Interstitial Laser Therapy

**Policy**

*Please see amendment for Pennsylvania Medicaid at the end of this CPB.*

Aetna considers interstitial laser therapy medically necessary for refractory epilepsy when criteria per CPB 0394 - Epilepsy Surgery (../300_399/0394.html) are met.

Aetna considers interstitial laser therapy experimental and investigational for the following indications (not an all-inclusive list) because of insufficient evidence of its effectiveness.

- Adrenal metastases
- Brain tumors (including brain metastases, intra-cranial meningiomas, and posterior fossa tumors)
- Breast tumors (i.e., benign or malignant)
- Chronic intractable non-malignant pain
- Epileptogenic periventricular nodular heterotopia
- Extra-axial menigiomas
- Fetal hydrops
- Fetal sacro-coccygeal teratomas
- Liver metastases
- Lung cancer and lung metastases
- Pancreatic cancer
- Placental chorioangiomas
- Prostate cancer
- Radionecrosis

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**Policy History**

- Last Review: 10/27/2019
- Effective: 04/10/2009
- Next Review: 08/27/2020

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**Definitions**

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**Additional Information**

- Clinical Policy Bulletin
- Notes
Minimally invasive therapy has been investigated as a potential means of treating breast tumors with minimal disruption to adjacent soft tissues. The purpose of this approach is to facilitate improved cosmesis and to offer treatment to women who are unfit for surgery (Hall-Craggs and Vaidya, 2002).

Interstitial laser therapy (ILT) is a microinvasive technique that uses image-guided needle probes to deliver laser energy into a tumor to slowly heat and destroy the tumor cells. It has been proposed as a minimally invasive alternative to lumpectomy for fibroadenomas (benign tumors) that are 2 cm or less in size and it is also under investigation for treatment of localized breast cancers. Potential advantages of laser ablation compared to surgical excision include: shorter procedure time, outpatient setting, smaller incision and minimal scarring, less bleeding and tissue damage, lowered risk of infection due to heat sterilization of surrounding tissue and decreased healing time.

The Novilase Interstitial Laser Therapy (Novian Health, Inc., Chicago, IL) system received 510(k) marketing clearance from the U.S. Food and Drug Administration in 2007 for the treatment of breast fibroadenomas that are 2 cm or less in size. It is also used for general surgery procedures (e.g., incision, excision and ablation of soft tissues; coagulative necrosis and interstitial laser coagulation of soft tissue).

In an uncontrolled prospective study, Basu et al (1999) reported the results of the effect of interstitial laser hyperthermia in breast fibroadenomas as an out-patient procedure. Patients younger than 35 years (n = 27) received laser phototherapy of their breast fibroadenomas under real-time ultrasound monitoring. Nd:YAG laser was used in a continuous wave mode to produce interstitial hyperthermia. Follow-ups were done at 2, 4, and 8 weeks. There was a significant decrease in clinical and sonographic sizes (p < 0.001). Follow-up ultrasound showed...
progressive change of hyperechoic texture, from a heterogeneous to a nearly homogeneous one. There were minimal scars (2 to 3 mm) and no keloid or abscess formation. The authors concluded that interstitial laser hyperthermia is a safe, precise, and minimally invasive outpatient procedure for in situ destruction of breast fibroadenomas, although it should be noted that excisional biopsy of residual lumps was performed.

In a non-randomized controlled trial, Dowlastshahi et al (2000) reported the results of stereotactically guided laser ablation of mammographically detected breast tumors (n = 36). Patients were treated on a stereotactic table, using a 16- to 18-gauge laser probe, with an optic fiber transmitting a pre-determined amount of laser energy. A multi-sensor thermal probe was inserted into the breast adjacent to the laser probe to monitor treatment. In the last 10 patients, the tumor blood flow was evaluated before and after laser therapy with contrast-enhanced color Doppler ultrasound. One to 8 weeks after laser therapy, the tumors were surgically removed and serially sectioned. Complete necrosis occurred in 66 % of the tumors. Microscopic examination at 1 week showed disintegration of malignant cells, with peripheral acute inflammatory response and at 4 to 8 weeks extensive fibrosis. Contrast-enhanced color Doppler ultrasound revealed loss of tumor circulation after therapy, and positron emission tomography scan correlated well with histologic findings. There were no systemic adverse effects. Two patients sustained 3 x 4-mm skin burns around the laser needle. The authors concluded that a stereotactically guided minimally invasive technique may be effective for the treatment of mammographically detected breast cancer.

Haraldsdóttir et al (2008) reported the results of ILT on invasive breast cancer patients (n = 24). All study patients underwent mammography, ultrasound and core biopsy before treatment. The tumors were classified as invasive ductal carcinoma (n = 15), lobular carcinoma (n = 8) and lobular-ductal cancer (n = 1). Average tumor diameter was 14 mm on ultrasound (range of 5 to 35). Patients were treated in the out-patient clinics under local anesthesia. Probes were placed under ultrasound guidance in 19 patients, and ILT was performed with a diode laser. Standard surgical excision was performed 12 (range of 4 to 23) days after ILT and was preceded by Doppler ultrasound. Treatment-induced necrosis of invasive cancer was 33 % (range 0 to 100) and was complete in 3 patients. At follow-up before surgery, the extent of laser damage could not be judged with ultrasound, although abolished tumor blood flow was demonstrated after treatment resulting in large necroses. Efficacy of treatment varied negatively with tumor size. The inefficacy of ILT was mainly due to the under-estimation of tumor size by mammography and ultrasound and the shortcomings of these methods to demonstrate tumor borders, tumor irregularity and carcinoma in situ (CIS). Interstitial laser therapy was well tolerated. Five patients had breast tenderness and 3 patients had pain during the first day after treatment. Small skin necroses were observed in 2 patients. The authors concluded that small breast
cancers can be treated radically with ILT and that the method may become useful in the treatment of breast cancer but needs further refinement, even for small well-defined breast cancers, if it is going to be employed for radical treatment.

No professional medical society recommends the use of ILT for breast tumors. Excisional biopsy is considered the gold standard for evaluating breast masses and it is both diagnostic and therapeutic. A completely removed mass with good margins of normal tissue may mean that further surgery is not required (Klein, 2005).

Recommendations by the Canadian Association of Radiation Oncologists (1998) on the palpable breast lump stated that whenever reasonable doubt remains as to whether a lump is benign or malignant, a biopsy to remove the entire lump in one piece along with a surrounding cuff of normal tissue for cytological examination should be carried out.

An assessment of ILT for fibroadenomas by the National Institute for Clinical Excellence (NICE, 2005) concluded that "current evidence on the safety and efficacy of interstitial laser therapy for fibroadeomas of the breast does not appear adequate for this procedure to be used without special arrangements for consent and for audit or research." The assessment noted that adverse events include local burns at the needle site and theoretical complications include local infection, and bleeding if the needle strikes a blood vessel. Furthermore, the specialist advisors noted that the lack of material for biopsy means that the benign diagnosis cannot be confirmed.

An assessment of ILT for breast cancer by the National Institute for Clinical Excellence (NICE, 2004) concluded that "Current evidence on the safety and efficacy of interstitial laser therapy for breast cancer does not appear adequate to support the routine use of this procedure. It is suitable for use only within good-quality research studies approved by a research ethics committee and with explicit patient consent." The assessment stated that publication of safety and efficacy outcomes will be useful in reducing the current uncertainty. The assessment stated that the evidence of efficacy was limited to three small case series and one case report. The Specialist Advisors to NICE noted that it was still uncertain whether the procedure could achieve thermal ablation of all malignant tissue. They also noted that there were no data comparing outcomes of the procedure with those of wide excision and radiotherapy. A Specialist Advisor stated that the potential adverse effects of the procedure includes necrosis, hemorrhage, and liquefaction caused by overheating of tissue.

Novian Health, Inc. is currently conducting a prospective, observational multi-center study which will evaluate the clinical outcomes of Novilase for benign breast fibroadenomas versus lumpectomy. A trial on the use of Novilase for malignant breast tumors is also being planned by Novian Health, Inc.
At this time, it is not clear who might benefit from ILT for fibroadenomas (e.g., age subgroup, tumor size, etc.) or malignant breast tumors. Benign breast lumps may spontaneously resolve on their own and require no intervention. However, some researchers consider fibroadenomas a long-term risk factor for breast cancer (Dupont, et al, 1994; El-Wakeel and Umpleby, 2003). While a few researchers have reported early results with ILT of breast tumors, no controlled or comparative trials to evaluate ILT versus lumpectomy have been published. Thus, it is not known whether ILT is as effective as lumpectomy for breast tumors.

In a prospective non-randomized study, Wietzke-Braun et al (2004) examined the quality-of-life (QOL) and outcome of ultrasound-guided laser interstitial thermo-therapy (US-LITT) in patients with liver metastases of colorectal cancer. A total of 45 patients with liver metastases of colorectal cancer were palliatively treated by US-LITT. Patient survival was analyzed by the Kaplan-Meier method and the QOL questionnaire C30 of the European Organization for Research and Treatment of Cancer before, and 1 week, 1 month, and 6 months after initiation of US-LITT. Median survival after initiation of US-LITT was 8.5 +/- 0.7 months with a range of 1.5 to 18 months. Body weight was constant 1 month after US-LITT. In the multi-variate analyses, QOL symptoms and functioning scales did not deteriorate in patients alive at 6 months after initiation of US-LITT. Uni-variate analyses outlined a significant increase of the pain subscale before and at 1 week after US-LITT. The authors concluded that this study first described the QOL in patients with liver metastases of colorectal cancer treated by US-LITT. Potential benefits of the minimal invasive procedure could be prolonged survival time by preserved QOL, but this first impression needs to be verified in a comparative study.

The Swedish Council on Health Technology Assessment's report on LITT for liver metastases (SBU, 2011) states that this method is experimental. It is unclear if LITT extends life in patients with liver metastases; comparative studies are lacking. Studies published to date show that LITT can ablate metastases, and that risks associated with the procedure are minor. However, the beneficial effects of metastases ablation, in terms of symptoms and QOL, has not been demonstrated in the literature. The SBU assessment notes that use of LITT should be limited to controlled trials.

Vogl et al (2007) evaluated the feasibility, safety and effectiveness of computed tomography (CT)-guided and MR-thermometry-controlled LITT in adrenal metastases. A total of 9 patients (7 males, 2 females; average age of 65.0 years; range of 58.7 to 75.0 years) with 9 unilateral adrenal metastases (mean diameter 4.3 cm) from primaries comprising colorectal carcinoma (n = 5), renal cell carcinoma (n = 1), esophageal carcinoma (n = 1), carcinoid (n = 1), and hepatocellular carcinoma (n = 1) underwent CT-guided, MR-thermometry-controlled LITT using a 0.5 T MR unit. Laser interstitial thermo-therapy was performed with an internally irrigated power laser application system with an Nd:YAG laser. A thermo-sensitive, fast low-angle shot 2D sequence
was used for real-time monitoring. Follow-up studies were performed at 24 hrs and 3 months and, thereafter, at 6-month intervals (median of 14 months). All patients tolerated the procedure well under local anesthesia. No complications occurred. Average number of laser applicators per tumor: 1.9 (range of 1 to 4); mean applied laser energy 33 kJ (range of 15.3 to 94.6 kJ), mean diameter of the laser-induced coagulation necrosis 4.5 cm (range of 2.5 to 7.5 cm). Complete ablation was achieved in 7 lesions, verified by MR imaging; progression was detected in 2 lesions in the follow-up. The authors concluded that these preliminary results suggested that CT-guided, MR-thermometry-controlled LITT is a safe, minimally invasive and promising procedure for treating adrenal metastases.

Schwarzmaier et al (2006) examined the survival after LITT in 16 patients suffering from recurrent glioblastoma multiforme. All patients received standard chemotherapy (temozolomide). The median overall survival (OS) time after the first relapse was 9.4 months, corresponding to a median OS time after laser irradiation of 6.9 months. During the study, however, the median survival after laser coagulation increased to 11.2 months. This survival time is substantially longer than those reported for the natural history (less than 5 months) or after chemotherapy (temozolomide: 5.4 to 7.1 months). These researchers concluded that cytoreduction by laser irradiation might be a promising option for patients suffering from recurrent glioblastoma multiforme. In addition, the data indicate the presence of a substantial learning curve. They stated that future work should optimize the therapeutic regimen and evaluate this treatment approach in controlled clinical trials.

Hawasli et al (2012) described the novel use of AutoLITT System (Monteris Medical, Winnipeg, MB) for focused LITT using intra-operative magnetic resonance imaging (MRI) and stereotactic image guidance for the treatment of metastatic adenocarcinoma to the left insula. The patient is a 61-year old right-handed male with a history of metastatic adenocarcinoma of the colon. He has previously undergone resection of multiple lesions, Gamma Knife and whole brain radiation. Despite treatment to a left insular tumor, serial imaging revealed that the lesion continued to enlarge. Given the refractory nature of this tumor to radiation and the deep seated location, the patient elected to undergo LITT treatment. The center of the lesion and entry point on the scalp were identified using STEALTH (Medtronic, Memphis, TN) image-guided navigation. The AXiiS Stereotactic Miniframe (Monteris Medical, Winnipeg, MB) for the LITT system was secured onto the skull and a trajectory was defined to achieve access to the centroid of the tumor. After performing a burr hole, a gadolinium template probe was inserted into the AXiiS base. The trajectory was confirmed via an intra-operative MRI and the LITT probe driver was attached to the base and CO2-cooled, side-firing laser LITT probe. The laser was activated and thermometry images were obtained. Two trajectories, posterior-medial and antero-lateral,
produced satisfactory tumor ablation. The authors concluded that LITT using intra-operative MRI and stereotactic image guidance is a newly-available, minimally-invasive, and therapeutically viable technique for the treatment of deep seated brain tumors.

