

Current and Future Applications of

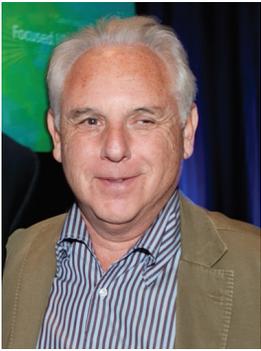
Focused Ultrasound 2012

3rd International Symposium

Event Summary

October 14–17, 2012

Bethesda North Marriott Hotel & Conference Center
Washington, DC Metro Area, USA



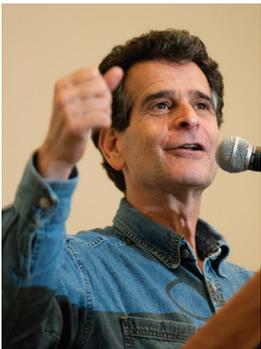
Welcome

Neal Kassell, MD, Founder and Chairman of the Focused Ultrasound Foundation (FUSF) and Professor of Neurosurgery at the University of Virginia in Charlottesville, Virginia, welcomed the audience of 354 people from 24 countries to the symposium. Noting that great progress had been made since the 2nd International Focused Ultrasound Symposium in 2010, he pointed to the increasing number of publications, abstract submissions, website visits, newsletter subscribers, funding from the National Institutes of Health (NIH), clinical use of focused ultrasound (FUS), media attention, and approved indications. Although these developments are notable and worth celebrating, the need to accelerate the adoption of FUS remains paramount. Future success is dependent on increased financial support from private investors, government funders and philanthropists and will require more FUS investigators and collaborative projects.



Honorary President

Symposium Honorary President Wladyslaw Gedroyc, MD, is a consultant radiologist at Imperial College and Saint Mary's Hospital in London. He is recognized worldwide as a pioneer in performing MR-guided focused ultrasound treatments for patients with uterine fibroids, facet joint disease and liver, pancreatic and other abdominal tumors.



Keynote Speakers

Symposium keynote speakers, medical device inventor Dean Kamen (left) and U.S. Senator Mark Warner (right), called upon the focused ultrasound community to advocate for support from public policy-makers and other stakeholders.

For more information, including the original abstracts from this meeting, go to:
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Current and Future Applications of Focused Ultrasound 2012

A Summary of the Focused Ultrasound Foundation's 3rd International Symposium

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Attendee feedback confirms that the symposium was a prolific incubator for collaboration, a factor considered key in advancing the field of focused ultrasound. Spontaneous discussion flows between sessions. Left: David Del Bourgo of Theraclion (left) and Lawrence Crum of the University of Washington (right). Right: Keyvan Farahani of the National Cancer Institute (center) meets with focused ultrasound researchers Dennis Parker (right) and Nick Todd (left) of the University of Utah.

Brain

Dr. Kassell introduced the brain portion of the symposium by describing the Foundation's research strategy and rationale for focusing on the brain. He strongly believes that the brain indications validate this technology: if we can treat the brain, we can treat less challenging areas of the body. Brain indications garner more attention than other areas of the body, thus building awareness more quickly and allowing for more progressive acceleration.

FUSF is fostering the development of brain indications by funding a dedicated brain team and establishing technical working groups, preclinical working groups, clinical trial steering committees, a resource library, brain workshops, mini brain workshops, technical projects, preclinical projects, and clinical trials. Clinical trials are underway to treat neuropathic pain, Parkinson's disease, and essential tremor. Investigators are studying the use of FUS to treat blood clots, stroke, and Alzheimer's disease. Furthermore, scientists are finding that FUS can be used to open the blood-brain barrier (BBB), allowing medications to reach previously unreachable areas of the brain.

Neuropathic Pain Daniel Jeanmonod, from the Center for Ultrasound Functional Neurosurgery in Solothurn, Switzerland, reported safe and successful treatment of neuropathic pain by using magnetic resonance-guided focused ultrasound (MRgFUS) to create lesions in the medial thalamus (central lateral nucleus). They found FUS lesioning to be more accurate than other lesioning techniques (including the gamma knife) in all three dimensions.

Parkinson's Disease Dr. Jeanmonod then reported the first study to use MRgFUS to successfully treat patients with Parkinson's disease by targeting the subthalamus with a pallido-thalamic tractotomy. He included their study parameters (safety/targeting accuracy/efficiency) and noted that the parameters were adjusted (increased number of end sonications) for the second group of patients to yield better results.

Jeff Elias and his group at the University of Virginia (UVA) reported that they will begin a phase I Parkinson's disease study focusing on tremor-dominant patients who are refractory to medication. They will create a lesion in a different area of the brain than the Swiss group: in the ventral intermediate nucleus of the thalamus. The double-blinded study will follow patients for 12 months after treatment, will include a control group (sham), and will treat 30 patients with the possibility of crossover for all control group participants. With safety as a primary outcome, the research team will also measure tremor improvement, quality of life, and higher cognitive function.

Essential Tremor Jeff Elias (UVA) reported results from their phase I study of 15 essential tremor patients who were refractory to medication. They successfully used MRgFUS to create a lesion in the ventral intermediate nucleus of the thalamus on the dominant side and improved tremor subscores on that side by 80%, along with significant improvement in quality of life measures. They noted edema at the lesion site that peaked at one week but subsided by one month. Tremor control results have been sustained up to one year in eight patients; two patients had some return of the tremor. The group discussed the possibility of using neuromodulation in future studies to guide the procedure based on what patients perceive during treatment, but concluded that MRgFUS is a feasible, safe, noninvasive option to treat tremor conditions and that it may bring lesioning back into greater use.

Jin Woo Chang from Seoul, Korea also reported a successful experience treating 8 essential tremor patients who were refractory to treatment with medication. The Korean group collected and reported very good serial images, technical information, and functional testing data. Dr. Chang discussed the importance of patient selection and had heating issues in two patients that may have been related to skull thickness or transducer misalignment. During the discussion, treatment time was discussed; most agreed that it needs to be significantly shortened (due to patient anxiety or headache experienced by some patients). Some patients tolerate treatment duration better than others.

Diane Huss from UVA presented the movement assessment testing protocol that her group developed to monitor adverse events and functionality in patients undergoing MRgFUS for brain indications. One innovative idea was outfitting the patients with tightly fitted prism glasses to allow the patients to see outside of the magnetic resonance imaging (MRI) bore and increase ease in completing the assessments.

Mechanical Effects of FUS in the Brain Nathan McDannold from Brigham and Women's Hospital/Harvard Medical School presented their research into ways to increase the MRgFUS treatment envelope in the brain. They used an ultrasound (US) contrast agent and changed the treatment parameters to achieve non-thermal ablation via sustained mechanical cavitation while performing *in vivo* experiments on monkey and rat models.

