate brain structures. Ablate is defined as the surgical removal of body tissue by destroying with heat or cutting the diseased tissue. It also explains that all brain surgeries carry a risk with them. Some of the possible adverse advents include hematoma, edema, bleeding, CSF leakage, infection, and so on.

II. A strength of this website is that it gives a list of possible adverse events that may occur, even when using the Neuroblate Fusion system. Just because Neuroblate is less invasive than traditional brain surgery, doesn't mean that there aren't any risks involved with this procedure. I like that this website gives some examples and makes patients aware that there is a chance something can still go wrong. This website also included a video that visually demonstrates how the probe is inserted into the small hole in the patient's skull and into the area of concern. It then shows how the laser ablates each section of the tumor or lesion section by section. A weakness of this website is that it isn't peer reviewed or a research-based source but it is the Monteris website.

III. This website is useful for my poster project because it provides different sections and explains the steps of plan and access, patient transfer, the procedure, and post-procedure protocols when using the Monteris system. This website is also useful because it is the first one I found about Neuroblate that defines what ablate is.

Newman, L., Ellin, A., Raeburn, P., Newman, L., McCoy, K., Calabro, S., & Rothman, J. (2018). *What Are the Signs and Symptoms of Glioblastoma?: Everyday Health.* EverydayHealth.com. https://www.everydayhealth.com/glioblastoma/symptoms/.

I. This website discusses the common signs and symptoms of having a glioblastoma. Glioblastomas can cause symptoms such as seizures and headaches by putting pressure on certain areas of the brain. Glioblastoma is a type of tumor that begins in the brain or spinal cord. This is considered a primary tumor because it originates in the brain. Other cancers such as breast cancer are considered secondary tumors because it can potentially end up spreading to the brain or other organs. The brain controls many functions throughout the body that sometimes symptoms begin to manifest far away from the brain. Symptoms relate to the location of the tumor, increased pressure on parts of the brain near the tumor, and size of the tumor. As the tumor grows, the symptoms will multiply and worsen. If a patient with a glioblastoma has surgery, radiation therapy, or chemotherapy, some symptoms may improve, but other symptoms may emerge related to the side effects of the treatment. For a newly diagnosed glioblastoma, the most common symptoms include headaches with nausea and vomiting, seizures, balance difficulties or loss of coordination, visual problems, speech abnormalities, and difficulty walking because of weak limbs. Headaches in glioblastoma patients are much different compared to a headache anyone gets. The pain begins when you wake up in the morning and is very persistent. It does not feel like a migraine and vomiting may occur along with the headache. Throbbing may be present and the pain will get progressively worse with coughing, exercise, or a change in body position. Common headache remedies are not helpful in alleviating these symptoms. Understanding the pattern of a headache is important. The patient's neurologists needs to be aware of the issue so the proper medicine can be prescribed. Keep a headache journal that tells the location of the headache, time of day of the headache, and degree of pain. Immediately call 911 if the headache is accompanied by a fever or a stiff neck. Seizures occur in about 60% of patients with brain tumors. Some signs of seizures in people with brain tumors are short duration (between 2-3 minutes), sudden onset, loss of consciousness, twitching and muscle contractions, tongue biting, 30-second periods of not breathing and possibly turning blue, or losing control of bodily functions such as urination or defecation. Seizures often come with no warning, but if a person feels one coming, they will experience an "aura" of sensations such as blurred vision, flashing lights, numbing, or speech difficulty. Watching someone have a seizure can be scary, but there are things you can do to help. It is important to avoid panicking because many seizures will stop on their own. You should check to see if the person is breathing, remove any sharp or dangerous objects that may be near them, make sure their head doesn't hit anything, don't put anything in or near their mouth, and do not attempt to restrain them. After a seizure, make sure to put the person on their side and make sure their airway is open. When they reorient, the person

may not remember what happened and you should encourage them to rest. Be sure to also keep track of the symptoms of the seizure. Call 911 if the seizure lasts more than 5 minutes, their breathing stops, the person injured themselves while seizing, the seizure happened in water, or if a second seizure occurs shortly after the first one. Memory loss is a common symptom of having a glioblastoma. It can be related to the cancer or the treatment. Short-term memory problems interfere with daily living. It is important to get a lot of sleep, reduce stimulation and noise, eat healthy, and drink fluids. Many patients with brain tumors also experience depression. Depression occurs in more than 25% of brain tumor patients. Personality and behavioral changes are also common.