Saccomandi et al (2011) developed and verified a theoretical model to reproduce the thermal response of pancreatic tissue undergoing laser-interstitial thermal therapy (LITT). The model provided the evaluation of: (i) ablated volumes induced by thermal ablation; (ii) tissue response time to irradiation; and (iii) heat extinction time. Theoretical volume values were compared with ex-vivo healthy tissue and in-vivo healthy and neoplastic tissue volume values. The theoretical model takes into account the differences between healthy and neoplastic tissue due to blood perfusion. Mathematical model showed that ablated volume of ex-vivo healthy tissue is greater than in-vivo one after the same treatment. Moreover, ablated neoplastic in-vivo tissue volume is greater than healthy in-vivo one, because of tumor angiogenesis. Ablated volume values were compared with experimental data obtained by laser treatment of 30 ex-vivo porcine pancreases. Experimental ablated volume values show a good agreement with theoretical values, with an estimated increase of 61 % when power increases from 3 W to 6 W, versus 46 % of experimental data, and an estimated increase of 14 % from 6 W to 10 W, versus 21 % of experimental values. LITT could be an alternative or a neo-adjuvant treatment to surgical resection for pancreas cancer removal, and the proposed model could be the basis to supervising the evolution of ablated volumes during tumor treatment.

Dossing and colleagues (2011) evaluated the long-term effectiveness of interstitial laser photocoagulation (ILP) in solitary benign thyroid nodules. A total of 78 euthyroid outpatients (45 participating in randomized trials) with a benign solitary solid and scintigraphically cold thyroid nodule causing local discomfort were assigned to ILP. Interstitial laser photocoagulation (using 1 laser fiber) was performed under continuous ultrasound (US) guidance and with an output power of 1.5 to 3.5 W. Thyroid nodule volume was assessed by US and thyroid function determined by routine assays, before and during follow-up. Pressure symptoms and cosmetic complaints were evaluated on a visual analog scale (0 to 10 cm). Of the 78 patients, 6 had thyroid surgery 6 months after ILP and 3 were lost to follow-up. The median follow-up for the remaining 69 patients was 67 months (range of 12 to 114). The overall median nodule volume decreased from 8.2 ml (range of 2.0 to 25.9) to 4.1 ml (range of 0.6 to 33.0; p < 0.001) at the final evaluation, corresponding to a median reduction of 51 % (range of -194 % to 95 %). This correlated with a significant decrease in pressure as well as cosmetic complaints. After 12 to 96 months (median of 38 months) of ILP, 21 patients (29 %) had thyroid surgery because of an unsatisfactory result. All had benign histology. Thyroid function was unaltered throughout and side effects were restricted to mild local pain. The authors concluded that US-guided ILP results in a satisfactory
long-term clinical response in the majority of patients with a benign solitary solid cold thyroid nodule. Moreover, they stated that further large-scale studies should aim at optimizing selection criteria for ILP, preferably in randomized studies.

Rahmathulla and colleagues (2012) noted that whole-brain radiotherapy and stereotactic radiosurgery (SRS) play a central role in the treatment of metastatic brain tumors. Radiation necrosis occurs in 5% of patients and can be very difficult to treat. The available treatment options for radiation necrosis include prolonged high-dose corticosteroids, hyperbaric oxygen, anti-coagulation, bevacizumab, and surgical resection. These investigators presented the first report and results using LITT for medically refractory radionecrosis in a 74-year-old diabetic patient who had a history of non-small cell lung cancer with brain metastases and subsequent treatment with SRS, and who presented with a focal lesion in the left centrum semiovale with progressively worsening edema. Image findings were consistent with radiation necrosis that was refractory despite prolonged, high-dose steroid therapy. His associated co-morbidities obviated alternative interventions and the lesion was not in a location amenable to surgical resection. These investigators used LITT to treat the biopsy-proven radionecrosis. The procedure was well-tolerated and the patient was discharged 48 hours post-operatively. Imaging at 7-week follow-up showed near complete resolution of the edema and associated mass effect. Additionally, the patient was completely weaned off steroids. To the authors' knowledge, this is the first report using LITT for the treatment of focal radiation necrosis. The authors concluded that LITT may be an effective approach for patients with medically refractory radiation necrosis with lesions not amenable to surgical decompression.

Sloan et al (2013) stated that LITT has been used as an ablative treatment for glioma; however, its development was limited due to technical issues. The NeuroBlate System incorporates several technological advances to overcome these drawbacks. The authors reported a phase I, thermal dose-escalation trial assessing the safety and effectiveness of NeuroBlate in recurrent glioblastoma multiforme (rGBM). Adults with suspected supra-tentorial rGBM of 15- to 40-mm dimension and a Karnofsky Performance Status (KPS) score of greater than or equal to 60 were eligible. After confirmatory biopsy, treatment was delivered using a rigid, gas-cooled, side-firing laser probe. Treatment was monitored using real-time MRI thermometry, and proprietary software providing predictive thermal damage feedback was used by the surgeon, along with control of probe rotation and depth, to tailor tissue coagulation. An external data safety monitoring board determined if toxicity at lower levels justified dose escalation. A total of 10 patients were treated at the Cleveland Clinic and University Hospitals-Case Medical Center. Their average age was 55 years (range of 34 to 69 years) and the median pre-operative KPS score was 80 (range of 70 to 90). The mean tumor volume was 6.8 ± 5 cm(3) (range of 2.6 to 19 cm(3)), the percentage of tumor treated was 78% ± 12% (range of 57% to 90%), and the conformality index was 1.21 ± 0.33 (range of 1.00 to 2.04). Treatment-related necrosis was
evident on MRI studies at 24 and 48 hours. The median survival was 316 days (range of 62 to 767 days); 3 patients improved neurologically, 6 remained stable, and 1 worsened. Steroid-responsive treatment-related edema occurred in all patients but 1; 3 had grade-3 adverse events at the highest dose. The authors concluded that the NeuroBlate represents new technology for delivering LITT, allowing controlled thermal ablation of deep hemispheric rGBM. This was a phase I clinical trial; its findings need to be validated by well-designed studies.

A technology assessment of MRI-guided LITT by the Australian Health Policy Advisory Committee on Technology (Jacobsen, 2013) concluded that “MRT-guided LITT is an emerging therapeutic technique for patients in cases where surgical resection of an intracranial neoplasm is not possible. At present, the effectiveness of MRT-guided LITT is unknown. Consequently, the small body of evidence cannot be used to make an informed decision regarding the use of MRT-guided LITT”.

Torres-Reveron et al (2013) stated that since the inception of radiosurgery, the management of brain metastases has become a common problem for neurosurgeons. Although the use of stereotactic radiosurgery and/or whole brain radiation therapy serves to control the majority of disease burden, patients who survive longer than 6 to 8 months sometimes face the problem of symptomatic radiographically re-growing lesions with few treatment options. These researchers investigated the feasibility of use of MRI-guided stereotactic LITT as a novel treatment option for these lesions. A total of 6 patients who had previously undergone gamma knife stereotactic radiosurgery for brain metastases were included in this study. All patients had an initial favorable response to radiosurgery but subsequently developed re-growth of at least 1 lesion associated with recurrent edema and progressive neurological symptoms requiring ongoing steroids for symptom control. All lesions were evaluated for craniotomy, but were deemed unresectable due to deep location or patient’s co-morbidities. Stereotactic biopsies were performed prior to the thermotherapy procedure in all cases. Laser interstitial thermo-therapy was performed using the Visualase system and follow-up MRI imaging was used to determine treatment response. In all 6 patients biopsy results were negative for tumor and consistent with adverse radiation effects (radiation necrosis). Patients tolerated the procedure well and were discharged from the hospital within 48 hours of the procedure. In 4/6 cases there was durable improvement of neurological symptoms until death. In all cases steroids were weaned off within 2 months. One patient died from systemic causes related to his cancer 1 month after the procedure. One patient had re-growth of the lesion 3 months after the procedure and required re-initiation of steroids and standard craniotomy for surgical resection. There were no complications directly related to LITT. The authors concluded that stereotactic LITT is a feasible alternative for the treatment of symptomatic re-growing metastatic lesions after radiosurgery. The procedure carries minimal
morbidity and, in this small series, showed some effectiveness in the symptomatic relief of edema and neurological symptoms paralleled by radiographic lesional control. Moreover, the authors stated that further studies are needed to elucidate the safety of this technology.

Voigt and Torchia (2014) reported on a systematic evidence review of LITT for the treatment of brain neoplasms. These investigators identified a total of 17 studies with 169 patients who received LITT. They found that most of these studies were case-series studies; 1 randomized study of LITT and brachytherapy was identified. These researchers stated that 99 patients were treated for GBM, recurrent malignant gliomas and, rGBM using LITT as a follow-on/salvage therapy. They opined that LITT used as the sole or as adjunctive therapy appeared to prolong survival when compared to historical controls receiving best/palliative care. A total of 24 patients were treated for astrocytomas (World Health Organization [WHO] I - III) and LITT was used mainly with de-novo lesions in areas of inoperability/eloquence. The authors stated that, in these tumor types, LITT appeared to be well-tolerated and significantly reduced lesion size; 23 patients were treated for metastatic disease. The authors stated that equivocal benefit was found in this small cohort study. The authors concluded that more published studies are needed, most especially in patients with metastatic disease and in less aggressive type cancers based on the small numbers of patients studied in these groups.

Mohammadi and Schroeder (2014) stated that initial results have shown the feasibility of LITT for a variety of brain pathologies; randomized controlled trials (RCTs) are currently planned to continue assessing the effectiveness of LITT for brain neoplasm and long-term follow-up data are awaited.

Fabiano and Alberico (2014) noted that stereotactic radiosurgery is often an effective tool for the treatment of brain metastases. A complication of radio-surgical treatment for brain metastasis can be persistent cerebral edema. Treatments of refractory cerebral edema include observation, corticosteroids, and surgical resection of the edema-inducing mass. Laser-interstitial thermal therapy is a minimally invasive technique for ablating intracranial lesions. It may provide a treatment option for metastases after radiosurgery causing refractory cerebral edema. These investigators reported the case of a 64-year old man with lung adenocarcinoma presenting to the authors’ department with left hemiparesis. Brain MRI showed an 18-mm enhancing lesion in the right external capsule with significant surrounding edema. The lesion was treated by radiosurgery. There was persistent edema after radiosurgery. The patient required continued corticosteroid therapy to maintain his ability to ambulate. He developed refractory hyperglycemia, weight gain, and bilateral proximal muscle weakness secondary to this therapy. Fourteen weeks after radiosurgery, he underwent LITT for lesion ablation. He was weaned off corticosteroids during 2 weeks and maintained his strength during the following month. The authors concluded that LITT may be a treatment option for refractory cerebral edema after
stereotactic radiosurgery to a metastasis. This therapy may be of particular use in deep-seated lesions refractory to corticosteroid therapy. Moreover, they stated that long-term outcome data for the treatment of brain metastases with LITT is not yet available; they stated that further study is needed to determine the exact role of LITT in the treatment of patients with brain metastases.

Rao et al (2014) stated that enhancing lesions that progress after stereotactic radiosurgery are often tumor recurrence or radiation necrosis. Magnetic resonance-guided LITT is currently being explored for minimally invasive treatment of intracranial neoplasms. These researchers reported the largest series to-date of local control with LITT for the treatment of recurrent enhancing lesions after stereotactic radiosurgery for brain metastases. Patients with recurrent metastatic intracranial tumors or radiation necrosis who had previously undergone radiosurgery and had a KPS of greater than 70 were eligible for LITT. A total of 16 patients underwent a total of 17 procedures. The primary end-point was local control using MRI scans at intervals of greater than 4 weeks. Radiographic outcomes were followed-up prospectively until death or local recurrence (defined as greater than 25 % increase in volume compared with the 24-hour post-procedural scan). A total of 15 patients (age of 46 to 82 years) were available for follow-up. Primary tumor histology was non-small-cell lung cancer (n = 12) and adenocarcinoma (n = 3). On average, the lesion size measured 3.66 cm (range of 0.46 to 25.45 cm); there were 3.3 ablations per treatment (range of 2 to 6), with 7.73-cm depth to target (range of 5.5 to 14.1 cm), ablation dose of 9.85 W (range of 8.2 to 12.0 W), and total ablation time of 7.43 minutes (range of 2 to 15 minutes). At a median follow-up of 24 weeks (range of 4 to 84 weeks), local control was 75.8 % (13 of 15 lesions), median progression-free survival was 37 weeks, and overall survival was 57 % (8 of 14 patients). Two patients experience recurrence at 6 and 18 weeks after the procedure. Five patients died of extracranial disease progression; 1 patient died of neurological progression elsewhere in the brain. The authors concluded that MRI-guided LITT is a well-tolerated procedure and may be effective in treating tumor recurrence/radiation necrosis. This was a small, single-arm, non-randomized study. Moreover, the authors stated that “larger studies with longer follow-up that include patient quality of life, decreased steroid dependence and neurological symptoms as end-points are necessary to confirm these findings and better define the appropriate patient for this therapy”.

Baud and associates (2013) reported 3 different antenatal therapeutic approaches for fetal lung masses associated with hydrops. Three prospectively followed cases were described, and all 30 previously published minimally invasive cases of fetal therapy for hydropic lung masses were reviewed. Three hydropic fetuses with large intra-thoracic lung masses were presented at 17, 25 and 21 weeks of gestation, respectively. An aortic feeding vessel was identified in each case and thus a broncho-pulmonary sequestration (BPS) was suspected. Under ultrasound guidance, the feeding vessel was successfully occluded with interstitial laser (case 1), radio-frequency ablation (RFA) (case 2) and thrombogenic coil embolization (case 3). Complete (cases 1 and 2)
or partial (case 3) resolution of the lung mass and hydrops was observed. A healthy infant was born at term after laser therapy (case 1), and the involved lung lobe was resected on day 2 of postnatal life. In case 2, hydrops resolved completely following RFA, but an iatrogenic congenital diaphragmatic hernia and abdominal wall defect became apparent 4 weeks later. The neonate died from sepsis following spontaneous preterm labor at 33 weeks. In case 3, despite technical success in complete vascular occlusion with coils, a stillbirth ensued 2 days after embolization. The authors concluded that the prognosis of large microcystic or echogenic fetal chest masses associated with hydrops is dismal. This has prompted attempts at treatment by open fetal surgery, with mixed results, high risk of premature labor and consequences for future pregnancies. These researchers had demonstrated the possibility of improved outcome following ultrasound-guided laser ablation of the systemic arterial supply. Moreover, they noted that despite technical success, RFA and coil embolization led to procedure-related complications and need further evaluation.