Jean-François Aubry's group at the Institut Langevin in Paris presented their studies on ultrasonic neuromodulation. Using a rat model, they applied low intensity US to produce pressure at the target site and

achieve very specific motor responses, even with a large focal spot and diffuse field. Their simulations show that due to reverberations in the rat head, the pressure in the brain is higher than assumed in previous studies.

Blood Clots and Stroke Three groups presented work using FUS to treat blood clots or stroke. Thilo Hoelscher from the University of California – San Diego presented his work to create an *in vivo* model to study transcranial sonothrombolysis. He studied thrombus characteristics in humans and rabbits and successfully created a rabbit carotid artery model with properties that are similar to an arterial blood clot in humans. He suggested further study of the use of FUS for this indication, including addressing current obstacles and counteracting the platelet activation caused by the US.

Dan Pajek from Sunnybrook Health Sciences Centre in Toronto presented their work in using the mechanical cavitation effect of FUS for thrombolysis in acute ischemic stroke. They tested their ideas *in vivo* in a rabbit femoral artery model. This work showed that FUS thrombolysis is a feasible way to quickly restore blood flow in occluded arteries but that transcranial phased arrays with higher frequency (between 1 and 1.5MHz) and higher transducer element counts than currently exist today will need to be developed (along with multi-channel driver technology) to continue work in this area.

Stephen Monteith* from UVA worked with researchers in Israel (Sheba Medical Center and InSightec) to study the ability of FUS to lyse intracerebral hemorrhage clots using the inertial cavitation effects of pulsed sonications followed by MRI-guided aspiration of the liquefied clot. Their study produced positive safety and efficacy results with *in vitro*, cadaveric, and swine models.

Crossing the Blood-Brain Barrier Using FUS to open the blood-brain barrier (BBB) was the subject of three presentations. Nathan McDannold and his group at Brigham and Women's Hospital/Harvard Medical School conducted experiments in rats to compare differences in the success of moving chemotherapy agents across the BBB when low intensity, contrast-infused FUS is used in conjunction with chemotherapy agents vs. chemotherapy alone or FUS alone. The FUS plus chemotherapy group had greater long-term survival and a strong treatment effect (the tumor shrank) in their rat model.

Elisa Konofagou and her colleagues at Columbia University studied the use of FUS plus microbubbles to open the BBB in various areas of the brain

* Young Investigator Award Recipient (see pp. 15-16)

(hippocampus/choroid plexus/caudate putamen) and allow localized delivery of three different systemically administered neurotropic (neuron-loving) molecules as a possible treatment mechanism for reversing the neuronal degeneration that causes Alzheimer's disease.

The same group from Columbia University also studied using FUS plus microbubbles to open the BBB in monkeys to further define the safety, targeting accuracy, and effect duration of this technology. Using US imaging, they monitored energy increases in real time (maintaining 0.2 MPa to 0.45 MPa) to avoid cavitation and optimize opening of the BBB. They found that the BBB opening effect lasted approximately 2 days.

Preclinical Studies John Snell from UVA presented their work using MRI to assess skull geometry. They found T-1 weighted imaging to be comparable to and mathematically predictable from CT imaging for measuring skull thickness, skull layer thickness, and skull intensity.

Because peripheral heating is an important factor in using FUS for brain indications, Nick Todd presented data from the University of Utah on their work using model predictive filtering image reconstruction techniques to create real-time, three-dimensional (3D) MR temperature maps with a root mean squared error of less than one degree Celsius that will allow clinicians to monitor heating in the entire treatment field rather than just around the focal point.

Costas Arvanitis and his colleagues at Brigham and Women's Hospital/Harvard Medical School studied the effects of combining MRI and US in the brain to allow better assessment of FUS therapy in real time and found the combined approach to be especially promising for guidance of cavitation-based therapies because it allows visualization of the exact location of the cavitation effects.

William Grissom from Vanderbilt University presented the work of their group in collaboration with four other institutions in validating MR-ARFI aberration tomography, a method that could potentially reduce treatment time because it enables automatic refocusing with fewer image acquisitions when adjusting treatment for phase aberrations and attenuation caused by the skull bone.

Uterine Fibroids

The treatment of uterine fibroids with FUS is the most advanced indication on this technology platform. Presentation topics included evaluation of the next-generation MRgFUS device, fibroid volume treated, long-term follow-up, outcomes measurements, cost analyses, pregnancy after FUS, racial disparities found through a large patient survey, reducing rate of hysterectomy by offering a multi-discipline fibroid treatment clinic, and the launch of a new global patient registry.

Increasing Non-Perfused Volume Matthias Matzko from the Amper Kliniken AG in Germany presented their safety and efficacy data while testing the ExAblate 2100, the next generation MRgFUS device produced by InSightec, Ltd. They treated an average non-perfused volume (NPV) of $88 \pm 15\%$ (range 38 to 100), which was done safely and exceeds what has been published in previous clinical trials. The new system allows cluster sonication, significantly reducing treatment time.

Similar data from Samsung Medical Center in Korea were presented by Min Jung Park.* This group also treated a higher fibroid volume than what is currently allowed by the United States Food and Drug Administration (50% or 150 cm³) with the goal to evaluate differences between treatment groups that received less than 80% ablation to those with $\geq 80\%$ of the fibroid volume (up to 100%) treated. They treated 79 women with 117 fibroids using the Philips Sonalleve system and determined that treating a greater fibroid volume was safe and resulted in superior therapeutic efficacy. They advocate for achieving as large an NPV as possible to produce the best outcomes.

Long-term Outcomes and Patient Selection Gina Hesley presented data from the Mayo Clinic on their one- to seven-year-follow-up (median 3 years, average 2.7 ± 1.7 years) of 140 women whose uterine fibroids were treated with MRgFUS. In this group, 22% needed further intervention for persistent or recurrent fibroid symptoms. Treatment success correlated with older patient age, higher confluence of ablated area, and T2 signal intensity of the dominant fibroid. In this study, the NPV was not a significant factor for determining treatment success.

Dr. Hesley later presented data from a retrospective review of their patient selection process, where they categorized patients as “good,” “questionable,” or “poor” based on MR screening images and patient symptoms. They found a significant difference for retreatment (those in the “questionable” group were three times more likely to need further intervention) and recommend their system of correlating MR screening images with patient

symptoms (and possibly patient age according to the discussion) to predict treatment success, counsel patients, and communicate with referring physicians.

Marlijne Ikink presented a study from the University Medical Center in Utrecht, The Netherlands, where they evaluated pre-treatment diffusion-weighted MRI images (DWI) to predict treatment efficacy by generating apparent diffusion coefficient (ADC) maps of each fibroid and then comparing the ADC values with post-treatment T-1 weighted MR images. The NPV to fibroid volume ratio was greater than or equal to 0.35 in the successfully treated group, and they discovered that for every one-unit increase in ADC, unsuccessful treatment becomes more probable. They suggest the use of DWI for patient selection if these results can be duplicated in a larger sample size and noted that increased vascularity was associated with a poor treatment outcome.