II. A strength of this website is that it explains how glioblastomas are considered primary tumors because they begin in the brain. It also explained the difference between primary tumors and secondary tumors. Secondary tumors, such as breast cancer, start in one area and can spread to other areas of the body as well. This article also explained that because the brain is the main control of all functions in the body, symptoms of a brain tumor can occur anywhere in the body. I think this article is very useful for my poster and I didn't find any weaknesses.

III. This website is useful for my poster project because it goes into great detail of all the signs and symptoms that can occur if someone may have a glioblastoma.

Rennert, R. C., MD, Khan, U. MD, PhD, Bartek, J. Jr., MD, PhD, Tatter, S. B., MD, PhD, Field, M., MD, Toyota, B., MD, Fecci, P. E., MD, Judy, K., MD, Mohammadi, A. M., MD, Landazuri, P., MD, Sloan, A. E., MD, Kim, A. H., MD, Leuthardt, E. C., MD, Chen, C. C., MD, PhD. (2019) *Laser Ablation of Abnormal Neurological Tissue Using Robotic Neuroblate System (LAANTERN): Procedural Safety and Hospitalization, Neurosurgery*. 86 (4), April 2020, Pages 538–547, https://doi.org/10.1093/neuros/nyz141

I. Stereotactic laser ablation (SLA) is another name for laser interstitial thermotherapy (LITT). The probe laser activation triggers thermocoagulation and tissue destruction in the area of interest. Thermocoagulation is monitored under real-time MR thermometry to minimize the risk of injury to the surrounding cerebrum. Data shows the safety and clinical efficacy of SLA as treatment for a numerous amount of neurosurgical pathologies. Data is often skewed by various forms of biases. To address these problems, a multi-institutional study was done to track, analyze, and report patterns of use and outcomes for patients undergoing intracranial SLA. Indication, safety, efficacy, and quality of life were recorded on a population of 1,000 SLA patients. More than 15 medical facilities participated in this research study. Data of pretreatment parameters, postoperative neurological condition, length of intensive care unit stay, length of hospital stay, complications and discharge location were all collected. The laser ablation of abnormal neurological tissue using robotic neuroblate system (LAANTERN) study was designed to identify complications that occur at greater than 0.1% frequency. Patients will briefly undergo general anesthesia and are pinned with an MRI-compatible head frame. The patient is positioned, and an MRI visible grid is used to localize the entry point. An MRI-compatible stereotactic