Van Mieghem et al (2014) stated that large solid sacro-coccygeal teratomas (SCT) can cause high output cardiac failure and fetal or neonatal death. These investigators described the outcomes of minimally invasive antenatal procedures for the treatment of fetal SCT. A total of 5 fetuses with large SCT's treated antenatally using minimally invasive techniques were included in this analysis; and systematic literature on fetal therapy for solid SCTs was reviewed. Five women were referred between 17.7 to 26.6 weeks gestation for large fetal SCTs with evidence of fetal cardiac failure. Vascular flow to the tumors was interrupted by fetoscopic laser ablation (n=1), RFA (n = 2) and interstitial laser ablation +/- vascular coiling (n = 2). There were 2 intra-uterine fetal deaths. The other 3 cases resulted in preterm labor within 10 days of surgery. One neonate died; 2 survived without procedure related complications; but had long-term morbidity related to prematurity. Systematic literature review revealed 15 SCTs treated minimally invasively for (early) hydrops. Including these researchers' subjects, 6 of 20 hydropic fetuses survived after minimally invasive therapy (30 %). Survival after RFA or interstitial laser was 45 % (n = 5/11). Of 12 fetuses treated for SCT without obvious hydrops, 67 % (n = 8/12) survived. Mean gestational age at delivery after minimally invasive therapy was 29.7 ± 4.0 weeks. Survival after open fetal surgery in hydropic fetuses was 55 % (n = 6/11) with a mean gestational age at delivery of 29.8 ± 2.9 weeks. The authors concluded that fetal therapy can potentially improve perinatal outcomes for hydropic fetuses with solid SCTs but is often complicated by intra-uterine death and preterm birth.

Furthermore, an UpToDate review on “Nonimmune hydrops fetalis” (Lockwood and Julien, 2014) does not mention the use of interstitial laser therapy as a therapeutic option.

In summary, ILT may be a promising minimally invasive technique for breast tumors and other tumors/malignancies, however, there is insufficient evidence of its clinical effectiveness.
Gomez et al (2014) reviewed the existing evidence on the techniques and results of ablation for pediatric solid malignant or aggressive benign tumors. These investigators searched MEDLINE for papers published between 1995 and 2012 that reported outcomes of radiofrequency, microwave and cryoablation, interstitial laser therapy, irreversible electroporation and percutaneous ethanol injection for patients younger than 18 years old. Data collection included factors related to the patient, tumor biology, ablation technique and cancer-specific endpoints. Additional series of predominantly adults including data on patients younger than 18 years old were also identified. These researchers identified 28 patients treated by ablation in 29 regions: 5 patients undergoing ablation for liver lesions, 9 patients for lung metastases, 11 patients for bone and/or soft tissue and 4 patients for kidney or pancreas. The ablation was performed to treat primary tumors, local recurrences and metastases. The histology of the tumors was osteosarcoma in 6 patients, Wilms tumor in 3, rhabdomyosarcoma in 3, hepatoblastoma in 3, desmoid tumor in 3, adrenocortical carcinoma in 2 and a single case each of leiomyosarcoma, Ewing sarcoma, paraganglioma, solid-pseudopapillary neoplasm, sacro-coccygeal teratoma, hepatic adenoma, juxtaglomerular cell tumor and plantar fibromatosis. Eighteen of the patients (64 %) experienced a complication, but only 6 (21 %) of these needed treatment other than supportive care. The authors concluded that although ablative techniques are feasible and promising treatments for certain pediatric tumors, large multi-center prospective trials are needed to establish their effectiveness.

Epileptogenic Peri-Ventricular Nodular Heterotopia

Hawasli and colleagues (2013) noted that surgical treatments for deep-seated intra-cranial lesions have been limited by morbidities associated with resection. Real-time MRI-guided focused LITT offers a minimally invasive surgical treatment option for such lesions. These investigators reviewed treatments and results of patients treated with LITT for intra-cranial lesions at Washington University School of Medicine. In a review of 17 prospectively recruited LITT patients (34 to 78 years of age; mean of 59 years), these investigators reported demographics, treatment details, post-operative imaging characteristics, as well as peri-operative and post-operative clinical courses. Targets included 11 gliomas, 5 brain metastases, and 1 epilepsy focus. Lesions were lobar (n = 8), thalamic/basal ganglia (n = 5), insular (n = 3), and corpus callosum (n = 1). Mean target volume was 11.6 cm, and LITT produced 93 % target ablation. Patients with superficial lesions had shorter intensive care unit stays; 10 patients experienced no peri-operative morbidities. Morbidities included transient aphasia, hemiparesis, hyponatremia, deep venous thrombosis, and fatal meningitis. Post-operative magnetic resonance imaging (MRI) showed blood products within the lesion surrounded by new thin uniform rim of contrast enhancement and diffusion restriction. In conjunction with other therapies, LITT targets often showed stable or reduced local disease. Epilepsy focus LITT produced seizure freedom at 8 months. The authors stated that preliminary overall median
progression-free survival (PFS) and survival from LITT in tumor patients were 7.6 and 10.9 months, respectively. However, they noted that this small cohort has not been followed for a sufficient length of time, necessitating future outcomes studies. The authors concluded that early peri- and post-operative clinical data demonstrated that LITT is a safe and viable ablative treatment option for intra-cranial lesions, and may be considered for select patients.

Esquenazi et al (2014) stated that peri-ventricular nodular heterotopia (PVNH) is a neuronal migrational disorder often associated with pharmaco-resistant epilepsy (PRE). Resective surgery for PVNH is limited by its deep location, and the overlying eloquent cortex or white matter. Stereotactic MR-guided LITT (MRgLITT) has recently become available for controlled focal ablation. These investigators demonstrated the novel application and techniques for the use of MRgLITT in the management of PVNH epilepsy. Comprehensive pre-surgical evaluation, including intra-cranial electroencephalography (EEG) monitoring in 2 patients revealed the PVNH to be crucially involved in their PRE. These researchers used MRgLITT to maximally ablate the PVNH in both cases. In the 1st case, seizure medication adjustment coupled with PVNH ablation, and in the 2nd, PVNH ablation in addition to temporal lobectomy rendered the patient seizure-free. A transient visual deficit occurred following ablation in the 2nd patient. The authors concluded that MRgLITT is a promising minimally invasive technique for ablation of epileptogenic PVNH, a disease not generally viewed as surgically treatable epilepsy. They also showed the feasibility of applying this technique through multiple trajectories and created lesions of complex shapes. They stated that the broad applicability and long-term effectiveness of MRgLITT need to be elaborated further.

Spinal Metastasis

Tatsui et al (2015) stated that high-grade malignant spinal cord compression is commonly managed with a combination of surgery aimed at removing the epidural tumor, followed by spinal stereotactic radiosurgery (SSRS) aimed at local tumor control. These researchers introduced the use of spinal LITT (SLITT) as an alternative to surgery prior to SSRS. Patients with a high degree of epidural malignant compression due to radio-resistant tumors were selected for study. Visual analog scale (VAS) scores for pain and QOL were obtained before and within 30 and 60 days after treatment. A laser probe was percutaneously placed in the epidural space. Real-time thermal MRI was used to monitor tissue damage in the region of interest. All patients received post-operative SSRS. The maximum thickness of the epidural tumor was measured, and the degree of epidural spinal cord compression (ESCC) was scored in pre- and post-procedure MRI. In the 11 patients eligible for study, the mean VAS score for pain decreased from 6.18 in the pre-operative period to 4.27 within 30 days and 2.8 within 60 days after the procedure. A similar VAS interrogating the percentage of QOL demonstrated improvement from 60 % pre-operatively to 70 % within both 30 and 60 days after treatment. Imaging follow-up 2 months after the
procedure demonstrated a significant reduction in the mean thickness of the epidural tumor from 8.82 mm (95% confidence interval [CI]: 7.38 to 10.25) before treatment to 6.36 mm (95% CI: 4.65 to 8.07) after SLITT and SSRS (p = 0.0001). The median pre-operative ESCC Grade 2 was scored as 4, which was significantly higher than the score of 2 for Grade 1b (p = 0.04) on imaging follow-up 2 months after the procedure. The authors presented the first report on an innovative minimally invasive alternative to surgery in the management of spinal metastasis. In their early experience, SLITT has provided local control with low morbidity and improvement in both pain and the QOL of patients. These preliminary findings need to be validated by well-designed studies.

Chronic Intractable Non-Malignant Pain

Patel and colleagues (2016) stated that MR-guided laser-induced thermal therapy (MRgLITT) can be used to treat intra-cranial tumors, epilepsy, and chronic pain syndromes. These investigators reported their single-center experience with 102 patients, the largest series to-date in which the Visualase thermal therapy system was used. They performed a retrospective analysis of all patients who underwent MRgLITT between 2010 and 2014. Pathologies included glioma, recurrent metastasis, radiation necrosis, chronic pain, and epilepsy. Laser catheters were placed stereotactically, and ablation was performed in the MRI suite. Demographics, operative parameters, length of hospital stay, and complications were recorded. The 30-day re-admission rates were calculated by using the standard method according to America's Health Insurance Plans Center for Policy and Research guidelines. A total of 133 lasers were placed in 102 patients who required intervention for intra-cranial tumors (87 patients), chronic pain syndrome (cingulotomy, 5 patients), or epilepsy (10 patients). The procedure was completed in 98% (100) of these patients; 92 patients (90.2%) had undergone previous treatment for their intra-cranial tumors. The average (± SD) total procedural time was 170.5 ± 34.4 minutes, and the mean laser-on time was 8.7 ± 6.8 minutes. The average intensive care unit (ICU) and hospital stays were 1.8 and 3.6 days, respectively, and the median length of stay for both the ICU and the hospital was 1 day. By post-operative Day 1, 54% of the patients (n = 55) were neurologically stable for discharge. There were 27 cases of morbidity, including new-onset neurological deficits, and 2 peri-operative deaths; 14 patients (13.7%) developed new deficits after the MRgLITT procedure, and of those 14 patients, 9 (64.3%) had complete resolution of deficits within 1 month, 1 (7.1%) had partial resolution of symptoms within 1 month, 2 (14.3%) had not had resolution of symptoms at the most recent follow-up, and 2 (14.3%) died without resolution of symptoms. The 30-day re-admission rate was 5.6%. The authors concluded that MRgLITT, although minimally invasive, must be used with caution. Thermal damage to critical and eloquent structures can occur despite MRI guidance. Once the learning curve is overcome, the overall procedural complication rate is low, and most patients can be discharged within 24
hours, with a relatively low re-admission rate. In cases in which they occurred, most neurological deficits were temporary. These investigators stated that therapeutic role of MRgLITT in various intra-cranial diseases will require larger and more rigorous studies.

**Drug-Resistant Epilepsy**

Lewis and colleagues (2015) reported the feasibility, safety, and clinical outcomes of an exploratory study of MRgLITT as a minimally invasive surgical procedure for the ablation of epileptogenic foci in children with drug-resistant, lesional epilepsy. These investigators performed a retrospective chart review of all MRgLITT procedures at a single tertiary care center. All procedures were performed using a Food and Drug Administration (FDA)-cleared surgical laser ablation system (Visualase Thermal Therapy System). Pre-defined clinical and surgical variables were extracted from archived medical records. A total of 17 patients underwent 19 MRgLITT procedures from May 2011 to January 2014. Mean age at seizure onset was 7.1 years (range of 0.1 to 14.8). Mean age at surgery was 15.3 years (range of 5.9 to 20.6). Surgical substrates were mixed but mainly composed of focal cortical dysplasia (n = 11); complications occurred in 4 patients. Average length of hospitalization post-surgery was 1.56 days. Mean follow-up was 16.1 months (n = 16; range of 3.5 to 35.9). Engel class I outcome was achieved in 7 patients (7/17; 41 %), Engel class II in 1 (1/17; 6 %), Engel class III in 3 (3/17; 18 %), and Engel class IV in 6 (6/17; 35 %); 3 patients (3/8; 38 %) with class I and II outcomes and 5 patients (5/9; 56 %) with class III and IV outcomes had at least 1 prior resection. Fisher’s exact test was not statistically significant for the association between Engel class outcome and previous resection (p = 0.64). The authors concluded that this study provided descriptive results regarding the use of MRgLITT in a mixed population of pediatric, lesional, drug-resistant epilepsy cases. The ability to classify case-specific outcomes and reduce technical complications is anticipated as experience develops. They stated that further multi-center, prospective studies are needed to delineate optimal candidates for MRgLITT, and larger cohorts are needed to more accurately define outcome and complication rates.

Karsy and associates (2016) stated that in the approximately 1 % of children affected by epilepsy, drug-resistance and early age of seizure onset are strongly correlated with poor cognitive outcomes, depression, anxiety, developmental delay, and impaired activities of daily living. These children often require multiple surgical procedures, including invasive diagnostic procedures with intra-cranial electrodes to identify the seizure-onset zone. The recent development of minimally invasive surgical techniques, including stereotactic electroencephalography (SEEG) and MRgLITT, and new applications of neuro-stimulation (e.g., responsive neuro-stimulation [RNS]), are quickly changing the landscape of the surgical management of pediatric epilepsy. The authors discussed these various technologies, their current applications, and limitations in the treatment of pediatric drug-resistant epilepsy, as well
as areas for future research. They stated that the development of minimally invasive diagnostic and ablative surgical techniques together with new paradigms in neuro-stimulation hold vast potential to improve the effectiveness and reduce the morbidity of the surgical management of children with drug-resistant epilepsy.

On behalf of the Epilepsy Foundation, Tatum (2015) noted that the best candidates for MRgLITT are patients with a well-defined epileptogenic focus. When focal seizures are uncontrolled by anti-seizure drugs, a solitary lesion of less than 2 cm on high-resolution magnetic resonance imaging (MRI) of the brain and a concordant pre-surgical evaluation is the optimal pre-operative situation for MR-g LITT.