Cost and Outcomes Data University of California San Francisco research presented by Vanessa Jacoby reported their experience conducting a placebo-controlled, randomized pilot study to determine the feasibility of designing a large (150 patients), multi-center clinical trial that could collect “gold standard” outcomes data and lead to improved procedural reimbursement. They treated 20 women, determined that a similar clinical study is feasible, and commented that finding a way to streamline the rigorous and extensive screening process should improve the screening-to-enrolled ratio.

Bijan Borah from the Mayo Clinic presented data on one-year cost comparison for FUS vs. uterine artery embolization (UAE) or myomectomy using data obtained from the MarketScan® Commercial Claims and Encounters Database. Cost differences were not statistically significant between these three uterine-sparing treatment options and ranged from \$19,313 to \$25,840. Compared with UAE and myomectomy, women who undergo FUS are older, more medically complicated, and reside in areas with a smaller proportion of African-American residents. Few women appear to have successful commercial coverage of FUS.

Anne Cain-Nielsen* from the University of Michigan reported their study of cost-effectiveness of uterine-preserving treatment options in a hypothetical population using a decision analysis Markov model to calculate dollars per quality adjusted life year (QALY). Repeated simulations showed that MRgFUS was most likely to be found optimal, especially when taking lost productivity into account. Increasing the proportion of patients eligible for MRgFUS also made it more cost-effective.

* Young Investigator Award Recipient (see pp. 15-16)

US vs. MRI Guidance of FUS Therapy

Jaron Rabinovici from Chaim Sheba Medical Center in Israel announced the opening of the RELIEF registry, a global registry to collect high volume data demonstrating safety, clinical effectiveness, and cost effectiveness for MRgFUS treatment of uterine fibroids. The registry will be initiated in 2013 and will collect data from at least 20 centers for a minimum of three years.

Pregnancy after FUS In an update to his 2010 publication of the first 54 pregnancies after MRgFUS, Jaron Rabinovici from Chaim Sheba Medical Center in Israel has continued to collect global data from 11 institutions to study post-FUS pregnancy. Now, a total of 117 pregnancies have been recorded with a mean time to conception of nine months post-procedure. In this group, 55% of the pregnancies proceeded to a healthy (mean weight 2.7 kg) live birth with more than half (59%) delivering vaginally. Otherwise, 19% spontaneously aborted, 9% were electively terminated, 8% are ongoing, and 10% were lost to follow-up. Researchers concluded that MRgFUS may be a safe and cost-effective treatment option for women who are interested in future pregnancy and potentially no worse than myomectomy or UAE.

African American Experience Elizabeth Stewart from the Mayo Clinic presented survey data that show notable racial differences between White and African-American women suffering from symptomatic uterine fibroids. African-American women had more severe symptoms that had a greater impact on their quality of life, employment, and relationships. They used different sources of information when deciding on treatment options and were significantly more likely to be concerned about future fertility. Dr. Stewart noted that individualized prognosis is an important step that leads to individualized intervention.

Uterine Fibroid Treatment Centers Nelly Tan from the University of California Los Angeles presented their data from creating a multi-disciplinary uterine fibroid treatment clinic and showed how it may facilitate a lower rate of hysterectomy (30% vs. 79% nationally). Although they arrived with pre-conceived notions of which treatment option was best for them, women became open to more options when the radiologists and gynecologists worked together. Gynecologists gained additional patients by providing the follow-up care when radiological treatments were chosen; in some cases, two different treatment options were performed for one patient.

During this panel discussion, panelists Gail ter Haar (United Kingdom), Christian Chaussy (Germany), Claire Tempany (United States), Yael Inbar (Israel), and Jean-François Aubry (France) discussed imaging capabilities of the two guidance systems. All panelists highlighted the importance of monitoring both the thermal and mechanical effects of FUS.

The benefits of MR guidance are that it gives 3D anatomic information (target visualization) and beam path representation, real-time thermometry, and closed-loop feedback; it can confirm tissue necrosis after treatment and assist during unexpected procedural events.

The benefits of US guidance are that it offers real time anatomic information, real time monitoring, and is less expensive. Cavitation detection can be performed with ultrasound alone, but additional detectors can be added to MR-guided devices. Elastography is an important feature of US guidance, especially for prostate treatment (better sensitivity and specificity).

One question that arose was whether we should use different systems for different indications (MR for brain and US for breast, liver, and kidney)? The cost of both systems was considered – should those who cannot afford MR use US? In the current economic climate and with the current cost of healthcare, should lower-cost options be more developed and promoted? Geographical differences in preference also exist. Panelists agree that both guidance systems are important, that both add different value for FUS, and that the future will most likely include a combined version that incorporates the best of both systems. Industry is already looking at this option.

Emerging Applications

The emerging applications portion of the symposium included presentations on focal drug delivery to tumors, developing software and hardware components for use in preclinical studies, using FUS to increase the uptake of mesenchymal stem cells to treat kidney disease, and using the mechanical effects of FUS in novel ways to treat diseases such as cardiac arrhythmia, benign prostatic hyperplasia, and tumors in the liver, kidney, and prostate.

Focal Drug Delivery Using temperature-sensitive liposomes (TSLs) to deliver doxorubicin to tumors was the subject of presentations from two different groups. Edwin Heijman presented research conducted at Eindhoven University of Technology in The Netherlands, where they are studying optimizing heating protocols for TSL activation at the site of a tumor. Combining heating with FUS ablation created both the highest bioavailability of the drug and the highest uptake of doxorubicin into the tumor area, and they found that the effect lasted 48 hours.

Similarly, Tyrone Porter and his group at Boston University presented their data using polymer-modified TSLs (pTSL), which are both temperature sensitive and pH sensitive, to improve the pharmacological profile of doxorubicin by increasing its tumor efficacy and decreasing its toxic systemic effects. They concluded that pTSL had superior responsiveness at the mildly hyperthermic temperature of 39 degrees Celsius and that the effect was increased when FUS was used.

Preclinical Research To further the ability of researchers to use FUS to induce hyperthermia in research models, Caitlin Burke and her colleagues from the NIH worked with Philips Healthcare to coordinate the use of a clinical software package with a novel preclinical sector-vortex transducer (small enough to be used in a rat model). Their mild hyperthermia control algorithm worked within the software to control heating, maintain accurate temperature, and minimize temperature overshoot during experimental procedures.

Jonathan Kopechek* from Boston University presented their work using the mechanical effects of FUS with nanoemulsion to ablate deep-seated solid tumors. Instead of using intravenously injected microbubbles (which do not extravasate into tumors), they developed a phase-shift nanoemulsion (PSNE) that would increase nanoparticle accumulation in the tumor. After *in vivo* rabbit model testing, they concluded that the PSNE could improve clinical feasibility by both reducing treatment time and

reducing the intensity needed to ablate solid tumors. The study produced nice images of the PSNE accumulating in the tumors.