targeting cannula is aligned to the specific trajectory. Other clinical variables were collected such as age, Karnofsky Performance Status (KPS), post-procedure KPS, any previous surgeries or radiation treatment, number of lesions treated, any biopsies performed prior to SLA, reason for surgery, how much of the lesion was ablated, total procedure time, total time spent in the ICU, medical conditions, and any post-procedure morbidities. Any adverse events (AEs) occurring within 30 days of the procedure were examined. Each AE could contain 1 or more complication and were later broken down into more specific complications. AEs were classified by medical AEs, AEs related to surgical manipulation and the known risks of biopsy, and Aes likely related to thermocoagulation injury by laser. If SLA wasn't available, an open craniotomy would have been the approach used. This study was mainly interested in comparing the safety of SLA compared to an open craniotomy. The demographics of the first 100 LAANTERN patients were recorded. There were 58 males and 42 females with an average age of 51. A majority of the patients, about 79%, underwent SLA for a single lesion through a single burr hole. About 66% of patients had a lesion biopsy immediately after their SLA procedure. Greater than 90% of the lesion was ablated to the "blue" thermal line, which indicates regions of irreversible damage, in 72% of treated lesions. Almost 25% of patients spent no time in postoperative care. Regarding discharge, 84.8% of patients went home, 7.6% went to a rehabilitation center, 4.3% went to a skilled nursing facility, 1.1% of patients were transferred to another acute care hospital, and 0% went to hospice. At the 1 month follow-up, there were 11 AEs recorded in only 9 of the patients. There was 1 patient death that occurred within the 30 day postoperative period, due to a intraventricular hemorrhage. It was noted after the biopsy, but before SLA was done, so they death was not caused by complications from the laser. AEs 4 and 6 were due to surgery, not the SLA because the target site was located more than 2 cm away from the site of the subdural hematoma. AE 9 was due to surgical manipulation since the infectious risk for these procedures is derived from skin entry. Energy deposition from laser ablation most likely contributed to 5 of the AEs. AE 10 was a delayed intraparenchymal hemorrhage and it was unknown whether it was a result of the disease progression or contribution from the laser. The safety of this procedure appears to be favorable, with only 4% related to surgical manipulation and 5% related to laser ablation. Nearly half of the lesions treated were considered difficult to access through conventional surgical approaches. The complication rate is lower than that reported for craniotomies. The average blood loss was also insignificant in SLA due to the minimally invasive nature of this treatment. It had been previously reported that rapid disease progression adjacent to ablation sites had been reported in glioblastoma patients who went through SLA but had failed to respond to previous chemotherapy. It should be communicated to patients looking to receive SLA that there will be a higher success rate only if the tumor responds to chemotherapy or radiation therapy prior to the laser treatment.

II. A strength of this research article is that in the first paragraph, it explains how the laser probe works with breaking down the targeted tissue. This is the first article I found about Neuroblate that includes details about how the laser activates thermocoagulation and focuses the tissue destruction. Thermocoagulation is causes localized tissue damage by exposing the tissue to electric current. The current creating heat which damages individual cells in the area of interest and impairs their function, causing them to die. Another strength of this article is that the study uses the Karnofsky Performance Status Scale (KPS) to assess patient. The KPS is an assessment

tool for functional impairment. It can be used to compare effectiveness of different types of therapy and assesses the prognosis in individual patients. The lower the score, the worse the likelihood of survival is. This is an effective assessment to perform on patients before and after a procedure, to record any changes. A third strength of this article was that the study included any adverse reactions and complications that occurred. This data was significant in helping prove the safety of this procedure. A weakness of this article is that there was some disease progression within the 30 days after SLA. This is a reminder that Neuroblate should not be misrepresented as a cure for tumors beyond what is visualized on an MRI. Complications can still occur even though it is a safer alternative to a craniotomy. Another weakness of this article is thar the study didn't really address the patient's quality of life after getting the procedure or the impact of the underlying disease process.

III. This article is useful because it explains how the laser works to break down tissues and discusses what thermocoagulation is. It also discusses the types of adverse events that can occur and the results showed that a majority of the adverse events didn't directly result from the laser therapy.

Schmitt, J. E. & Stein, J. M. (2016). *Chapter 7: Radiographic Detection and Advanced Imaging of Glioblastoma*. Glioblastoma E-book (pp. 81-100) Elsevier. Retrieved from file:///C:/Users/agold/Downloads/Glioblastoma_E-Book_----_(_Chapter_7_-_Radiographic_Detection_and_Advanced_Imaging_of_Glioblasto...).pdf