An assessment by the Australian Safety and Efficacy Register of New Intervventional Procedures - Surgical (ASERNIP-S, 2016) found that there have been a number of new studies published on the use of MRI-guided LITT for intracranial neoplasms and epilepsy. All of the studies identified were level IV case series; therefore, the evidence base remains poor due the absence of a control group. In the absence of comparative data it is not possible to determine the efficacy of MRI-guided LITT compared with existing treatment techniques. In patients with intracranial neoplasms, MRI-guided LITT offers a minimally invasive means of potentially extending survival to patients with limited therapeutic options. However, no comparative data was available to quantify this survival benefit. Overall the procedure appears to be well tolerated; however, complications have been observed that may impact negatively on quality of life, such as worsening (or new-onset) neurological deficit. In patients with epilepsy, MRT-guided LITT has been the subject of small case series studies. One study found the majority of patients experienced a meaningful reduction in seizure frequency following ablation treatment. No evidence comparing the results of surgical resection and ablation of epilepsy-causing tissue were identified. Hence, the assessment concluded, “the place of MRT-guided LITT in the therapeutic management of intractable epilepsy and its safety and comparative clinical effectiveness are unclear.”

Willie et al (2014) stated that open surgery effectively treats mesial temporal lobe epilepsy (mTLE), but carries the risk of neurocognitive deficits, which may be reduced with minimally invasive alternatives. These researchers described technical and clinical outcomes of stereotactic laser amygdalohippocampotomy with real-time magnetic resonance thermal imaging guidance. With patients under general anesthesia and using standard stereotactic methods, a total of 13 adult patients with intractable mesial temporal lobe epilepsy (with and without mesial temporal sclerosis [MTS]) prospectively underwent insertion of a saline-cooled fiberoptic laser applicator in amygdalohippocampal structures from an occipital trajectory. Computer-controlled laser ablation was performed during continuous magnetic resonance thermal imaging followed by confirmatory contrast-enhanced anatomic imaging and volumetric reconstruction. Clinical
outcomes were determined from seizure diaries. A mean 60% volume of the amygdalohippocampal complex was ablated in 13 patients (9 with MTS) undergoing 15 procedures. Median hospitalization was 1 day. With follow-up ranging from 5 to 26 months (median of 14 months), 77% (10/13) of patients achieved meaningful seizure reduction, of whom 54% (7/13) were free of disabling seizures. Of patients with pre-operative MTS, 67% (6/9) achieved seizure freedom. All recurrences were observed before 6 months. Variances in ablation volume and length did not account for individual clinical outcomes. Although no complications of laser therapy itself were observed, 1 significant complication, a visual field defect, resulted from deviated insertion of a stereotactic aligning rod, which was corrected before ablation. The authors concluded that real-time magnetic resonance-guided stereotactic laser amygdalohippocampectomy is a technically novel, safe, and effective alternative to open surgery. Moreover, they stated that further evaluation with larger cohorts over time is needed.

Dredia et al (2016) noted that the most effective treatment for drug-resistant seizures associated with mTLE is surgical resection. Neurocognitive sequelae may occur and are especially likely to occur after left temporal lobectomy. Smaller resections observed with selective amygdalohippocampectomy have resulted in a more favorable neurocognitive outcome in some cases when compared to standard anterior temporal lobectomy. Specifically, MRgLITT uses a super-selective stereotactic amygdalohippocampectomy that has been reported to preserve object recognition and naming abilities compared with standard temporal lobe resection. These investigators reported 2 patients with drug-resistant mTLE and a normal high-resolution 3-T brain MRI who underwent neuropsychological assessment pre- and post-left temporal MRgLITT. Both patients demonstrated preserved visual naming ability following surgery. Semantic verbal fluency declined after surgery, but the magnitude of decline did not reach the statistical threshold for reliable change. Both patients demonstrated statistically significant and clinically meaningful declines in memory, but abilities across other non-memory neurocognitive domains (i.e., visuospatial ability, attention) were preserved.

Dadey et al (2016) stated that the precision of laser probe insertion for interstitial thermal therapy of deep-seated lesions is limited by the method of stereotactic guidance. These researchers evaluated the feasibility of customized STarFix 3D-printed stereotactic platforms to guide laser probe insertion into mesio-temporal and posterior fossa targets. The authors conducted a retrospective review of 5 patients (12 to 55 years of age) treated with LiTT in which STarFix platforms were used for probe insertion. Bone fiducials were implanted in each patient’s skull, and subsequent CT scans were used to guide the design of each platform and incorporate desired treatment trajectories. Once generated, the platforms were mounted on the patients’ craniums and used to position the laser probe during surgery. Placement of the laser probe and the LiTT procedure were monitored with intra-operative MRI. Peri-operative and follow-up MRI were performed to identify and monitor changes in target lesions. Accurate placement of the
laser probe was observed in all cases. For all patients, thermal ablation was accomplished without intra-operative complications. Of the 4 patients with symptomatic lesions, 2 experienced complete resolution of symptoms, and 1 reported improved symptoms compared with baseline. The authors concluded that while these results are promising, this study was limited by its inherent retrospective design. The small number of patients (n = 5) these investigators were able to include precluded the possibility of making statistical conclusions on treatment outcomes. Thus, additional larger studies are needed to fully characterize the impact that personalized stereotactic platforms can have on the therapeutic efficacy of LITT.

The authors also noted that STarFix and the Waypoint Navigation Software are FDA-approved, and the applications of these platforms continue to grow. However, disadvantages of the STarFix approach include the need for 2 procedures under general anesthesia within a short time span. Furthermore, the cost associated with the service, STarFix components, and use of the Waypoint Navigator Software may increase the total cost of any given LITT procedure. However, a systematic financial comparison between a standard Mini-Bolt case and a STarFix-based LITT procedure has yet to be performed.

Pruitt et al (2017) stated that complications of LITT are under-reported. The authors discussed how they have modified their technique in the context of technical and treatment-related adverse events. The Medtronic Visualase system was used in 49 procedures in 46 patients. Between 1 and 3 cooling catheters/laser fiber assemblies were placed, for a total of 62 implanted devices. Devices were placed using frameless stereotaxy (n = 3), frameless stereotaxy with intra-operative MRI (iMRI) (n = 9), iMRI under direct vision (n = 2), MRI alone (n = 1), or frame-based (n = 47) techniques. LITT was performed while monitoring MRI thermometry. Indications included brain tumors (n = 12), radiation necrosis (n = 2), filum terminale ependymoma (n = 1), mTLE (n = 21), corpus callosotomy for bi-frontal epilepsy (n = 3), cavernoma (n = 1), and hypothalamic hamartomas (n = 6). Some form of adverse event occurred in 11 (22.4 %) of 49 procedures. These included 4 catheter mal-positions, 3 intra-cranial hemorrhages, 3 cases of neurological deficit related to thermal injury, and 1 technical malfunction resulting in an aborted procedure. Of these, direct thermal injury was the only cause of prolonged neurological morbidity and occurred in 3 of 49 procedures. Use of frameless stereotaxy and increased numbers of devices were associated with significantly increased complication rates (p < 0.05). A number of procedural modifications were made to avoid complications, including the use of (i) frame-based catheter placement, a 1.8-mm alignment rod to create a track and titanium skull anchors for long trajectories to improve accuracy; (ii) a narrow-gauge instrument for dural puncture and co-registration of contrast MRI with CT angiography to reduce intra-cranial hemorrhage; (iii) general endotracheal anesthesia for posterior-placed skull anchors to reduce the likelihood of damage to the cooling catheter; (iv) use of as few probes as possible to reduce complications overall; and (v) dose modification of thermal treatment and use of short (3-mm)
diffusing tips to limit treatment when structures to be spared do not have intervening CSF spaces to act as heat sinks. The authors concluded that laser ablation treatment may be used for a variety of neurosurgical procedures for patients with tumors and epilepsy. While catheter placement and thermal treatment may be associated with a range of sub-optimal operative and post-operative courses, permanent neurological morbidity is less common. The authors' institutional experience illustrated a number of measures that may be taken to improve outcomes using this important new tool in the neurosurgical arsenal.

Jermakowicz et al (2017) identified features of ablations and trajectories that correlate with optimal seizure control and minimize the risk of neurocognitive deficits in patients undergoing LITT for mTLE. Clinical and radiographic data were reviewed from a prospectively maintained database of all patients undergoing Lit for the treatment of mTLE at the University of Miami Hospital. Standard pre-operative and post-operative evaluations, including contrast-enhanced MRI and neuropsychological testing, were performed in all patients. Laser trajectory and ablation volumes were computed both by manual tracing of mesio-temporal structures and by non-rigid registration of ablation cavities to a common reference system based on 7T MRI data. Among 23 patients with at least 1-year follow-up, 15 (65 %) were free of disabling seizures since the time of their surgery. Sparing of the mesial hippocampal head was significantly correlated with persistent disabling seizures (p = 0.01). A lateral trajectory through the hippocampus showed a trend for poor seizure outcome (p = 0.08). A comparison of baseline and post-operative neurocognitive testing revealed areas of both improvement and worsening, which were not associated with ablation volume or trajectory. The authors concluded that at 1-year follow-up, LITT appeared to be a safe and effective tool for the treatment of mTLE, although a longer follow-up period is needed to confirm these observations. Better understanding of the impact of ablation volume and location could potentially fine-tune this technique to improve seizure-freedom rates and associated neurologic and cognitive changes.

Yin et al (2017) stated that LITT has become an alternative to open-resective surgery for refractory mTLE. Occurrence of visual field defects (VFDs) following open surgery for mTLE has been reported at 52 to 100 %. These researchers examined the rate of VFDs following LITT for amygdalohippocampectomy (AHE) and correlated the occurrence of VFDs with damage to the optic radiations, assessed by diffusion tensor tractography (DTI). They performed a retrospective analysis of 5 patients who underwent LITT-AHE for medically refractory mTLE. They examined the association between VFDs and optic radiation damage by correlating post-procedural visual field testing with qualitative assessment of optic radiation fiber tracts. Post-operative assessments showed that 4 patients had normal visual field testing, and 1 had a right superior quadrantanopsia (20 %). These investigators performed 3-D reconstruction of the optic radiation, laser probe trajectory, and ablation volume. Damage to Meyer's loop was determined consistent with the VFD. The authors concluded that short-term follow-up in this series
suggested that laser ablation AHE may be associated with a lower rate of VFD than has been reported for open AHE; these findings suggested that incorporating optic radiation mapping through DTI may pre-operatively help to minimize the risk of VFD following laser ablation AHE. Moreover, they stated that a larger series with long-term follow-up is needed to assess the robustness of this finding.

Shukla and colleagues (2017) stated that medically intractable epilepsy is associated with increased morbidity and mortality. For those with focal epilepsy and correlated electrophysiological or radiographic features, open surgical resection can achieve high rates of seizure control, but can be associated with neurologic deficits and cognitive effects. Recent innovations have allowed for more minimally invasive methods of surgical seizure control such as magnetic resonance-guided laser interstitial therapy (MRgLITT). MRgLITT achieves the goal of ablating seizure foci while preserving neuropsychological function and offering real-time feedback and monitoring of tissue ablation. These investigators summarized the utilization of MRgLITT for mesial temporal lobe epilepsy (MTLE) and other seizure disorders. The authors concluded that MRgLITT is a safe and effective therapeutic option for the management of medically intractable epilepsy in the adult and pediatric populations. Of particular significance is the minimally invasive nature of MRgLITT, which enables the surgical management of patients who are not good candidates for, or are otherwise averse to, open resection. Compared to other minimally invasive procedures, MRgLITT is associated with improved outcomes and better side effect profile. While open surgical procedures have demonstrated slightly higher rates of seizure freedom, MRgLITT is associated with reduced hospitalization time, decreased post-operative pain, and improved neuropsychological function. However, they noted that the studies reviewed were limited by small samples sizes and the relative novelty of the procedure. Other limitations of the currently available data included the lack of long-term outcomes data and a scarcity of randomized controlled trials. They stated that future studies may seek to address these gaps while also looking at questions around the use of the procedure for multi-focal epilepsy and the relationship between time from diagnosis and MRgLITT efficacy.

Lagman and associates (2017) stated that MRgLITT is a novel minimally invasive modality that uses heat from laser probes to destroy tissue. Advances in probe design, cooling mechanisms, and real-time MR thermography have increased laser utilization in neurosurgery. These researchers performed a systematic analysis of 2 commercially available MRgLITT systems used in neurosurgery: the Visualase thermal therapy and NeuroBlate Systems. Data extraction was performed in a blinded fashion. A total of 22 articles were included in the quantitative synthesis; 223 patients were identified with the majority having undergone treatment with Visualase (n = 154, 69 %). Epilepsy was the most common indication for Visualase thermal therapy (n = 8 studies, 47 %). Brain mass was the most common indication for NeuroBlate therapy (n = 3 studies, 60 %). There were no significant differences, except in age, wherein the
NeuroBlate group was nearly twice as old as the Visualase group (p < 0.001). Frame, total complications, and length-of-stay (LOS) were non-significant when adjusted for age and number of patients. The authors concluded that laser neurosurgery has evolved over recent decades. Clinical indications are currently being defined and will continue to emerge as laser technologies become more sophisticated. Moreover, they stated that head-to-head comparison of these systems was difficult given the variance in indications (and therefore patient population) and disparate literature.

Waseem and co-workers (2017) stated that there is a new focus on minimally invasive treatments for medically refractory MTLE; MRgLITT is one such minimally invasive procedure, which utilizes MRI guidance and real-time feedback to ablate an epileptogenic focus. A total of 38 patients presenting exclusively with MTLE and no other lesions (including neoplasia), who underwent MRgLITT were reviewed. These investigators evaluated a number of outcome measures, including seizure freedom, neuropsychological performance, complications, and other considerations; 18 (53 %) patients had an Engel class I outcome, 10 had repeat procedures/operations, and 12 post-procedural complications occurred. Follow-up time ranged from 6 to 38.5 months. There was a decreased length of procedure time, hospitalization time, and analgesic requirement when compared to open surgery. In cases of well-localized MTLE this procedure may offer similar (albeit slightly lower) rates of seizure freedom versus traditional surgery. The authors concluded that MRgLITT may be an alternative therapeutic option for high-risk surgical patients and, more importantly, could increase referrals for surgery in patients with medically refractory MTLE. Moreover, they stated that available data are limited and long-term outcomes have not been evaluated; further investigation is needed to understand the potential of this minimally invasive technique for MTLE.