Targeted Stem Cell Delivery/Migration Scott Burks* from the NIH presented their study using pulsed FUS (pFUS) to deliver mesenchymal stem cells (MSC) to the kidneys for the treatment of acute tubular necrosis. The results showed that pFUS could improve enhanced homing permeability and retention of the MSCs during both the acute inflammation stage of the disease and during the post-inflammation stage, thereby improving renal function. Furthermore, the pFUS plus MSC produced a greater retention effect than did MSC alone. The pFUS alters the molecular structure and cellular profile without creating tissue destruction. Further research is indicated for use in other types of stem cells, including neurological stem cells for brain applications.

Boiling Histotripsy Lawrence Crum from the University of Washington presented work done by their group in collaboration with Moscow State University to emulsify tissue using the mechanical effects of pFUS, stating that this mechanism may be useful for indications such as cardiac arrhythmia, benign prostatic hyperplasia, and tumors in the liver, kidney, and prostate. Their work showed that the “boiling histotripsy” (tissue erosion by bubble clouds originating from tissue boiling) method can be monitored with US imaging, can create sharp borders between the treated and untreated areas, can control the degree of thermal effect, and can vary the location, size, and shape of the lesion.

Atherosclerotic Lesions John Ballard from the University of Minnesota presented work they have done on the feasibility of using FUS with a dual mode ultrasound array (DMUA, which allows imaged based refocusing) to treat atherosclerosis. They treated lesions in the femoral artery of hypercholesterolemic swine and were able to produce localized, discrete, and contiguous thermal lesions that had necrotic cores and neutrophil-infiltrated peripheries. The vessels were not perforated, and the intima was undamaged (the damage was confined to the plaque tissue).

* Young Investigator Award Recipient (see pp. 15-16)

Breast Tumors

Breast tumors and breast fibroadenomas are currently being treated with FUS while research into new systems and new uses for the technology are in development.

Excisionless Study for Small Breast Cancer Hidemi Furusawa from the Breastopia Hospital in Japan performed successful safety and efficacy studies on MRgFUS plus radiotherapy as a treatment for breast cancer. It is important to note that this study is not a treat and resect model; the tissue is left intact. They have now treated 65 lesions (average size 11.0 mm) at an average treatment time of 124 minutes. The patients have been followed for an average of 53 months with no local or distant recurrence. Dr. Furusawa cautioned about strict patient selection and reported only one adverse event: a severe skin burn that was caused by human error.

Treat and Resect Breast Cancer Study Laura Merckel described a new breast cancer study that is beginning at the University Medical Center in Utrecht, The Netherlands. A dedicated system and defined treatment parameters have been established to conduct their first safety and efficacy breast cancer treatment study. The first patient has been treated, and they plan to enroll ten patients in the treat and resect protocol (resection will take place 48 to 168 hours after MR-HIFU treatment) with the Philips system.

Roel Deckers*, also from the University Medical Center in Utrecht, later presented additional work of their group in optimizing the use of MR thermometry before beginning this phase I breast tumor ablation study. The goal was to optimize the proton resonance frequency shift-based thermometry sequence and the multi-baseline algorithm (MBL) for correcting respiration-induced susceptibility artifacts for MR-HIFU breast indications. They determined the optimal echo time (30 seconds) and flip angle (20 degrees) that would lead to the lowest temperature standard deviation and were able to drastically improve the thermometry precision before beginning the patient study. The MBL must be performed before each sonication, so it is somewhat time consuming.

Breast Fibroadenoma Roussanka Kovatcheva from the University Hospital of Endocrinology in Bulgaria presented a study underway in four European centers where USg-HIFU is successfully being used in place of surgery to treat patients with one or more breast fibroadenomas. With a current average treatment time of 1.5 hours, volume reductions have reached an average of 68.5% at 12 months, and one patient had a successful pregnancy and was able to breastfeed without complication after the procedure. Side effects include skin edema (30%) and skin irritation/erythema (13%).

Preclinical Research University of Utah research presented by Allison Payne described their in-progress study of the use of various sized goat udders to perform *in vivo* evaluation (mammary gland ablation) of a breast-specific MRgFUS system designed by Image Guided Therapy and Siemens. The dedicated system includes laterally directed beams and a tensioning device to fixate the tissue during treatment (which also allows for different volumes of tissue to be treated). The system has real-time MR thermometry and allows for good focal point accuracy.

At the University of Chicago, Elizabeth Hipp and her colleagues used MRgFUS in a rabbit model to create an internal muscle marker or “tattoo” that could potentially be used to more accurately guide surgical or radiotherapy procedures used in breast cancer treatment (or other types of treatments that require biomarkers, staples, or clips). They then evaluated the visualization of the tattoos via MRI (80%), CT (60%), and US (60%) and used color matching technology from the textiles industry to compare images.

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Prostate

In the prostate sessions of the symposium, a 15-year retrospective study of FUS treatment for prostate cancer was presented along with research on focal therapy for localized prostate cancer, a hemi salvage treatment study, the treatment of benign prostatic hyperplasia, treatment mapping techniques, and new devices that allow transurethral access to the prostate gland.

New Treatment Centers Several FUS treatment centers are now beginning to treat prostate cancer patients, and a lunch discussion session included presentations from these groups. Abhijit Patil* from Jaslok Hospital and Research Centre in Mumbai, India, presented their experience using the ExAblate 2100 to treat seven patients with locally confined prostate cancer that was determined to be low- or intermediate risk (PSA < 15 ng/dl), that had a Gleason score of 7 = 3+4 or less, and that had a prostate gland volume of less than 40 cubic centimeters. One adverse event was a ureter stricture. PSA levels dropped from 5 to 15 ng/ml to 1 to 3.8 ng/ml at six weeks follow-up.

Similarly, Vladimir Turkevich from the Petrov Research Institute of Oncology in the Russian Federation presented the work of his group in treating seven patients (eight treatments). While follow-up is still underway, their initial results with the ExAblate 2100 show MRgFUS as a promising, safe, and effective treatment for early low-risk prostate cancer. One patient had an adverse event of acute urinary retention. They reported extent of ablation to be a more valid measurement of success than PSA results. While the first patient took six to eight hours to treat, they have been able to decrease treatment time to an average of 4.5 hours, and this treatment time was similar for the Mumbai group.

Research at Yonsei University College of Medicine in Seoul, Korea, was presented by Young Taik Oh, whose group is also using the ExAblate 2100 to treat organ-confined prostate cancer. They treated two patients using a protocol similar to the Mumbai group and report a positive experience to date. After describing both patients, discussion revolved around whole gland vs. focal ablation, procedure-related morbidity, and anatomical variation between patients.