I. This article discusses and compares the usefulness of both computed tomography (CT) and magnetic resonance imaging (MRI) for detecting glioblastomas in the brain. While CT lacks the soft tissue detail that MRI offers, it is still better at showing bony anatomy and significant diagnostic information can still be obtained in most cases. A patient's CT should not be ignored because it may provide complementary information the doctor needs in order to make a differential diagnosis. The CT scanner consists of 1 or more x-ray sources positioned across a ring from an array of detectors. Just like in general radiographs, high-energy photons are attenuated as they travel through tissues. Reconstructions of images can help emphasize different tissue types, such as bone or soft tissue, and the range of gray-scale values can be adjusted to enhance different features. Iodinated contrast is commonly used in CT and increases density whenever it accumulates. Images are able to be reformatted into different planes to visualize bones, vessels, and other structures in 3D. Computed tomography is superior to MRI in its spatial resolution, assessment of osseous structures, speed, and availability. It is important to recognize when 1 or more signs of mass effect, edema, cellularity, or infiltration indicate that a scan is not showing a typical case of chronic small vessel ischemic disease and further evaluation is needed with an enhanced MRI. Contrast enhanced MRI remains the primary form of imaging for brain tumors, minimizing the risk of an incorrect diagnosis, and identifying potential complications of tumor or therapy. Magnetic resonance images are created by measuring the current generated when spinning protons, usually hydrogen nuclei in water molecules, are induced by radiofrequency pulses to flip out, and then return to alignment with a strong magnetic field. The timing of the pulses enables localization of signals in 3D and variates in signal intensity

depending on the tissue type. In T1-weighted images, white matter is bright and gray matter is dark. In T2-weighted images, white matter is dark and gray matter is bright. Cerebrospinal fluid (CSF) is bright on T2-weighted images and dark on T1-weighted images. Gadolinium based contrast agents are typically used in MRI. Routine MRI brain scan sequences include T2-weighted, fluid-attenuated inversion recovery (FLAIR), diffusion-weighted imaging (DWI), and pre-gadolinium and post-gadolinium T1-weighted images. Advanced imaging techniques requires additional post-processing and allows for further characterization of tumor tissues. These advanced imaging techniques include perfusion imaging and permeability imaging. Most glioblastomas appear on T2 and FLAIR images. White matter abnormalities are usually subtle, but readily identifiable when compared to more typical-appearing white matter. DWI images assess the flow of water molecules within tissues which produces images that are brighter. The necrotic components of glioblastoma can show restrictive diffusion and are occasionally difficult to distinguish from abscess. DWI is greatly affected by magnetic susceptibility, so alterations in signal may be caused by substances such as blood products, as seen in hemorrhagic tumors. Contrast is useful for MRIs of the brain because parenchymal accumulation highlights areas of BBB breakdown due to pathology. In glioblastomas, contrast reflects both inflammation and abnormal vasculature. A defining pathologic feature of glioblastomas is the presence of thick, irregular nodules. An increase in patient age is directly related to an increase in lesions. Advanced imaging techniques have become standard part of any brain evaluation at most facilities. This article includes images of other pathologies that tend to mimic glioblastomas and how they visually compare side by side in the same MR imaging sequences. These pathologies include metastases, lymphoma, and radiation necrosis. It is critical to be able to differentiate between these pathologies on an image to determine the proper treatment and management.

II. A strength of this research article is that it explains what glioblastoma should look like on an MRI image and the abnormalities that a technologist may see when scanning. This information is critical if I choose to become an MRI technologist in the future. If glioblastoma can be easily spotted on an image, the patient can begin receiving treatment as soon as possible for this aggressive disease. Another strength of this article is that it indicates why MRI is the better imaging modality for glioblastomas over CT. A weakness of this article is that I feel that the set up of this article could have been a little clearer and more organized. I also think it could have been a little shorter as well. It started to get very wordy and I felt there was a lot of unnecessary information in there that could have been condensed or left out.

III. This article is useful because it compares CT to MRI and explains why MRI is the primary modality used for visualizing glioblastomas and gives neurosurgeons better detail of the pathology when deciding on their treatment plan. This article also provides the reader with both CT and MRI images of the brain and compares the soft tissue resolution side by side. This article includes many other images comparing MRIs before and after contrast enhancement. There is also a table of images included showing the standard MRI brain sequences used and compares what other pathologies besides glioblastomas look like on these sequences such as lymphoma, metastases, and radiation necrosis. This is a useful article for my poster because it briefly overviews what MRI is and how it works.