Tao and colleagues (2018) determined the outcomes of combined stereo-electroencephalography-guided and MRgLITT in the treatment of patients with drug-resistant MTLE. These researchers prospectively assessed the surgical and neuropsychological outcomes in 21 patients with medically refractory MTLE who underwent LITT at the University of Chicago Medical Center. They further compared the surgical outcomes in patients with and without mesial temporal sclerosis (MTS). Of the 21 patients, 19 (90 %) underwent Invasive EEG study and 11 (52 %) achieved freedom from disabling seizures with a mean duration of post-operative follow-up of 24 ± 11 months after LITT; 8 (73 %) of 11 patients with MTS achieved freedom from disabling seizures, whereas 3 (30 %) of 10 patients without MTS achieved freedom from disabling seizures. Patients with MTS were significantly more likely to become seizure-free, as compared with those without MTS (p = 0.002). There was no significant difference in total ablation volume and the percentage of the ablated amygdalo-hippocampal complex between seizure-free and non-seizure-free patients. Pre-surgical and post-surgical neuropsychological assessments were obtained in 10 of 21 patients. While there was no group
decline in any neuropsychological assessment, a significant post-operative decline in verbal memory and confrontational naming was observed in individual patients. The authors concluded that MRgLITT is a safe and effective alternative to selective amygdalo-hippocampectomy and anterior temporal lobectomy for MTLE with MTS. Nevertheless, its efficacy in those without MTS appeared modest. Moreover, they stated that large multi-center and prospective studies are needed to further determine the efficacy and safety of LITT.

Bezchlibnyk and colleagues (2018) noted that stereotactic laser ablation of mesial temporal structures is a promising new surgical intervention for patients with MTLE. Since this procedure was first used to treat MTLE in 2010, the literature contains reports of 37 patients that underwent MR-guided stereotactic laser amygdalo-hippocampotomy (SLAH) using LITT with at least 1 year of follow-up. This early body of data suggested that SLAH is a safe and effective treatment for MTLE in properly selected patients. Moreover, SLAH is substantially less invasive when compared with open surgical procedures including standard anterior temporal lobectomy and its more selective variants, resulted in immediate destruction of tissue in contrast to radio-surgical treatments for MTLE, and can more readily ablate larger volumes of tissue than is possible with techniques employing radiofrequency ablation. Finally, evidence is accruing that SLAH is associated with lower overall risk of neuropsychological deficits compared to open surgery. The authors concluded that LITT constitutes a novel minimally invasive tool in the neurosurgeon's armamentarium for managing medically refractory seizures that may draw eligible patients to consider surgical interventions to manage their seizures.

Drane (2018) reviewed cognitive outcome data regarding the use of MR-guided stereotactic laser ablation (SLA) as an epilepsy surgical procedure, with comparisons drawn to traditional open resection procedures. Cognitive outcome with SLAH appeared better than open resection for several functions dependent on extra-mesial temporal lobe (TL) structures, including category-related naming, verbal fluency, as well as object/familiar person recognition. Preliminary data suggested episodic, declarative verbal memory can decline following SLAH in the language dominant hemisphere, although early findings suggested comparable or even superior outcomes compared with open resection. The hippocampus has long been considered a central structure supporting episodic, declarative memory, with epilepsy surgical teams attempting to spare it whenever possible. However, ample data from animal and human neuroscience research suggested declarative memory deficits were greater following broader mesial TL lesions that include para-hippocampal gyrus and lateral TL inputs. Thus, utilization of a neurosurgical technique that restricts the surgical lesion zone holds promise for achieving a better cognitive outcome. Focal SLA lesions outside of the amygdalo-hippocampal complex may impair select cognitive functions, although few data have been published in such patients to-
The author concluded that SLA is being effectively employed with adults and children with TL or lesional epilepsies across several U.S. epilepsy centers, which may simultaneously optimize cognitive outcome while providing a curative treatment for seizures.

Kang and Sperling (2018) stated that a procedure called LITT has been utilized to treat drug resistant epilepsy. With this technique, a probe is stereotactically inserted into a target structure responsible for seizures, such as mesial temporal lobe, hypothalamic hamartoma, or a small malformation of cortical development, and the tip is then heated by application of laser energy to ablate structures adjacent to the probe tip. This procedure has the advantage of selectively targeting small lesions responsible for seizures, and is far less invasive than open surgery with shorter hospitalization, less pain, and rapid return to normal activities. Initial results in MTLE are promising, with perhaps 50% of patients becoming seizure-free after the procedure. Neuropsychological deficits appeared to be reduced because of the smaller volume of ablated cortex in contrast to large resections. The authors concluded that more research must be carried out to establish optimal targeting of structures for ablation and selection of candidates for surgery, and more patients must be studied to better establish efficacy and adverse effect rates.

Youngerman and co-workers (2018) noted that SLAH using MRgLITT is emerging as a therapeutic option for drug-resistant MTLE; SLAH is less invasive than open resection, but there are limited series reporting its safety and efficacy, particularly in patients without clear evidence of mesial temporal sclerosis (MTS). These investigators reported seizure outcomes and complications in their first 30 patients who underwent SLAH for drug-resistant MTLE between January 2013 and December 2016. They compared patients who required stereo-electroencephalography (SEEG) to confirm mesial temporal onset with those treated based on imaging evidence of MTS. A total of 12 patients with SEEG-confirmed, non-MTS MTLE and 18 patients with MRI-confirmed MTS underwent SLAH. MTS patients were older (median age of 50 versus 30 years) and had longer standing epilepsy (median of 40.5 versus 5.5 years) than non-MTS patients. Engel class I seizure freedom was achieved in 7 of 12 non-MTS patients (58%, 95% confidence interval [CI]: 30% to 86%) and 10 of 18 MTS patients (56%, 95% CI: 33% to 79%), with no significant difference between groups (odds ratio [OR] 1.12, 95% CI: 0.26 to 4.91, p = 0.88). Length of stay was 1 day for most patients (range of 0 to 3 days). Procedural complications were rare and without long-term sequelae. The authors reported similar rates of seizure freedom following SLAH in patients with MTS and SEEG-confirmed, non-MTS MTLE. Consistent with early literature, these rates were slightly lower than typically observed with surgical resection (60% to 80%). However, SLAH was less invasive than open surgery, with shorter hospital stays and recovery, and severe procedural complications were rare. They stated that SLAH may be a reasonable first-line surgical option for patients with both MTS and SEEG confirmed, non-MTS MTLE.
Englot (2018) noted that epilepsy surgery has seen numerous technological advances in both diagnostic and therapeutic procedures in recent years. This has increased the number of patients who may be candidates for intervention and potential improvement in quality of life. However, the expansion of the field also necessitates a broader understanding of how to incorporate both traditional and emerging technologies into the care provided at comprehensive epilepsy centers. The author summarized both old and new surgical procedures in epilepsy using an example algorithm. While treatment algorithms are inherently over-simplified, incomplete, and reflect personal bias, they provided a general framework that can be customized to each center and each patient, incorporating differences in provider opinion, patient preference, and the institutional availability of technologies. For instance, the use of minimally invasive SEEG has increased dramatically over the past decade, but many cases still benefit from invasive recordings using subdural grids. Furthermore, although surgical resection remains the gold-standard treatment for focal mesial temporal or neocortical epilepsy, ablative procedures such as LITT or stereotactic radiosurgery (SRS) may be appropriate and avoid craniotomy in many cases. Furthermore, while palliative surgical procedures were once limited to disconnection surgeries, several neuro-stimulation treatments are now available to treat eloquent cortical, bi-temporal, and even multi-focal or generalized epilepsy syndromes.

Brown and colleagues (2018) noted that epilepsy is a common neurological disorder occurring in 3% of the US adult population. It is characterized by seizures resulting from aberrant hyper-synchronous neural activity. Approximately 1/3 of newly diagnosed epilepsy cases fail to become seizure-free in response to anti-seizure drugs. Optimal seizure control, in cases of drug-resistant epilepsy, often requires surgery targeting seizure foci, such as the temporal lobe. Advances in minimally invasive ablative surgical approaches have led to the development of MRgLITT. For refractory epilepsy, this surgical intervention offers many advantages over traditional approaches, including real-time lesion monitoring, reduced morbidity, and in some reports increased preservation of cognitive and language processes. These researchers reviewed the use of LITT for epileptogenic indications in the context of its application as a curative (seizure freedom) or palliative (seizure reduction) measure for both lesional and non-lesional forms of epilepsy. Furthermore, they addressed the use of LITT for a variety of extra-temporal lobe epilepsies.

An UpToDate review on “Surgical treatment of epilepsy in adults” (Cascino, 2018) states that “The most common surgical procedure for mesial temporal epilepsy is resection of the anterior temporal pole, hippocampus, and part of the amygdala ... Selective amygdalohippocampectomy has been explored as an alternative to anterior temporal lobectomy that spares the temporal lobe neocortex. Seizure control rates might be inferior with a selective approach, however, and
potential differences in neurocognitive outcomes have not been well studied. Other minimally invasive or noninvasive approaches are under investigation. The role of radiosurgery in mesial temporal lobe epilepsy related to mesial temporal sclerosis is not yet clear”.

Focal Cortical Dysplasias

Ellis and colleagues (2016) noted that anatomically complex focal cortical dysplasias may present significant challenges to safe and complete surgical resection via standard operative corridors. Laser interstitial thermal therapy is an emerging minimally invasive technique that may address some of these challenges, enabling stereotactic ablation of deep and/or surgically inaccessible regions. However, complete ablation may not be feasible in all cases. To address this dilemma, these researchers designed a protocol utilizing staged LITT followed by topectomy to effect complete obliteration of a complex focal cortical dysplasia. The authors concluded that this approach demonstrated the feasibility, safety, and clinical utility of combining laser ablation and open surgery for the definitive management of this lesion. The clinical value of this approach needs to be ascertained in well-designed studies.

Mesial Temporal Lobe Epilepsy

Waseem and co-workers (2015) noted that selective anterior mesial temporal lobe (AMTL) resection is considered a safe and effective treatment for medically refractory mesial temporal lobe epilepsy (mTLE). However, as with any open surgical procedure, older patients (aged 50+ years) face greater risks. Magnetic resonance-guided laser interstitial thermal therapy has shown potential as an alternative treatment for mTLE. As a less invasive procedure, MRgLITT could be particularly beneficial to older patients. To the authors’ knowledge, no study has evaluated the safety and effectiveness of MRgLITT in this population. In this case-series study, a total of 7 consecutive patients (aged 50+) undergoing MRgLITT for mTLE were followed prospectively to assess surgical time, complications, post-operative pain control, length of stay (LOS), operating room (OR) charges, total hospitalization charges, and seizure outcome; 5 of these patients were assessed at the 1-year follow-up for seizure outcome. These data were compared with data taken from 7 consecutive patients (aged 50+) undergoing AMTL resection. Both groups were of comparable age (mean of 60.7 years (MRgLITT) versus 53 years (AMTL)); 1 AMTL resection patient had a complication of aseptic meningitis; 1 MRgLITT patient experienced an early post-operative seizure, and 2 MRgLITT patients had a partial visual field deficit. Seizure-freedom rates were comparable (80 % (MRgLITT) and 100 % (AMTL) (p > 0.05)) beyond 1 year post-surgery (mean follow-up of 1.0 years (MRgLITT) versus 1.8 years (AMTL)). Mean LOS was shorter in the MRgLITT group (1.3 days versus 2.6 days (p < 0.05)). Neuropsychological outcomes were comparable. The authors concluded that short-term follow-up suggested that MRgLITT was safe and provided outcomes comparable to AMTL resection in
This population. It also decreased pain medication requirement and reduced LOS. Moreover, they stated that further studies are needed to evaluate the long-term effectiveness of the procedure.

Gross and colleagues (2016) stated that stereotactic laser amygdalo-hippocampotomy (SLAH) uses MRgLITT. This novel intervention can achieve seizure freedom while minimizing collateral damage compared to traditional open surgery, in patients with mTLE. An algorithm was presented to guide treatment decisions for initial and repeat procedures in patients with and without mesial temporal sclerosis. The authors concluded that SLAH may improve access by medication-refractory patients to effective surgical treatments and thereby decrease medical complications, increase productivity, and minimize socioeconomic consequences in patients with chronic epilepsy.

Kang and associates (2016) described mesial temporal lobe ablated volumes, verbal memory, and surgical outcomes in patients with medically intractable mTLE treated with MRgLITT. These researchers prospectively tracked seizure outcome in 20 patients at Thomas Jefferson University Hospital with drug-resistant mTLE who underwent MRI-guided LITT. Surgical outcome was assessed at 6 months, 1 year, 2 years, and at the most recent visit. Volume-based analysis of ablated mesial temporal structures was conducted in 17 patients with mesial temporal sclerosis (MTS) and results were compared between the seizure-free and not seizure-free groups. Following LITT, proportions of patients who were free of seizures impairing consciousness (including those with auras only) were as follows: 8 of 15 patients (53 %, 95 % CI: 30.1 to 75.2 %) after 6 months, 4 of 11 patients (36.4 %, 95 % CI: 14.9 to 64.8 %) after 1 year, 3 of 5 patients (60 %, 95 % CI: 22.9 to 88.4 %) at 2-year follow-up. Median follow-up was 13.4 months after LITT (range of 1.3 months to 3.2 years). Seizure outcome after LITT suggested an all or none response; 4 patients had anterior temporal lobectomy (ATL) after LITT; 3 were seizure-free. There were no differences in total ablated volume of the amygdalo-hippocampus complex or individual volumes of hippocampus, amygdala, entorhinal cortex, para-hippocampal gyrus, and fusiform gyrus between seizure-free and non-seizure-free patients. Contextual verbal memory performance was preserved after LITT, although decline in non-contextual memory task scores were noted. The authors concluded that MRI-guided stereotactic LITT is a safe alternative to ATL in patients with medically intractable mTLE. Individualized assessment is needed to examine if the reduced odds of seizure freedom are worth the reduction in risk, discomfort, and recovery time. They stated that larger prospective studies are needed to confirm these preliminary findings, and to define optimal ablation volume and ideal structures for ablation.