Sangeet Ghai from the University Health Network in Toronto, Canada, described their experience as the first North American center to treat prostate cancer patients. They have treated three patients with the ExAblate 2100 and are further developing treatment parameters. They are allowing the prostate to heal for one month after biopsy before performing the MRgFUS treatment.

European 15-Year Retrospective Study Christian Chaussy at the University of Regensburg in Germany presented his retrospective study and up to 15-year follow-up of 2,500 robotic-assisted HIFU prostate cancer treatments in Europe (78.5% of who had intermediate or high-risk disease) and described the evolution of the use of HIFU over time (whole gland to focal treatment). Patients were divided into three groups: those who received HIFU alone, those who had HIFU plus transurethral resection of the prostate (TURP) in one session, and those who had HIFU plus TURP in two sessions. HIFU treatment provided a high rate of cancer-specific survival and an exceptionally high rate of freedom from salvage treatment in low-risk patients. Prof. Chaussy feels it is now safe to treat patients with any size of prostate and that new strategies include nerve sparing, partial treatment, and focal therapy to protect potency.

Localized Prostate Cancer Louise Dickinson* from the University College Hospital in London reviewed medium-term outcomes on patients who received focal therapy for localized prostate cancer. They reviewed 88 patients and found 72% absence of any cancer and 86% absence of clinically significant cancer at a median follow-up of 32 months. Their previously reported positive short-term results seemed to extend to medium term (>2 years).

Alessandro Napoli from the University of Rome presented data from their phase I safety and efficacy trial using MRgFUS to treat localized prostate cancer via a treat and resect model. They described patient setup, defined inclusion criteria, and performed real time T mapping on ten patients, then confirmed desired results via pathological analysis. They found MRgFUS to be an attractive alternative for localized prostate cancer.

Eduard Baco from Oslo University Hospital in Norway presented a study from their group where they performed a Hemi Salvage treatment using Ablatherm HIFU in patients with unilateral localized radiorecurrent prostate cancer. They treated 43 men to evaluate the effect of the treatment in this population and found the procedure to be efficient, with cancer control that was comparable to whole gland treatment, a 7% rate of severe urinary incontinence, and no significant reduction in quality of life scores.

Rajiv Chopra, who is now at the University of Texas Southwestern, presented work done at Sunnybrook Research Institute in Toronto on creating a transurethral MR-HIFU system to treat localized prostate cancer.

* Young Investigator Award Recipient (see pp. 15-16)

Their system will be used in an NIH-sponsored clinical trial where MR-HIFU with real-time temperature monitoring will be used to impact a targeted region of thermal coagulation. This treat and resect study that is currently recruiting patients is hoping to treat the localized areas without passing through sensitive nearby tissue, achieve increased ablation rates, and prove safety and efficacy for this approach.

Panel Discussion of Prostate Controversies Panelists Andreas Blana (Germany), Christian Chaussy (Germany), Louise Dickinson* (United Kingdom), Mark Hurwitz (United States), and Peter Scardino (United States) discussed a wide range of topics. Regarding whole gland vs. focal ablation, panelists noted that improved imaging has allowed the field to progress toward more options in focal therapy. Some panelists questioned whether focal ablation is appropriate in multi-focal disease, and the group discussed the definition of focal therapy, the benefits of focal therapy, and patient selection for focal therapy when only 15% of prostate cancer patients have a focal tumor.

The panelists noted how the dialog has moved from treating patients who are too old or too sick for other treatments to treating patients with low-risk disease earlier. Other treatment options still exist if disease returns after FUS, and this is an advantage that FUS has over radiation therapy. With regard to US vs. MR guidance in the prostate, several panelists agreed that MR guidance is not needed for treatment; it is only needed and important for diagnosis. In fact, the panelists discussed the importance of non-invasive MR imaging vs. biopsy diagnosis of prostate cancer due to the invasiveness and potential unreliability of template biopsies.

The topic of using FUS to debulk a prostate tumor and therefore decrease the amount of radiation needed afterwards was discussed, along with how much or how little of the tumor(s) to treat, whether we treat patients to improve their quality of life or to decrease the spread of the disease, and how long to allow active surveillance before moving to active treatment. Dr. Chaussy noted that 60% of patients will ask for active treatment after 3.5 years of active surveillance.

Benign Prostatic Hyperplasia Punit Prakash and research groups at Kansas State University and Stanford University have developed a real-time, closed-loop thermometry-controlled algorithm for use with their transurethral approach to treating benign prostatic hyperplasia (BPH) with a dual-sectored US device. Their algorithm allowed them to achieve ablation temperatures within 2 degrees Celsius of optimal treatment endpoint temperatures, which differed based on the radial depth of the target and ranged from 9.3 mm to 17 mm. They created an integrated system specific to BPH whereby the feedback control terminates the treatment when the boundary temperature exceeds the threshold.

Tissue Viability and Treatment Mapping In an effort to differentiate temperature and tissue viability parameters when ablating prostate tissue, Kim Butts Pauly of Stanford University presented additional collaborative work with Kansas State University looking at the relationship of the apparent diffusion coefficient (ADC) to a thermal dose threshold of 240 equivalent minutes. A canine model was used to capture ADC data along with PRF temperature maps, and these data were used to calculate a scaling factor for the ADC axis. They found real-time mapping to be possible, and their results showed the correlation between ADC and temperature to be a sensitive marker for loss of tissue viability.

Louise Dickinson* from the University College Hospital in London described their work using MRI imaging to create a treatment map that allows greater precision for targeting focal therapies in the prostate. This type of tumor morphometry could be used to plan treatment. They developed a software system to compare images, compiled data from 17 patients, and were able to demonstrate that the registration system was capable of locating lesions, thereby potentially improving the accuracy of focal treatment.

* Young Investigator Award Recipient (see pp. 15-16)

Bone Metastasis

Phase III Study Results and Quality Assurance Ten international research centers were represented in a study presented by Mark Hurwitz from Brigham and Women's Hospital/Harvard Medical School. Their rigorous phase III trial to assess the role of MRgFUS in treating painful bone metastases was conducted with patients for whom radiation therapy was not appropriate and included a successful sham arm. In 134 patients enrolled, 67% had significant pain reduction at three months compared with 21% of the sham subjects. Patients reported pain improvement within one day, which leveled out by day 30 but remained sustained after that. A markedly improved quality of life was also observed in the treated patients (a 2.4-point improvement on average). They recommend MRgFUS for eligible bone metastasis patients when radiation therapy is contraindicated and noted that the message needs to get out to oncologists.

Lili Chen from Fox Chase Cancer Center in Philadelphia presented their work to establish a comprehensive quality assurance program for using FUS to treat bone metastases and established the parameters based around the phase III study mentioned above. Quality assurance measures included 1) pre-treatment machine and software calibration (including the mechanical motion control system and patient safety devices); 2) thermometry-guided effective FUS focal spot verification on a phantom; 3) patient positioning; 4) acoustic coupling and gas bubble removal of the interface between the treatment table, the gel pad, and the patient; and 5) redundant sedation monitoring.