Singh, H., Essayed, W. I., Deb, S., Hoffman, C., & Schwartz, T. H. (2017). *Minimally Invasive Robotic Laser Corpus Callosotomy: A Proof of Concept*. Cureus, 9(2), e1021. https://doi.org/10.7759/cureus.1021

I. This article discusses how the Neuroblate robotic laser is effective for corpus callosotomy in the brain. Corpus callosotomy is surgical disconnection for medically intractable non-focal epilepsy. By interrupting the interhemispheric propagation of the seizure reduces the magnitude as well as the frequency of the seizures. A traditional callosotomy is performed through a craniotomy, typically entering through the lateral ventricle. With the traditional approach, many complications are likely to occur such as contusion, hydrocephalus, venous infarct, and infection. This article discusses how a craniotomy can be avoided with the use of a minimally invasive robotic laser thermotherapy. In this study, 10 trajectory points were plotted on normal MRI scans using the Brainlab Stereotactic Planning Software. The volume of the callosotomy to be reached was recorded on each MRI. The corpus callosum can be ablated anywhere along the fiber tract before the fibers diverge, approximately 2 cm from the midline. The entry site points were chosen relative to known anatomic landmarks, such as the coronal and sagittal sutures, the nasion, and the torcula. A single trajectory is sufficient for an anterior two-thirds callosotomy and 2 trajectories are sufficient for a complete callosotomy. Prior to this study, each patient's case was considered for either an anterior two-thirds or complete callosotomy, based on the severity of their seizures. Due to the corpus callosum being the midline of the brain, either side is an appropriate choice for an entry site. The measurements from the entry points were recorded. The distances between the posterior trajectory tip and the genu and the anterior trajectory tip and the splenium were also recorded. The results of this study showed that an anterior two-thirds callosotomy was possible in all patients. The average entry point on the cranium from the midline was 3.64 cm. The average point from behind the coronal suture was 10.62, and the average point above the torcula was 9.19 cm. For the complete callosotomy's, the anterior trajectory was effective in targeting the posterior one-third of the corpus callosum. The average entry point on the cranium from the midline was 3.6 cm and 9.1 cm above the nasion. The average distance measured from the probe tip to the genu was 1.43 cm. The average distance of the posterior trajectory from the genu to the entry pointy was 4.09 cm. The average distance of the anterior trajectory from the probe tip to the splenium was 0.94 cm. Even though Neuroblate is an effective alternative for patients with medically intractable epilepsy, this procedure is still associated with multiple morbidities. Vagal Nerve stimulation (VNS) is an alternative to corpus callosotomy that can be used on patients with similar issues. The Neuroblate system allows a directional firing of the laser, which is appealing due to the curved shape of the corpus callosum. A laser distance of less than 2 cm is sufficient to reach the entire corpus callosum.

II. A strength of this research article is that a study was conducted to show how effective Neuroblate is for corpus callosotomy in the brain. The introduction, methods, results, and conclusion are all included in this article as well as images of the trajectory planning with the probe done with the MRI software and computers. A weakness of this study is that it discusses how this procedure is still associated with multiple morbidities.

III. This article is useful because it shows that Neuroblate isn't only used for tumors, but for seizures as well. Tumors are more commonly operated on in the brain with the Neuroblate Fusion system, but patients with certain types of seizures can also opt for this option.

Thaiwani, J. P. & Brem, S. (2016). Chapter 1: The story of glioblastoma: History and modern correlates. Glioblastoma E-book (pp. 1-7) Elsevier. Retrieved from file:///C:/Users/agold/Downloads/Glioblastoma_E-Book_----_(_Chapter_1_-_The_Story_of_Glioblastoma_History_and_Modern_Correlates_).pdf