Placental Chorioangiomas
Hosseinzadeh et al (2015) reviewed techniques and outcomes of different prenatal treatments for large placental chorioangiomas. These investigators presented case of laparoscopic-assisted laser coagulation and performed a systematic review of the literature for articles related to intervention for placental chorioangioma. A total of 37 cases of definitive (n = 23) and supportive therapy (n = 14) were evaluated, including 1 case treated in the authors’ center. Approximately 35 % of the patients had a spontaneous preterm delivery in definitive treatment group versus 36 % in the supportive group. The infant survival rates were 65 % and 71 % in the 2 groups, respectively. These researchers further compared the 2o types of laser ablation: (i) fetoscopic (n = 10) and (ii) interstitial (n = 4). Approximately 30 % of the patients in the fetoscopic and 25 % in interstitial group, had a spontaneous preterm delivery. Survival rates were 60 % and 100 % in fetoscopic and interstitial groups, respectively. The authors concluded that laser ablation and embolization of chorioangiomas via minimally invasive approach may prevent or reverse fetal hydrops due to high cardiac states. However, they stated that further studies are needed to refine the appropriate selection criteria that will justify the risk of this invasive in-utero therapy for chorioangiomas.

Brain Tumors

Lee and colleagues (2016) reviewed the role of LITT in the treatment of recurrent high-grade gliomas (HGGs) and discussed the possible role of LITT in the disruption of the blood-brain barrier (BBB) to increase delivery of chemotherapy locoregionally. These researchers performed a Medline search and identified 17 articles potentially appropriate for review. Of these 17, 6 reported currently commercially available systems and as well as magnetic resonance thermometry to monitor the ablation and, thus, were thought to be most appropriate for this review. These studies were then reviewed for complications associated with LITT. Ablation volume, tumor coverage, and treatment times were also reviewed. A total of 64 lesions in 63 patients with recurrent HGGs were treated with LITT. Frontal (n = 34), temporal (n = 14), and parietal (n = 16) were the most common locations. Permanent neurological deficits were seen in 7 patients (12 %), vascular injuries occurred in 2 patients (3 %), and wound infection was observed in 1 patient (2 %). Ablation coverage of the lesions ranged from 78 % to 100 %. The authors concluded that although experience using LITT for recurrent HGGs is growing, current evidence is insufficient to offer a recommendation about its role in the treatment paradigm for recurrent HGGs.

Thomas and associates (2016) noted that GBM is the most common and deadly malignant primary brain tumor. Better surgical therapies are needed for newly diagnosed GBMs that are difficult to resect and for GBMs that recur despite standard therapies. The authors reviewed their institutional experience of using LITT for the treatment of newly diagnosed or recurrent GBMs. This study reported on the pre-LITT characteristics and post-LITT outcomes of 8 patients with
newly diagnosed GBMs and 13 patients with recurrent GBM who underwent LITT. Compared with the group with recurrent GBMs, the patients with newly diagnosed GBMs who underwent LITT tended to be older (60.8 versus 48.9 years), harbored larger tumors (22.4 versus 14.6 cm³), and a greater proportion had IDH wild-type GBMs. In the newly diagnosed GBM group, the median PFS and the median survival after the procedure were 2 months and 8 months, respectively, and no patient demonstrated radiographic shrinkage of the tumor on follow-up imaging. In the 13 patients with recurrent GBM, 5 demonstrated a response to LITT, with radiographic shrinkage of the tumor following ablation. The median PFS was 5 months, and the median survival was greater than 7 months. The authors concluded that in carefully selected patients with recurrent GBM, LITT may be an effective alternative to surgery as a salvage treatment. Moreover, they stated that the role of LITT in the treatment of newly diagnosed unresectable GBMs is not established yet and requires further study.

Wright and co-workers (2016) described a combined approach of LITT followed by minimally invasive transsulcal resection for large and difficult-to-access (DTA) intracranial tumors. These investigators retrospectively reviewed the results of LITT immediately followed by minimally invasive, transsulcal, transportal resection in 10 consecutive patients with unilateral, DTA malignant tumors greater than 10 cm³. The patients, 5 males and 5 females, had a median age of 65 years; 8 patients had GBM, 1 had a previously treated GBM with radiation necrosis, and 1 had a melanoma brain metastasis. The median tumor volume treated was 38.0 cm³. The median tumor volume treated to the yellow thermal dose threshold (TDT) line was 83 % (range of 76 % to 92 %), the median tumor volume treated to the blue TDT line was 73 % (range of 60 % to 87 %), and the median extent of resection was 93 % (range of 84 % to 100 %); 2 patients suffered mild post-operative neurological deficits, 1 transiently; 4 patients died since this analysis and 6 remain alive. Median PFS was 280 days, and median OS was 482 days. The authors conclude that LITT followed by minimally invasive transsulcal resection is a novel option for patients with large, DTA, malignant brain neoplasms. There were no unexpected neurological complications in this series, and operative characteristics improved as surgeon experience increased. Moreover, they stated that further studies are needed to elucidate any differences in survival or QOL metrics.

Dadey and colleagues (2016) noted that sub-ependymal giant cell astrocytoma (SEGA) is a rare tumor occurring almost exclusively in patients with tuberous sclerosis complex. Although open resection remains the standard therapy, complication rates remain high. To minimize morbidity, less invasive approaches, such as endoscope-assisted resection, radiosurgery, and chemotherapy with mTOR pathway inhibitors, are also used to treat these lesions. Laser interstitial thermal therapy is a relatively new modality that is increasingly used to treat a variety of intracranial lesions. The authors described 2 pediatric cases of SEGA that were treated with LITT. In both patients the lesion responded well to this treatment modality, with tumor shrinkage
observed on follow-up MRI. They concluded that these cases highlighted the potential of LITT to serve as a viable minimally invasive therapeutic approach to the management of SEGAs in the pediatric population.

Leggett et al (2016) of the University of Calgary Health Technology Assessment Unit evaluated LITT for intracranial lesions and epilepsy. Two studies on epilepsy and four on intracranial lesions (two of which assessed the same patient population) were included in this systematic review of LITT. Three studies were case series, and two were non-randomized controlled studies. The authors found that there was substantial heterogeneity among the included studies, in terms of LITT device used, type of LITT, comparator, patient population, and outcomes measured. Among the two studies on epilepsy, one found that the LITT group experienced significantly less decline in famous face recognition and common names compared to SLAH. The other study found no statistically significant difference between seizure rates for those who had MRgLITT compared to anterior mesial temporal resection. Findings showed that length of stay was significantly shorter as was surgical time for those in the MRgLITT group, and the need for pain control was significantly less. Despite not finding a statistically significant improvement in seizure rates for those in the LITT group, this result suggests that LITT is equally effective at reducing seizures, while resulting in less pain, and shorter length of stay for patients. Among the studies on intracranial lesions, one found that in the seven months after LITT, 71% of patients had tumor progression with a median progression free survival of 5.1 months. Another found mean time to progression was 16 months for low grade astrocytomas, 10 months for anaplastic gliomas and 4 months for glioblastomas. After LITT, this study found that mean survival times were 34 months for low grade astrocytomas, 30 months for anaplastic gliomas and 9 months for glioblasmas. The last study did not present survival or time to progression, but reported that the area of thermal damage ranged from 0.95-9.63 cm2, and the median length of hospitalization was 24 hours.

Radiation Necrosis

In a single-center, retrospective study, Smith and colleagues (2016) evaluated the radiographic response and effectiveness of MRgLITT for biopsy-confirmed post-radiation treatment effect (PRTE) and the QOL outcomes of patients following MRgLITT. These investigators reviewed radiographic responses and clinical outcomes of 25 patients with previously treated primary or secondary brain neoplasms (WHO grades 4 [n = 8], 3 [n = 5], 2 [n = 5]) and metastatic brain tumors (n = 7); MRgLITT was applied directly following stereotactic needle biopsy confirming PRTE without any evidence of tumor presence. Mean OS times (months) for grades 4 and 3 and for metastatic brain tumors were 39.2 (standard error [SE], 7.6; 95 % CI: 24.3 to 54.1), 29.1 (SE, 7.7; 95 % CI: 14.0 to 44.2), and 55.9 (SE, 10.0; 95 % CI: 36.3 to 75.4), respectively. Mean PFS times after MRgLITT were 9.1 (SE, 3.6; 95 % CI: 2.1 to 16.1), 8.5 (SE, 2.4; 95 % CI: 3.9 to 13.2),
and 11.4 (SE, 3.9; 95 % CI: 3.8 to 19.0), respectively. Mean survival times after MRgLITT were 13.1 (SE, 2.3; 95 % CI: 8.5 to 17.6), 12.2 (SE, 4.0; 95 % CI: 4.4 to 20.0), and 19.2 (SE, 5.3; 95 % CI: 8.9 to 29.6), respectively. The SF-36 indicated significant overall effects on mental health (p = 0.029) and vitality (p = 0.005). The authors concluded that MRgLITT may be a viable option for patients with symptomatic advancing PRTE and is less invasive than open craniotomy. Moreover, they stated that although these findings suggested a positive effect for MRgLITT on PRTE, prospective randomized trials with larger numbers of patients are needed to validate the study results.

Rammo and associates (2018) noted that cerebral radiation necrosis (CRN) is a known complication of radiation therapy; and therapeutic options are limited and include steroids, bevacizumab, and surgery. These researchers examined the safety of LITT for CRN and identified the pattern of post-ablation volume change over time. Patients undergoing LITT for tumor treatment at Henry Ford Hospital between November 2013 and January 2016 with biopsy-confirmed CRN were prospectively collected and retrospectively reviewed with attention to ablation volume, survival, demographic data, steroid dose, and complications. Imaging occurred at set intervals beginning pre-ablation. A total of 10 patients with 11 ablations were evaluated; 4 patients had a primary diagnosis of high-grade glioma, while 6 had metastatic lesions. An average of 86 % of CRN volume was ablated. Ablation volume increased to 430 % of initial CRN volume at 1 to 2 weeks before decreasing to 69 % after 6 months. No patient had a decline in baseline neurological examination while in the hospital; 4 patients developed delayed neurological deficits likely due to post-operative edema, of which 3 improved back to baseline. The 6-month survival was 77.8 % and the 1-year survival was 64.8 % based on Kaplan-Meier curve estimates. The authors concluded that LITT was a relatively safe treatment for CRN, providing both a diagnostic and therapeutic solution for refractory patients. Significant increase in ablation volume was noted at 1 to 2 months, gradually decreasing in size to less than the original volume by 6 months. These investigators stated that further studies are needed to better-define the role of LITT in the treatment of CRN.

Seizures due to Hypothalamic Hamartoma

Du and colleagues (2017) noted that successful treatment of hypothalamic hamartoma (HH) can result in the resolution of its sequelae including epilepsy and rage attacks. Risks and morbidity of open surgical management of this lesion have motivated the development of LITT as a less invasive therapeutic approach to the disease. Although overall morbidity and risk would appear to be lower, complications related to LITT therapy have been reported, and the longer-term follow-up that is now possible after initial experience helps address the question of whether LITT provides equivalent efficacy compared to other therapeutic options. These researchers performed a retrospective analysis of clinical outcomes in 8 patients undergoing LITT for HH at...
their center using the Visualase/Medtronic device; 5 patients had refractory epilepsy, 1 had rage
attacks, and 2 had both. These investigators also compared the published seizure-free
outcomes over time and the complication rates for different interventional approaches to the
treatment of epilepsy due to HH including open craniotomy, neuro-endoscopic, radio-surgical,
and RF approaches. With a mean follow-up of 19.1 months in this series of 8 patients, 6 of 7
epilepsy patients achieved seizure freedom, whereas the 1 patient with rage attacks only did not
have improvement of his symptoms. A length of hospital stay of 2.6 days reflected low morbidity
and rapid post-operative recuperation with LITT. Considering other reported series and case
reports, the overall published seizure freedom rate of 21 of 25 patients was superior to published
outcomes of HH cases treated by stereotactic radiosurgery (SRS), craniotomy, or neuro-
endoscopy, and comparable to RFA. The authors concluded that the cumulative experience of
their center with other published series supported relatively lower operative morbidity than more
invasive approaches and efficacy that was as good or better than open craniotomy procedures
and SRS. They stated that although morbidity appeared to be lower than other open
approaches, complications related to LITT and their avoidance should be considered carefully.
Moreover, these investigators stated that these findings added to the ongoing collection of
patient experiences at multiple HH referral centers and provided encouraging results for
establishing LITT as a primary consideration for treatment planning when available. They noted
that important tasks remain to determine long-term Engel outcomes as longer-term clinical
follow-up becomes available and more patients undergo LITT.

Lagman and associates (2017) stated that MRgLITT is a novel minimally invasive modality that
uses heat from laser probes to destroy tissue. These investigators performed a systematic
analysis of 2 commercially available MRgLITT systems used in neurosurgery: (i) the Visualase
thermal therapy, and (ii) NeuroBlate System. Data extraction was performed in a blinded
fashion. A total of 22 articles were included in the quantitative synthesis. A total of 223 patients
were identified with the majority having undergone treatment with Visualase (n = 154, 69 %).
Epilepsy was the most common indication for Visualase therapy (n = 8 studies, 47 %). Brain
mass was the most common indication for NeuroBlate therapy (n = 3 studies, 60 %). There were
no significant differences, except in age, wherein the NeuroBlate group was nearly twice as old
as the Visualase group (p < 0.001). Frame, total complications, and length-of-stay (LOS) were
non-significant when adjusted for age and number of patients. The authors concluded that laser
neurosurgery has evolved over recent decades. Clinical indications are currently being defined
and will continue to emerge as laser technologies become more sophisticated.