Palliative Study Results Vladimir Turkevich from Saint Petersburg, Russian Federation, reported treatment results from 31 patients there. They found significant improvement in pain but no change in uptake of pain medication. The average pain score dropped from 6.8 to 0.9 during the 85-day follow-up period. During the discussion period, Dr. Turkevich stressed the importance of patient selection.

Pain Control and Tumor Suppression Researchers at the University of Rome are looking not only at pain control of bone metastases, but also at the ability of FUS to control the growth of the bone tumor itself. They treated 18 patients and found statistically significant pain control. The potential for local tumor control (bone necrosis) was established, and the group proposed tumor necrosis as a predictor of treatment efficacy. Discussion items included whether this treatment could be used for weight-bearing bones (not yet studied) and how early this treatment could be started.

* Young Investigator Award Recipient (see pp. 15-16)

Unique Case Report Merel Huisman and colleagues at Utrecht Medical Center in The Netherlands used a new volumetric ablation method for treating a painful costal metastasis in a patient with a rare and inoperable soft tissue mass located in the infraclavicular area of the chest. They used a two-step approach (tumor de-bulking and pain palliation) that allowed them to obtain an NPV of 75% of the tumor mass. The pain rating dropped to one after three days and remained there one month post-procedure. Dr. Huisman noted that anatomical variation can pose challenges and that uniform treatment protocols and response definitions are important.

Preclinical Rat Model Sin Yui Yeo* and her group at Eindhoven University in The Netherlands are creating a preclinical rat model for studying the use of FUS in treating bone metastases. After inducing bone tumors in rats, pain was measured as a decrease in limb usage on a sensory mat. Imaging techniques (MRI, SPECT/CT, and microCT) were used along with behavior tests and histological analysis to assess study results. Initial results revealed differences between treated and untreated rats in tumor outgrowth, ^{99m}Tc-MDP radiomarker uptake, limb usage, and bone characteristics (higher volume but lower density in the untreated bone). Future work will include studies to understand the interaction between the bone and the US.

Panel Discussion: Bone Metastasis Mark Hurwitz (Brigham and Women's Hospital/Harvard Medical School), Carlo Catalano (University of Rome-Sapienza), Pejman Ghanouni (Stanford University), and James Larner (UVA) discussed a variety of topics with the audience. The panelists began by comparing the technical infancy of FUS to the 50 to 75 years of development of radiation oncology and noted the benefits of FUS over radiation, such as the fact that the cells are denatured but not killed, the speed of therapeutic onset, the radio-resistance of some tumors that does not exist with FUS, and the ability of FUS to preserve the bone marrow. From a patient perspective, many patients are refusing treatments that involve radiation therapy and would be open to FUS for this reason.

In terms of patient selection for FUS, the panel discussed different patient populations (palliative vs. recently diagnosed), patient selection parameters (pain score, weight-bearing vs. non-weight-bearing bones, patient life expectancy), the location and accessibility of different bone lesions, and the disadvantages of FUS (long treatment time, long anesthesia time, the technical challenge of thermometry especially if the patient moves

during treatment). They cautioned that we do not yet know the duration of treatment effects over time and that time is needed to answer this question.

A question was raised: Should FUS only be used to treat painful metastases in bone, or should treatment be applied before the patient experiences pain? The group consensus was that at this time they would reserve it for only the metastases that cause pain until further studies have been done. With regard to future directions after the phase III trial, the panelists envisioned the use of FUS as a first-line treatment for patients with a single lesion or with radioresistant tumors like renal cell carcinoma. They also mentioned the ability of FUS to de-bulk a tumor before treating it with radiation therapy, the ability of FUS to de-sensitize a tumor, and the potential of FUS to ablate the tumor itself.

Panelists discussed but did not necessarily agree on whether FUS should or could be used in combination with radiation therapy due to economic reasons. Other economic concerns that were raised included the cost benefit of taking a patient off of expensive pain medication after successful treatment with FUS, the cost of treatment in one of the new proton centers that have recently opened, and the cost of the long treatment time and MRI usage time that accompanies FUS treatment.

Bone Non-metastasis

Osteoid Osteoma In a feasibility and initial efficacy study, Beatrice Cavallo Marincola* and colleagues at the University of Rome used FUS to treat seven patients with osteoid osteoma (a painful, benign bone lesion that affects young people). The group found a statistically significant reduction in pain, complete clinical success in six of seven patients, and no treatment-related morbidity.

Chronic Backache Abhijit Patil* and his colleague Shrinivas Desai from Jaslok Hospital in Mumbai, India used FUS to treat radiculopathy-free lumbar facet arthropathy causing chronic backache. They successfully treated 20 patients and achieved 65% to 70% reduction in pain on a numerical rating scale and 60% to 65% reduction in disability scores at 6 months follow-up.

Bone Thermometry Wilson Miller from UVA presented his preclinical study to measure thermal changes in bone tissue. He used T1 imaging with ultrashort echotime (UTE) pulse sequencing to visualize the temperature rise in the cortical bone. The UTE pulse sequence techniques allowed him to capture the extremely short (less than half a second) T2 relaxation time of the bone to an image that shows the bone marrow and the cortical bone, and this image was further enhanced by subtracting the conventional-TE image from the UTE image (which removes the water and fatty marrow). He theorized that this type of imaging could lead to quantitative thermometry measurements for bone tissue and that UTE pulse sequences could be used with FUS for bone density mapping or for correcting beam aberrations, especially with differences in skull thickness for brain patients.

* Young Investigator Award Recipient (see pp. 15-16)

Focused Ultrasound Foundation

Journal of Therapeutic Ultrasound Arik Hananel announced the launch of the Journal of Therapeutic Ultrasound (JTU), created by collaboration between the International Society for Therapeutic Ultrasound (ISTU) and FUSF. The open-access journal will serve as the official publication of both organizations. The first issue will be published in February 2013, and the website, which is currently accepting submissions, is located at www.jtultrasound.com. Basic, preclinical, translational, and clinical studies are acceptable and encouraged, along with case studies, reviews, meeting reports, and study protocols. (Please see the announcement on the last page.)

FUS Technology Overview Jessica Foley presented an overview of the bioeffects and clinical applications that are currently being used, studied, or theorized on the FUS technology platform. Topics included clinical indications, localized thermal and mechanical bioeffects, and the range, shapes, and sizes of sonication fields. FUS has truly become an important technology platform with a variety of biological effects that can be used to treat many different types of tissue over a wide range of clinical conditions.

Liver and Pancreas

FUSF Liver and Pancreas Program Arik Hananel announced the formation of the FUSF liver and pancreas program, which will be creating collaborative projects, hosting workshops, and funding research to further the use of FUS to treat liver and pancreatic diseases.