I. This chapter describes the history of glioblastoma and gives an outline of the evolution of diagnosis and treatment of this tumor. To this day, glioblastoma is still a powerful, dangerous pathology. Without the necessary tools to make a neurological diagnosis, patient survival with this tumor significantly decreases. Neurosurgeons and physicians still struggle to provide positive outcomes for patients living with glioblastoma, even with major advancements in modern medicine. The first documentation of a medical procedure was done by Hippocrates. Trephination is an act of perforating the skull with a surgical instrument. This was done to alleviate seizures, headaches, and growths. The ancient surgeon, Abu al-Qasim Al-Zahrawi of Andalusia, was the first to develop operations to treat neurological disorders, including those within the central nervous system. Rudolph Ludwig Carl Virchow was the first to define gliomas and separate them into what are now considered low-grade and high-grade disorders. During this time, in the late 1850's, tumors in the brain were named according to their normal cellular counterpart. Much later, in 1926, Percival Bailey and Harvey Cushing used histologic staining techniques to study 254 gliomas and form them into 13 groups. Tumors were grouped according to patient survival. Bailey and Cushing identified spongioblastoma multiforme as a distinct tumor with a specific cell origin, different from the other gliomas. Patients with these tumors all experienced a rapid decline in their trajectories and by the late 1940's, spongioblastoma multiforme became known as glioblastoma. Imaging modalities such as radiography, CT, and MRI have significantly changed the way to help diagnose and manage glioblastoma. In MRI, image sequences done with and without the administration of gadolinium serve as standard imaging sequences for newly diagnosed glioblastoma. Using gadolinium results in enhancement on T1-weighted images. In 1928, Walter Dandy performed right hemispherectomy procedures on patients with glioblastomas and relapses were noted. Through these procedures along with many other studies, gave clinicians an understanding that glioblastoma is a microscopic disease. With advancements in MR, physicians can obtain approximations of functional regions of the brain. High-quality mapping techniques have improved the safety of neurosurgical resection for patients with glioblastoma. Across the globe, groups continue to differ in terms of strategies to treat glioblastoma with and without surgery. Methods such as surgical resection, biopsy, radiation therapy, and chemotherapeutic agents are used.

II. A strength of this article is that it goes way back in history to when we first began to discover treatments for neurological disorders. I like how this article shows how the next doctor or scientist expanded upon and improved the ideas of the ones before them. It really helped to show the progression of treatment and advancement of technology, all the way up to current society.

Through trial and error, we are now able to successfully treat glioblastomas in a safer way. Another strength of this article is that is showed how glioblastomas used to be broken down and the change to how they are grouped today. A weakness of this article is that it tended to jump around from one surgeon or doctor to the next, which got confusing when trying to follow the overall timeline of things.

III. This article is useful for my Neuroblate poster project because it goes into detail about the history of glioblastomas and how the treatment has progressed over the years. Even though Neuroblate Fusion is the newest treatment to be created for patients with glioblastomas, something else will come along in the future that is even more beneficial and safer than before.

University Hospitals. (2020). *Inoperable Brain Tumor: New Neuroblate Technology Gives New Hope for Patients*. Retrieved from https://www.uhhospitals.org/services/neurology-and-neurosurgery-services/technology-and-innovation/neuroblate

I. This University Hospitals website talks about how Neuroblate technology gives a new hope to patients with inoperable brain tumors or lesions who were previously diagnosed as untreatable. Neuroblate is a pain-free alternative to open surgery or radiosurgery. Radiosurgery is a form of radiotherapy in which a high dose of radiation is delivered to a small, selected area. This website also supports the claim that Neuroblate is most effective in treating glioblastoma; one of the most aggressive types of brain cancers and one of the most difficult to treat. It is also effective for other inoperable brain tumors for patients who are considered a high risk for getting surgery. Only a small number of hospitals in the United States are utilizing this technology. It was approved by the U.S Food and Drug Administration (FDA) in 2009. There are advantages of Neuroblate for both the patient and the physician.

II. A strength of this website is that it explains how Neuroblate is a good option for patients who have lost all hope and were previously told that their tumors or leisons were inoperable or unable to be treated. This may be a great alternative treatment for those who can't afford traditional surgery. I also liked that this article mentioned that only a few hospitals across the United States use this technology, which indicates that only the best of the best and most renowned hospitals use it. A weakness of this website is that it doesn't go into that much detail and it could have explained why it is a better alternative to radiation therapy or chemotherapy.

III. This website is useful because it not only gives a list of advantages for the patient, but for the physician as well. This website also compares Neuroblate to other available treatment options out there such as surgery, radiation therapy, or chemotherapy.