Spinal Cord Compression and Spinal Instability
Tatsui et al (2015) stated that high-grade malignant spinal cord compression is commonly managed with a combination of surgery aimed at removing the epidural tumor, followed by spinal stereotactic radiosurgery (SSRS) aimed at local tumor control. These investigators introduced the use of spinal laser interstitial thermotherapy (SLITT) as an alternative to surgery prior to SSRS. Patients with a high degree of epidural malignant compression due to radio-resistant tumors were selected for study. Visual analog scale (VAS) scores for pain and quality of life (QOL) were obtained before and within 30 and 60 days after treatment. A laser probe was percutaneously placed in the epidural space. Real-time thermal MRI was used to monitor tissue damage in the region of interest. All patients received post-operative SSRS. The maximum thickness of the epidural tumor was measured, and the degree of epidural spinal cord compression (ESCC) was scored in pre- and post-procedure MRI. In the 11 patients eligible for study, the mean VAS score for pain decreased from 6.18 in the pre-operative period to 4.27 within 30 days and 2.8 within 60 days after the procedure. A similar VAS interrogating the percentage of QOL demonstrated improvement from 60 % pre-operatively to 70 % within both 30 and 60 days after treatment. Imaging follow-up 2 months after the procedure demonstrated a significant reduction in the mean thickness of the epidural tumor from 8.82 mm (95 % confidence interval [CI]: 7.38 to 10.25) before treatment to 6.36 mm (95 % CI: 4.65 to 8.07) after SLITT and SSRS (p = 0.0001). The median pre-operative ESCC Grade 2 was scored as 4, which was significantly higher than the score of 2 for Grade 1b (p = 0.04) on imaging follow-up 2 months after the procedure. The authors presented the first report on an innovative minimally invasive alternative to surgery in the management of spinal metastasis. In their early experience, SLITT has provided local control with low morbidity and improvement in both pain and the QOL of patients. This study represented the authors’ initial experience with this technique, and they recognize several limitations, including the small size of the cohort, the short follow-up, the lack of randomization, no direct comparison with surgery, and no standardization in the time for post-procedure SSRS. We believe this report laid the foundation for further investigation through a randomized prospective study to compare this technique with separation surgery prior to SSRS.

In a teaching case (a 39-year old man with imaging revealing widespread osseous lesions and biopsy confirming paraganglioma), Ghia et al (2016) demonstrated for the first time that quantitative SSRS is dosimetric advantages LITT may provide as a result of an effective decompression of the spinal canal. The procedure was performed without surgical morbidity and with fast recovery, avoiding a relatively extensive 2-level vertebrectomy with thoracolumbar stabilization. No significant artifacts on post-ablation MRI are noted following LITT, and treatment planning delineation of the target and critical structures such as the spinal cord were not affected. Given the minimally invasive nature of the procedure, patients may undergo SSRS with minimal delay following thermal ablation; as such, there is a potential for initiating systemic
therapy much sooner in patients treated with this method. The authors concluded that prospective analysis is needed to completely characterize the toxicity and effectiveness of this approach.

Jimenez-Ruiz et al (2016) described the anesthetic considerations in patients undergoing LITT for neurosurgical procedures. PubMed was searched in April 2016 using different combinations of the following MeSH terms: “Central nervous System”, “laser therapy”, “Ablation Techniques”, “Anesthesia”, and “Spinal Cord Neoplasms”. A total of 54 relevant manuscripts were included in this review article. The authors concluded that LITT is a promising therapeutic approach for multiple central nervous system disorders. Anesthesiologists must be familiar with the anesthetic considerations and the technical aspects of the procedure when providing care for patients undergoing LITT. The literature is scarce on the impact of different anesthesia and analgesia techniques on clinical outcomes. Therefore, studies comparing different anesthetic regimens and the impact on outcomes are needed to make relevant recommendations on the anesthesia care of these patients. These investigators noted that LITT has become increasingly popular for neurosurgical procedures. Current studies show promising outcomes for the treatment of intracranial and spinal tumors, radiation necrosis, and epilepsy. There is no relevant literature about the anesthetic care of these patients. Therefore, the authors cannot recommend a particular anesthesia-analgesia technique or intra-operative monitoring for patients undergoing LITT procedures. Careful understanding of the targeted lesions, patient’s co-morbidities and potential intra-operative and post-operative complications is needed in the planning of the anesthetic care of these patients.

Tatsui et al (2016a) stated that although surgery followed by radiation effectively treats metastatic epidural compression, the ideal surgical approach should enable fast recovery and rapid institution of radiation and systemic therapy directed at the primary tumor. These researchers evaluated SLITT as an alternative to surgery monitored in real time by thermal magnetic resonance (MR) images. Patients referred for spinal metastasis without motor deficits underwent MR-guided SLITT, followed by stereotactic radiosurgery. Clinical and radiological data were gathered prospectively, according to routine practice. MR imaging-guided SLITT was performed on 19 patients with metastatic epidural compression. No procedures were discontinued because of technical difficulties, and no permanent neurological injuries occurred. The median follow-up duration was 28 weeks (range of 10 to 64 weeks). Systemic therapy was not interrupted to perform the procedures. The mean preoperative VAS scores of 4.72 (SD ± 0.67) decreased to 2.56 (SD ± 0.71, p = 0.043) at 1 month and remained improved from baseline at 3.25 (SD ± 0.75, P = .021) 3 months after the procedure. The pre-operative mean EQ-5D index for QOL was 0.67 (SD ± 0.07) and remained without significant change at 1 month 0.79 (SD ± 0.06, p = 0.317) and improved at 3 months 0.83 (SD ± 0.06, p = 0.04) after SLITT. Follow-up MR imaging after 2 months revealed significant decompression of the neural component in 16
patients. However, 3 patients showed progression at follow-up, 1 was treated with surgical decompression and stabilization and 2 were treated with repeated SLITT. The authors concluded that MR-guided SLITT can be both a feasible and safe alternative to separation surgery in carefully selected cases of spinal metastatic tumor epidural compression. This was a small study (n= 19) with short-term follow-up (28 weeks). These preliminary findings need to be validated by well-designed studies.

Tatsui et al (2016b) noted that an emerging paradigm for treating patients with ESCC caused by metastatic tumors is surgical decompression and stabilization, followed by stereotactic radiosurgery. In the setting of rapid progressive disease, interruption or delay in return to systemic treatment can lead to a negative impact in overall survival. To overcome this limitation, these researchers introduced the use of SLITT in association with percutaneous spinal stabilization to facilitate a rapid return to oncological treatment. The authors retrospectively reviewed a consecutive series of patients with ESCC and spinal instability who were considered to be poor surgical candidates and instead were treated with SLITT and percutaneous spinal stabilization. Demographic data, Spine Instability Neoplastic Scale score, degree of epidural compression before and after the procedure, length of hospital stay, and time to return to oncological treatment were analyzed. A total of 8 patients were treated with thermal ablation and percutaneous spinal stabilization. The primary tumors included melanoma (n = 3), lung (n = 3), thyroid (n = 1), and renal cell carcinoma (n = 1). The median Karnofsky Performance Scale score before and after the procedure was 60, and the median hospital stay was 5 days (range of 3 to 18 days). The median Spine Instability Neoplastic Scale score was 13 (range of 12 to 16). The mean modified post-operative ESCC score (2.75 ± 0.37) was significantly lower than the pre-operative score (4.5 ± 0.27) (Mann-Whitney test, p = 0.0044). The median time to return to oncological treatment was 5 days (range of 3 to 10 days). The authors presented the first cohort of SLITT associated with a percutaneous spinal stabilization for the treatment of ESCC and spinal instability. This minimally invasive technique can allow a faster recovery without prejudice of adjuvant systemic treatment, with adequate local control and spinal stabilization.

This study demonstrated the authors’ initial experience with the concept of percutaneous separation surgery. The drawbacks of this study included: (i) the retrospective nature, (ii) the small sample size (n = 8) of the population, (iii) the short follow-up (follow-up imaging is performed generally 6 to 12 weeks after SLITT), (iv) the heterogeneity of histologies, and (v) the lack of comparison with the standard surgical technique, which may limit the interpretation of these findings. The authors stated that a randomized prospective study comparing open and percutaneous separation surgery is needed to evaluate the role of this new concept in the management of ESCC.
Tatsui et al (2017) stated that image guidance for spinal procedures is based on 3D-fluoroscopy or CT, which provide poor visualization of soft tissues, including the spinal cord. To overcome this limitation, these researchers developed a method to register intra-operative MRI (iMRI) of the spine into a neuro-navigation system, allowing excellent visualization of the spinal cord. This novel technique improved the accuracy in the deployment of LITT probes for the treatment of metastatic spinal cord compression. Patients were positioned prone on the MRI table under general anesthesia. Fiducial markers were applied on the skin of the back, and a plastic cradle was used to support the MRI coil. T2-weighted MRI sequences of the region of interest were exported to a standard navigation system. A reference array was sutured to the skin, and surface matching of the fiducial markers was performed. A navigated Jamshidi needle was advanced until contact was made with the dorsal elements; its position was confirmed with intra-operative fluoroscopy prior to advancement into a target in the epidural space. A screenshot of its final position was saved, and then the Jamshidi needle was exchanged for an MRI-compatible access cannula. MRI of the exact axial plane of each access cannula was obtained and compared with the corresponding screenshot saved during positioning. The discrepancy in millimeters between the trajectories was measured to evaluate accuracy of the image guidance. A total of 13 individuals underwent implantation of 47 laser probes. The median absolute value of the discrepancy between the location predicted by the navigation system and the actual position of the access cannulas was 0.7 mm (range of 0 to 3.2 mm). No injury or adverse event (AE) occurred during the procedures. The authors concluded that the findings of this study demonstrated the feasibility of image guidance based on MRI to perform LITT of spinal metastasis. They noted that their method permits excellent visualization of the spinal cord, improving safety and workflow during laser ablations in the epidural space. The results can be extrapolated to other indications, including biopsies or drainage of fluid collections near the spinal cord. This appeared to be a feasibility study.

Breast Cancer

Kerbage and colleagues (2017) stated that while breast specialists debate on therapeutic de-escalation in breast cancer, the treatment of benign lesions is also discussed in relation to new percutaneous ablation techniques. The purpose of these innovations is to minimize potential morbidity. Laser interstitial thermos-therapy is an option for the ablation of targeted nodules. These investigators evaluated the scientific publications investigating the LITT approach in malignant and benign breast disease; 3 pre-clinical studies and 8 clinical studies (2 studies including fibro-adenomas and 6 studies including breast cancers) were reviewed. The authors concluded that although the feasibility and safety of LITT have been confirmed in a phase-I clinical trial, heterogeneous inclusion criteria and methods appeared to be the main reason for LITT not being yet an extensively used therapeutic option. They stated that further development is needed before this technique can be used in daily practice.
Lung Cancer and Lung Metastases

Nour-Eldin and associates (2017) retrospectively compared the local tumor response and survival rates in patients with non-colorectal cancer lung metastases post-ablation therapy using LITT, RFA and microwave ablation (MWA). These researchers carried out a retrospective analysis of 175 CT-guided ablation sessions performed on 109 patients (43 men and 66 women, mean age of 56.6 years); 17 patients with 22 lesions underwent LITT treatment (tumor size: 1.2 to 4.8 cm), 29 patients with 49 lesions underwent RFA (tumor size: 0.8 to 4.5 cm) and 63 patients with 104 lesions underwent MWA treatment (tumor size: 0.6 to 5 cm); CT scans were performed 24-hour post-therapy and on follow-up at 3, 6, 12, 18 and 24 months. The OS rates at 1-, 2-, 3- and 4-year were 93.8, 56.3, 50.0 and 31.3 % for patients treated with LITT; 81.5, 50.0, 45.5 and 24.2 % for patients treated with RFA and 97.6, 79.9, 62.3 and 45.4 % for patients treated with MWA, respectively. The mean survival time was 34.14 months for MWA, 34.79 months for RFA and 35.32 months for LITT. In paired comparison, a significant difference could be detected between MWA versus RFA (p = 0.032). The PFS showed a median of 23.49 ± 0.62 months for MWA, 19.88 ± 2.17 months for LITT, and 16.66 ± 0.66 months for RFA (p = 0.048). The lowest recurrence rate was detected in lesions ablated with MWA (7.7 %; 8 of 104 lesions) followed by RFA (20.4 %; 10 of 49 lesions) and LITT (27.3 %; 6 of 22 lesions); p value of 0.012.

Pneumothorax was detected in 22.16 % of MWA ablations, 22.73 % of LITT ablations and 14.23 % of RFA ablations. The authors concluded that LITT, RFA and MWA may provide an effective therapeutic option for non-colorectal cancer lung metastases with an advantage for MWA regarding local tumor control and PFS rate. The sample size for the LITT-treated group was small (n = 17) and the 2- to 4-year OS rates were low-to modest. These findings need to be further investigated.

Casal and colleagues (2018) stated that population aging and lung cancer screening strategies may lead to an increase in detection of early-stage lung cancer in medical inoperable patients. Recent advances in peripheral bronchoscopy have made it a suitable platform for ablation of small peripheral tumors. These investigators examined the tissue-ablative effect of a diode laser bronchoscopically applied by a laser delivery fiber (LDF) with wide aperture on porcine lung parenchyma. Laser was tested ex-vivo and in-vivo to identify the most effective power settings and LDF. Chest CT were obtained immediately after ablation and after 3 days of observation. At day 3, necropsy was performed. On the basis of these ex-vivo and in-vivo experiments, these researchers selected the round-tip LDF to be activated at 25 W for 20 seconds; 10 ablations were performed in 5 pigs; 1 ablation resulted in a pneumothorax requiring aspiration. All animals remained stable for 72 hours; CT findings at days 1 and 3 showed an area of cavitation surrounded by consolidation and ground glass. Median size of CT findings (long axis) was 26 mm (range of 24 to 38) at day 1, and 34 mm (range of 30 to 44) at day 3. Necropsy showed an area of central char measuring from 0.8×0.7×0.9 cm to 2.4×3.5×1.2 cm, surrounded by a gray-
brown to dark red area. On histology, variable degrees of necrosis were evident around the charred areas. The authors concluded that bronchoscopic LITT can achieve relatively large areas of ablation of normal lung parenchyma with a low rate of peri-procedural complications.

Brain Metastases

Salehi et al (2018) stated that treatment approaches for metastatic brain tumors continue to evolve, with increasing recent emphasis on focal therapies whenever possible. Magnetic resonance imaging (MRI)-guided laser interstitial thermal therapy (LITT) is a minimally invasive surgical option that has broadened the capability of the neurosurgeon in treating difficult-to-treat intracranial lesions. This technology uses image-guided delivery of laser to the target lesion to generate heat and thereby ablate pathological tissue and has expanded the neurosurgical armamentarium for surgical treatment of brain metastases. In this study, these researchers described the indications for LITT in the management of intracranial metastatic disease and reported their institutional experience with LITT. These investigators stated that the efficacy of LITT as frontline therapy, particularly in small tumors, remains to be determined and will likely require a clinical trial testing the clinical benefit of LITT versus stereotactic radiosurgery (SRS) with a larger number of patients. But it is the opinion of the authors that safe supra-marginal ablation by LITT might represent an interesting alternative to SRS.