Hepatocellular Carcinoma and Pancreatic

Adenocarcinoma Feng Wu, from the Institute of Ultrasonic Engineering in Medicine and Clinical Centre for Tumour Therapy in Chongqing, China, provided an update and overview of the use of USgFUS to treat hepatocellular carcinoma in Asia and Europe (China, Hong Kong, Japan, UK, and Italy). With clinical trial data from the past 14 years, they have determined this noninvasive ablation technique to be safe, effective, and feasible for patients with hepatocellular carcinoma (even in difficult to reach lesions). In one study of 55 patients, they found a 76% survival at 5 years with continuing tumor shrinkage 36 months out. In studies combining FUS with transcatheter arterial chemoembolization (TACE), the survival rates were better for the combined treatment than for FUS alone. Discussion about the progression of the technology followed.

Michele Anzidei and the group at the University of Rome presented their experience using MRgFUS to successfully treat one patient with hepatocellular carcinoma and three patients with pancreatic adenocarcinoma (including celiac plexus and portal vein involvement). They used a pretreatment simulation model, and no adverse events were reported during or after the procedures. The patients with pancreatic cancer all needed retreatment, so two had radiotherapy and one underwent another MRgFUS procedure.

Pancreatic Cancer Drug Delivery Navid Farr presented work done at the University of Washington in collaboration with Eindhoven University of Technology in The Netherlands. This group studied the use of FUS for drug delivery in pancreatic cancer in three different mouse models using a clinically available MR-HIFU system. They were able to show increased uptake of doxorubicin (delivered in TSLs) in the tumors treated with HIFU.

Liver Metastasis David Melodelima from INSERM in Lyon, France presented their phase I evaluation of a handheld, US-guided, toroidal HIFU transducer to treat liver metastases prior to resection. They successfully treated six patients and 12 lesions with no adverse events. The US imaging worked well to visualize sharp margins, and the shape of the new transducer made the treatment

time very brief (40 seconds for a 5 to 6 cm³ ablation). Their procedure made it possible to access 80% of the hepatic volume. Phase IIa of the study focused on the targeting accuracy. They were able to correctly target lesions within 1 to 2 mm in 11 of 12 treatments. Phase IIb will enroll 20 patients to further the study.

Preclinical Research Stefan Braunewell presented a consortium project progress report from the Focused Ultrasound in Moving Organs (FUSIMO) study, which involves nine institutions in Europe and two in Israel. The first steps of the FUSIMO study have been to design patient-specific modeling that can simulate the biological environment for abdominal therapy, including organ physiology, target movement, tissue disposition of energy, and heat transfer. Software assistance was needed and developed for the project and includes abdominal organ modeling, patient-specific breathing modeling, and tissue reaction modeling. The entire integrated tracking and electronic steering system will be validated in phantom and cadaver models and will be important for therapy planning, prediction, and monitoring. They are hoping to present the entire system by the end of 2013.

John Ballard and colleagues from collaborative laboratories at the University of Minnesota have been developing US thermometry (UST) to measure and validate thermal and mechanical tissue property changes (absorption/diffusion/stiffness) during FUS treatment. A small animal model was used.

Martijn de Greef and the University Medical Center group in Utrecht, The Netherlands, presented results from their work modifying the US transducer to incorporate a switch-off element when sonicating near rib bones. They used a deactivation algorithm with an intensity threshold so that the bone temperature would not be elevated more than 10 degrees Celsius. This element switch-off method based on acoustic intensity calculations was successful.

Paul Baron and colleagues at University Medical Center in Utrecht, The Netherlands performed a study to determine if dynamic T2 mapping could provide adequate thermometry measurements to monitor heating in near-field adipose tissue. They conducted *ex vivo* calibration and *in vivo* experiments in a porcine model and found a completely reversible linear temperature dependence of 5.3 ms/degree Celsius (for both heating and cooling) and a cooling time constant of 200 seconds during sonication with a near field thermometric precision of 1.1 degree Celsius (range 0.2-3.8). They determined the method to be feasible with acceptable

levels of precision and accuracy but cautioned that they found a large variation in the measured temperatures and therefore recommended individual monitoring of temperature during treatment.

Joost Wijlemans from University Medical Center in Utrecht, The Netherlands, presented their work using intrapleural fluid injection to fill the costophrenic angle with fluid in order to move the lung tissue out of the therapeutic field and make it possible to perform FUS in the cranial part of the liver. They successfully performed experiments using a swine model and were able to show feasibility of the technique, also suggesting that the technique might be useful in treating other abdominal or thoracic sites.

Samuel Pichardo presented a study done at the Thunder Bay Regional Research Institute in Canada where they tested an agarose-based tumor phantom for MR targeting and thermometry studies with FUS therapy (due to the absence of an animal model for liver tumors). In experiments, the phantom was visible on T1 and T2 imaging. The thermal properties and sonication parameters were established to make it a viable tool for preclinical studies. One important point was that the injection needles should be prewarmed to avoid air pocket formation.

Dose Painting and Targeted Drug Delivery with FUS

Pavel Yarmolenko from the NIH presented a study done in collaboration with six other institutions to create, test, and evaluate a mild hyperthermia algorithm that could be used to deliver chemotherapy drugs encapsulated in image-able TSLs to a large variety of solid tumors using the thermal effects of FUS to create the release. The results indicated that the system was effective, novel, and potentially useful for clinical oncology.

In conjunction with the NIH, Dieter Haemmerich from the Medical University of South Carolina studied heating regimens for optimal delivery of chemotherapy via FUS-induced hyperthermia. The group was able to create computational models to predict temperature and amount of drug delivery with results lasting up to two hours, and found that the amount of drug delivered was dependent on the length of the period of hyperthermia.

Future Challenges

Dr. Neal Kassell closed the meeting by noting that 79 abstracts and 94 posters were accepted for a total of 173 presentations. Attendees included clinicians, scientists, engineers, undergraduate and graduate students, industry professionals, philanthropists, inventors, government representatives, and a U.S. Senator. Dr. Kassell challenged the audience, which was 60% from the United States and 40% international, to consider the daunting public policy issues that are confronting this field. He implored the group to answer the call to action to communicate the importance and impact of our work. We must affect our own futures, find ways to work smarter and more efficiently with fewer resources, and collaborate with one another. The FUS Foundation looks forward to hosting the Symposium again in 2014 and will host workshops in the interim. Upcoming 2013 meetings include a winter FUS workshop in France, ISTU in Shanghai in May, a spring meeting in Aruba, and the European Symposium in September. Dr. Kassell thanked Robin Jones and Arik Hananel for organizing this meeting and bid safe travels to all.