Hernandez et al (2019) noted that in patients who have previously undergone maximum radiation for metastatic brain tumors, a progressive enhancing inflammatory reaction (PEIR) that represents either tumor recurrence or radiation necrosis, or a combination of both, can occur; and MRI-guided LITT offers a minimally invasive therapeutic option for this problem. These investigators reported their single-center experience using LITT to treat PEIRs after radiosurgery for brain metastases. Patients with progressive, enhancing reactions at the site of prior radiosurgery for metastatic brain tumors and who had a Karnofsky performance status of greater than or equal to 70 were eligible for LITT. The primary end-point was local control. Secondary end-points included dexamethasone use and procedure-related complications. Between 2010 and 2017, a total of 59 patients who underwent 74 LITT procedures for 74 PEIRs met inclusion criteria. The mean pre-LITT PEIR size measured 3.4 ± 0.4 cm³. At a median follow-up of 44.6 weeks post-LITT, the local control rate was 83.1 %. Most patients were weaned off steroids post-LITT. Patients experiencing a post-LITT complication were more likely to remain on steroids indefinitely. The rate of new permanent neurological deficit was 3.4 %. The authors concluded that LITT is an effective treatment for local control of PEIRs after radiosurgery for metastatic brain disease. When possible, these researchers recommended offering LITT once PEIRs are identified and prior to the initiation of high-dose steroids for symptom relief.
This study had several drawbacks. First, 15 (20.3%) of the 74 treated lesions were lost to or had inadequate follow-up at the time of data analysis, which may contribute to selection bias. Second, while these researchers have reported local control with a moderate follow-up period, they did not have data on quality of life (QOL) measures. As LITT continues to emerge as a minimally invasive therapeutic option for intracranial lesions, it would be important to know its effect on QOL. These researchers stated that future studies should include such data. Finally, although this present study represented the largest series examining LITT for PEIRs following radiosurgery for brain metastases, with the longest follow-up (about 45 weeks) to-date, larger studies with longer follow-up are needed.

Alattar et al (2019) stated that the optimal treatment of brain metastases recurring after radiosurgery (BMRS) remains an area of active investigation. Stereotactic laser ablation (SLA, also known as LITT) has recently emerged as a potential therapeutic option. These investigators examined the available literature on SLA as treatment for BMRS and synthesized findings on local control, OS, neurological outcome, imaging findings, morbidity, and post-procedure clinical course. They performed a comprehensive search of PubMed for articles investigating SLA as treatment for BMRS. A total of 13 peer-reviewed publications met search criteria. Local control was a function of percent of tumor that was thermally ablated. In completely ablated tumors, 3-month local control was 80 to 100%. Median survival ranged from 5.8 to 19.8 months. About 2/3 of treated lesions showed post-ablation expansion of contrast-enhancing and FLAIR volumes (CEv and FLAIRv). Expansion could start within an hour of treatment and resolution typically occurred within 6 months. Notably, maximal expanded CEv could reach greater than 3-fold the pre-operative lesion volume. The incidence of SLA-related permanent neurologic injuries was less than 10%. The most common complications were hemorrhage, thermal injury causing neurological deficit, and malignant cerebral edema. While nearly all patients were treated with dexamethasone, there was variability in dose and duration of therapy. Median hospital stay was 1 to 2 days (range of 1 to 5), and most treated patients were discharged home (range of 59.5 to 100%). The authors concluded that this analysis provided support for continued development of SLA as a treatment for BMRS; standardization of peri-procedural management are needed.

Extra-Axial Meningiomas

Ruiz et al (2019) examined the applicability of laser thermal ablation and its utility in the treatment of extra-axial (EA) brain neoplasms, mainly meningioma. These investigators described their experience in a group of symptomatic patients from their institution with EA masses, mainly recurrent meningiomas, that failed previous more conventional treatment therapies such as surgery and radiotherapy. They emphasized patient selection, indications for the procedure, and post-treatment imaging characteristics of the ablated lesions. The authors concluded that their preliminary experience of 5 patients -- EA meningiomas (4 patients), and
fibrous tumor (1 patient) – suggested that a successfully ablated lesion would have the following imaging characteristics: no significant change in size or configuration of the lesion in the initial post ablation periods, lack of gadolinium enhancement (vanishing enhancing sign) at the core of the ablated mass within the radius of effective thermal ablation (3 cm), with the lack of core enhancement being the most reliable imaging sign of successful treatment. Recurrence, if it occurs, will present at the periphery of the treated mass beyond the radius of effective thermal ablation. These preliminary findings need to be validated by well-designed studies.

Glioblastoma

Missios et al (2015) noted that laser interstitial thermal therapy (LITT) is a minimally invasive technique for treating intra-cranial tumors, originally introduced in 1983. Its use in neurosurgical procedures was historically limited by early technical difficulties related to the monitoring and control of the extent of thermal damage. The development of magnetic resonance thermography and its application to LITT have allowed for real-time thermal imaging and feedback control during laser energy delivery, allowing for precise and accurate provision of tissue hyperthermia. Improvements in laser probe design, surgical stereotactic targeting hardware, and computer monitoring software have accelerated acceptance and clinical utilization of LITT as a neurosurgical treatment alternative. Current commercially available LITT systems have been used for the treatment of neurosurgical soft-tissue lesions, including difficult to access brain tumors, malignant gliomas, and radiosurgery-resistant metastases, as well as for the ablation of such lesions as epileptogenic foci and radiation necrosis. The authors analyzed the literature to describe the advent of LITT as a neurosurgical, laser excision tool, including its development, use, indications, and efficacy as it related to neurosurgical applications. The authors concluded that LITT has emerged as a promising modality in neurosurgery for the treatment of lesions that are surgically inaccessible or have failed to be resolved by standard treatment modalities. The initial technical difficulties that limited its initial use have been largely overcome, and several studies have demonstrated the safety profile of this technique. Moreover, these researchers stated that larger prospective series and standardized indications and protocols are needed to demonstrate the efficacy of this technique for these challenging pathologies.

Kamath et al (2019) stated that despite the multitude of available treatments, glioblastoma (GBM) remains an aggressive and uniformly fatal tumor; LITT is a novel, minimally invasive treatment that holds promise for treating patients with GBM who are not candidates for traditional open craniotomy. However, due to the recent introduction of LITT into clinical practice, large series that evaluate safety and long-term outcomes after LITT are lacking. These investigators presented their institution's series of over 50 GBM patients treated with LITT, with regard to safety, efficacy, and outcomes. They carried out a retrospective descriptive study of patients with histologically proven GBM who underwent LITT. Data collected included demographics, tumor
location and volume, tumor genetic markers, treatment volume, peri-operative complications, and long-term follow-up data. These researchers performed 58 LITT treatments for GBM in 54 patients over 5.5 years; 41 were recurrent tumors while 17 were frontline treatments; 40 GBMs were lobar in location, while 18 were in deep structures (thalamus, insula, corpus callosum).

Average tumor volume was $12.5 \pm 13.4$ cm³. Average percentage of tumor treated with the yellow thermal damage threshold (TDT) line (dose equivalent of 43°C for 2 mins) was $93.3 \% \pm 10.6 \%$, and with the blue TDT line (dose equivalent of 43°C for 10 mins) was $88.0 \% \pm 14.2 \%$. There were 7 peri-operative complications (12 %) and 2 mortalities (3.4 %). Median overall survival (OS) following LITT for the total cohort was 11.5 months, and median progression-free survival (PFS) was 6.6 months. The authors concluded that LITT appeared to be a safe and effective treatment for GBM in properly selected patients.

The drawbacks of this study included its retrospective, descriptive design/nature; and it was a single-center, 2-surgeon trial, which may limit its generalizability. Furthermore, research-phase drugs and devices were not controlled. The authors stated that future studies comparing LITT and craniotomy are needed.

An UpToDate review on “Overview of the treatment of brain metastases” (Loeffler, 2019) states that “Other local techniques, such as laser interstitial thermal therapy, are also under investigation for recurrent brain metastases as well as radiation necrosis”.

Furthermore, National Comprehensive Cancer Network’s clinical practice guideline on “Central nervous system cancers” (Version 1.2019) does not mention LITT as a therapeutic option.

Intra-Cranial Meningioma

Rammo et al (2019) noted that recurrent meningiomas can prove problematic for treatment, especially if anaplastic, as options are limited primarily to surgery and radiation therapy. These researchers examined the use of LITT in the setting of recurrent meningiomas. Patients undergoing LITT for tumor treatment at the authors’ institution between November 2014 and February 2016 were identified. Those with biopsy-confirmed meningiomas were reviewed with attention to ablation volume, survival, demographic data, and complications. Data from imaging performed at set intervals post-operatively were available for all. A total of 4 patients were identified, 3 had successful treatment with a total of 4 ablations. The 1 case that did not result in a successful ablation was due to problems with stereotactic placing of the laser catheter. One patient had a Grade-1 meningioma, with the other 2 being Grade-3. Immediate ablation volumes averaged 75 % of pre-operative tumor volume and increased to 97 % at 2 weeks before dropping to 65 % at 3 months. One patient had acute hemiparesis with speech difficulty, which resolved after 6 months. At the last follow-up, 2 of 3 subjects had progression at an average of 9
weeks, and 1 had no progression at 28 weeks. The authors concluded that LITT appeared to be a potentially viable treatment for recurrent meningiomas. Ablation volumes increased over time, but not beyond the initial meningioma volume. Moreover, these researchers stated that larger studies are needed to better determine complications and outcomes.

Posterior Fossa Tumors

Borghei-Razavi et al (2019) noted that the application of LITT for intra-cranial lesions in the posterior fossa tumors remains challenging due to the smaller size of this compartment as well as the thickness and angle of the occipital bone. These investigators retrospectively reviewed their series of 8 patients with posterior fossa tumors treated with LITT from an Institutional Review Board (IRB)-approved brain tumor database (2012 to 2017) of more than 200 cases at their institution. The 8 patients underwent LITT targeting 3 metastases, 2 pilocytic astrocytomas, 2 zones of radiation necrosis after radiosurgery, and 1 GBM. The mean pre-operative lesion volume was 4.35 cm3. A 6 months post-surgery, the mean lesion volume had decreased from 9.64 cm3 to 5.72 cm3; 2 of the tumors (the GBM and a metastatic adenocarcinoma) progressed after 8.5 and 7.5 months, respectively, with mortality after 1.1 and 1.6 years, respectively. Surgical resection was performed in 1 patient with metastatic adenocarcinoma tumor at 7.7 months after LITT. All other lesions remained stable or were diminished at a median follow-up of 14.8 months (range of 0.4 to 37.5 months); MRI on the 1st post-operative day, showed an increase in mean tumor-related edema volume from 9.45 cm3 to 14.10 cm3. After a post-operative follow-up of at least 1 month, this mean decreased to 8.70 cm3. One case each of transient partial unilateral 6th cranial nerve palsy, superficial wound infection, and a late obstructive hydrocephalus were noted post-operatively. No mortality was associated with the procedure. The authors concluded that LITT is a safe and feasible treatment modality even in challenging locations like the posterior fossa. However, surgical indications should be tailored for each individual patient based on the size and location of tumor. This was a small study (n = 8) with short-term follow-up (6 months). These preliminary findings need to be confirmed with more studies with larger sample size and longer follow-up duration.

Tremor Disorders

Harris et al (2019) stated that medically intractable tremors are a common, difficult clinical situation. Deep brain stimulation decreases Parkinson's disease (PD) resting tremor and essential tremor, but not all patients are candidates from a diagnostic, medical, or social standpoint, prompting the need for alternative surgical strategies. These researchers described the findings of 13 patients with medically intractable tremor treated with laser interstitial thermal thalamotomy performed under general anesthesia using live MRI-guidance and the Clearpoint stereotactic system. All patients had a dramatic decrease in tremor immediately post-
operatively, which has been sustained through follow-up (3 to 17 months) in all but 1 patient (mean tremor score reduction of 62%; 10.33 ± 2.69 to 3.89 ± 3.1). Objective side effects were transient and included imbalance and paresthesia. The authors concluded that medically intractable tremor treated with laser interstitial thermal thalamotomy may be a useful addition to the treatment armamentarium for medically intractable tremor disorders. These preliminary findings need to be validated by well-designed studies.

Appendix

Recall for NeuroBlate Probe by Monteris Medical

In March 2018, the FDA provided preliminary information regarding the potential for unintended heating and patient injury with use of the Monteris Medical NeuroBlate probe, which is part of the NeuroBlate System, and announced a Class I recall for the device. A Class I recall is the most serious type of recall and is issued when use of the device may cause serious injuries or death. Monteris issued 3 product advisories between October and December 2017, which were part of the Class I recall; however, the FDA has concerns that the information provided by Monteris has not sufficiently mitigated the risk of unintended probe tip heating. They are working with the manufacturer to address these concerns. The device is currently the subject of a voluntary recall that was initiated by the firm, and classified as Class I by the FDA, due to several instances of unintended heating and damage to the probe, which may have resulted in unintended damage to surrounding brain tissue. The FDA has received medical device reports (MDRs) related to over-heating of the probe, including 1 report of a patient who experienced an intra-cranial hemorrhage and died, although causality with the device malfunction could not be concluded with certainty. The FDA stated that until appropriate mitigation strategies have been identified by the manufacturer and evaluated by the FDA, health care providers should strongly consider treating patients using alternative procedures if available. The risks and benefits of the device, as well as the availability and benefits and risks of alternative treatment modalities, should be considered on an individual patient basis. Healthcare providers who do not believe there is a viable alternative should use the device with extreme caution.

CPT Codes / HCPCS Codes / ICD-10 Codes

Information in the [brackets] below has been added for clarification purposes. Codes requiring a 7th character are represented by "+".

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www.aetna.com/cpb/medical/data/700_799/0781.html
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The above policy is based on the following references:


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AETNA BETTER HEALTH® OF PENNSYLVANIA

Amendment to
Aetna Clinical Policy Bulletin Number: 0781
Interstitial Laser Therapy

There are no amendments for Medicaid.