Young Investigator Awards



Sarfraz Ahmad, PhD, Clinical Research Fellow in Urology at the Ninewells Hospital, University of Dundee in Dundee, UK. Awarded for “Localisation of Prostate Cancer foci with Transrectal Quantitative Shear Wave Elastography - a step towards focal therapy for Prostate Cancer.”



Muna Aryal, PhD, Student in the Boston College physics department and Brigham and Women’s Hospital radiology department. Awarded for “Enhanced delivery of liposomal doxorubicin via permeabilization of the blood-brain/ blood-tumor barriers using focused ultrasound and microbubbles significantly improves survival in a rat glioma model after multiple treatments.”



Scott Burks, Postdoctoral fellow in radiology and imaging sciences at the NIH Clinical Center in Bethesda, Maryland, USA. Awarded for “Pulsed focused ultrasound (pFUS) induces targeted homing of therapeutic mesenchymal stem cells (MSC) to kidneys during acute tubular necrosis and leads to improved renal function.”



Anne Cain-Nielsen, Master of Science candidate at the University of Michigan School of Public Health. Awarded for “Cost-Effectiveness Analysis of Uterine-Preserving Procedural Treatments for Uterine Fibroids, Including Magnetic Resonance-Guided Focused Ultrasound.”



Beatrice Cavallo Marincola, MD, PhD candidate in the department of Radiological, Oncological, and Pathological Sciences at the University of Rome—Sapienza. Awarded for “Osteoid Osteoma: preliminary results of a non-invasive treatment using Magnetic Resonance guided Focused Ultrasound.”



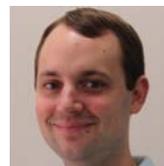
Roel Deckers, PhD, Postdoctoral researcher in the Image Sciences Institute at the University Medical Center in Utrecht, The Netherlands. Awarded for “Optimizing MR thermometry for clinical phase I breast tumor ablation study.”



Louise Dickinson, MD, Academic Clinical Fellow in Urology at the University College Hospital in London, UK. Awarded for “Medium term outcomes following primary focal therapy using HIFU for localised prostate cancer.”



Ji Hee Kim, Clinical Fellow in the department of Neurosurgery at Yonsei University College of Medicine in Seoul, Korea. Awarded for “Patterns of Magnetic Resonance Imaging Change After Transcranial Magnetic Resonance Guided High Intensity Focused Ultrasound Treatment for Essential Tremor: Result From ET001K, ET002K.”



Jonathan Kopechek, Postdoctoral Fellow in Mechanical Engineering at Boston University, Boston, Massachusetts, USA. Awarded for “Enhanced MR-guided HIFU Ablation of Rabbit VX2 Tumors *In Vivo* using Phase-Shift Nanoemulsions.”



Emilee Minalga, PhD, Graduate Research Assistant in the Radiology Department at the University of Utah in Salt Lake City, Utah, USA. Awarded for “Radio Frequency Coil Design for Magnetic Resonance Guided Focused Ultrasound in the Brain.”



Stephen Monteith, MD, Neuro-Endovascular Fellow in the Department of Neurosurgery at Thomas Jefferson University in Philadelphia, Pennsylvania, USA. Awarded for “Transcranial MR Guided Focused Ultrasound Treatment of ICH.”

Continued, next page

Young Investigator Awards (continued)



Min Jung Park, Fellow in Radiology at Samsung Medical Center in Seoul, Korea. Awarded for “Complete or Near-complete Ablation of Symptomatic Uterine Fibroids by Volumetric MR-guided High-intensity Focused Ultrasound Therapy: Assessments of Safety and Therapeutic Efficacy.”



Vasant Salgaonkar, PhD, Research Specialist in Radiation Oncology at the University of California, San Francisco, USA. Awarded for “Targeted hyperthermia in prostate with an MR-guided endorectal ultrasound phased array: patient specific modeling and preliminary experiments.”



Sin Yuin Yeo, MSc, Doctoral student in the department of Biomedical Engineering at Eindhoven University of Technology in Eindhoven, The Netherlands. Awarded for “Effects of HIFU Ablation on Bone Metastases: From MRI, SPECT/CT and MicroCT Point of View.”



Abhijit Patil, MD, DNB, Clinical and Research Associate in the Department of CT, MRI, and MRgFUS at Jaslok Hospital and Research Centre in Mumbai, India. Awarded for “Role of Magnetic Resonance Guided Focused Ultrasound Surgery (MRgFUS) in treatment of patients with Lumbar Facetal Arthropathy.”



Young Investigator Award recipients at the Symposium with Dr. Kassell



Graduate students, research fellows, clinical fellows and junior faculty members are eligible to apply for the awards, which provide up to \$2,000 in reimbursement for symposium registration, travel and lodging expenses. The 2012 Young Investigator Awards are funded in part by a \$19,000 grant from the National Cancer Institute (R13CA171719). The funding comes from the National Institutes of Health (NIH) Conference Grant Program which supports high quality conferences that are relevant to the scientific mission of the NIH and to public health.



Symposium Organizer

About the Focused Ultrasound Foundation

The Focused Ultrasound Foundation is a medical technology research, education and advocacy organization dedicated to improving the lives of millions of people with serious medical disorders by accelerating the development and adoption of focused ultrasound. The Foundation is unique in that it supports development of improved treatment for a wide variety of diseases utilizing a platform technology that exerts multiple mechanisms of action.

Positioned at the nexus of the large, diverse group of stakeholders comprising the ultrasound community, the Foundation functions as an independent, trusted and unbiased third-party, aligning organizations into a cohesive ecosystem with a single goal: To make focused ultrasound technology available to patients in the shortest time possible. The Foundation works to establish a patient centric culture, instill a sense of urgency in all stakeholders, and alleviate barriers to progress.

The Foundation catalyzes collaboration and partnerships, organizes and funds research, spearheads advocacy and patient support initiatives, and sponsors meetings, symposia and workshops to create and disseminate knowledge and increase awareness of focused ultrasound. Early-stage research funded by the Foundation “de-risks” subsequent investment, thus encouraging other funding sources such as disease specific foundations, the National Institutes of Health (NIH), and industry to become more involved.

The Foundation is on the leading edge of the venture philanthropy and social entrepreneurship movements and is a model of how private philanthropy can work in concert with academia, industry and government to bridge the gap between research and commercialization of a high impact medical technology. To learn more about focused ultrasound and the Focused Ultrasound Foundation, visit the Foundation’s website: www.fusfoundation.org

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The Focused Ultrasound Foundation Team
(left to right)

Front: Robin Jones, David Moore, Neal Kassell,
Kimberly Skelly, Matthew Eames

Middle: Ellen McKenna, Emily McDuffie,
Jessica Foley, Heather Huff-Simonin, Arik Hananel

Back: Rachel Browning, John Snell

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Editors-in-Chief

- Robert Muratore (ISTU)
- Arik Hananel (Focused Ultrasound Foundation)



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