

Awareness of Transcranial Focused Ultrasound in India – Approaches and Utilization

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Abstract— The concept of Focused Ultrasound is yet at its initial stages in various countries including India. Its awareness among renowned practitioners was analysed at various hospitals in both rural and urban areas in India to understand the intensity of need to make more people aware of it.

Index Terms—Focused Ultrasound, Transducer Array, Apollo Hospitals

1. INTRODUCTION

It was in year 1950 when first ultrasound instrument was introduced but similar type of units were made available for limited and experimental purpose by 1960. The early ultrasound machines were difficult to use and the quality of images obtained by them was very difficult to interpret but gradually in early 1980s, the technology was improved to this extent that the users were able to view sonographic images with the help of real time ultrasounds [1].

With advancement in electronic technologies, the ultrasound has emerged as a great tool not only for diagnostic purposes but also for treatment of various diseases. The focused ultrasound technique has earned worldwide appreciation for being able to address the issues related to intravenous drug delivery. The concept of Magnetic Resonance guided Focused Ultrasound (MRgFUS) has emerged as a big ray of hope for curing various chronic diseases related to areas of Cardiovascular, Neurological, and Oncological etc.

2. MR GUIDED FOCUSED ULTRASOUND

A targeted tissue is thermally ablated using a minimally invasive method known as MR guided focused ultrasound. This mechanism also finds its usage in nonthermal and mechanical effects e.g. for the excitability of brain cells, disruption of blood clots. It can also be used for neuromodulation which is a nonthermal and nonmechanical effect on the excitability of brain cells.

The technology is carried out in three steps – 1) to localize the target, 2) to verify the thermal ablation during the procedure and 3) to assess the treatment effects.

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In all of these approaches, MR imaging is used to localize the target, verify thermal ablation during the procedure, and assess the treatment effects. This technology has proved a boon for the treatment of symptomatic uterine fibroids and painful osseous metastases[3]. It is being investigated for[2] the treatment of primary cancers in the breast[4] and prostate gland[5]. The transcranial MRgFUS system has also depicted

favorable results for treatment of brain lesions through an intact skull[6]. Patients suffering from central neuropathic pain[7],[8], essential tremor[9], Parkinson tremor[10] and tumors in brain[11] can also find relief with this system. In a preclinical study, it has been made possible to deliver drug at the specific target in the brain after temporarily disrupting the blood brain barrier[12]. On the basis of these facts, it is well predicted that MRgFUS system has the capability to bring revolutionary change in functional neurosurgery [13].

3. APPLICATIONS

1. The Ultrasound has emerged as most widely available and frequently used electro physical agent used by Physiotherapists from past six decades. This technology has been intervening for acute and chronic conditions, different types of tissues and anatomic locations as well. In case of Physiotherapy, the areas focused for treatment with ultrasound have been reported as ligament, muscle, tendon, treating mostly the areas of peripheral joints. The therapists have been using two trends of treatment dosages i.e pulsed wave ultrasound at an intensity in the range of 0.51 to 1.5 W/cm² and continuous wave

- ultrasound at a spatial averaged intensity of 1.01 to 2.1 W/cm². By this phase, the therapists had been promoting the non-thermal effects of ultrasound.[14]
2. A survey was conducted on registered surgeons in Australia and New Zealand and it was observed that 47% of surgeons were of less than 1 year clinical experience and the results indicated that surgeons with good clinical experience were more comfortable adopting this technology for diagnosis of Breast Cancer with almost same perfection level as radiologists.[15]
 3. Osteoporosis being a systematic skeletal disease is characterized by low bone mass and micro architectural deterioration of bone tissue which results into bone fragility and susceptibility to fracture. A number of non-invasive techniques like single photon absorptiometry (SPA), single X-ray absorptiometry (SXA), dual X-ray absorptiometry (DXA), and quantitative computed tomography (QCT) have been developed to quantify bone mineral density (BMD) in the axial and peripheral skeleton but they provide very limited information related to bone material and bone structure properties. The introduction of QUS (Quantitative Ultrasound) methods has been offering favourable results and has been recognised with appreciating potential by researchers and clinicians.[16]
 4. The myocardial deformation in longitudinal, radial and circumferential direction can be determined by ultrasound machine thus serving as reference tool in detecting the subtle and early damages of heart tissues.[17]
 5. For detection of Prostate Cancer, Conventional transrectal greyscale ultrasound technique is used, though it has been proposed that by using multiparamter ultrasound, the results obtained can be far better.[18]
 6. The most common movement disorder namely Essential Tremor occurs due to rhythmic oscillations of around 8 to 12 Hz of agonist and antagonist muscle groups.
 7. Recent advances have enabled delivery of high-intensity focused ultrasound through the intact human cranium with magnetic resonance imaging (MRI) guidance. This preliminary study investigates the use of transcranial MRI-guided focused ultrasound Thalamotomy for the treatment of essential tremor. Essential tremor, the most common movement disorder, with a prevalence as high

as 4%, is characterized by a rhythmic oscillation of agonist and antagonist muscle groups, typically between 8 and 12 Hz. The existing medical therapies though being successful but are not feasible for all patients due to their intolerance towards such medications. It was always an area of interest for researchers to try to use ultrasound techniques for brain disorders as well but due to limitations of transcranial sonication and the absence of cranial window, favourable results could not be observed for such experiments until 1950s. The advancement in Biomedical Technologies and Instrumentation in the past decades made it possible to have transcranial sonication through the human skull. It was with the aid of phased arrays of transducers and computed tomographic (CT) correction algorithms that the first successful transcranial sonication was adapted to treat the patients with malignant glioma. The fusion of high-intensity ultrasound and magnetic resonance imaging has made it possible to have precise intracerebral targeting with real time clinical and radiographic monitoring of the treatment location and intensity with the use of thermal imagery.[19]

8. The *Table 1* depicts the areas where the focused ultrasound is expected to increase the curing rate of patients who get diagnosed with diseases mentioned in this table.

TABLE 1– Existing and Proposed Areas For FUS Applications

| AREA | DISEASE |
|---------------------|---|
| Cardiovascular | Hypertension, AVM, Atherosclerosis, Atrial Fibrillation, Hemostasis, Heart Block and many more |
| Endocrine Disorders | Thyroid Nodules, Diabetes and Obesity |
| Neurological | Essential Tremor, Neuropathic Pain, Parkinson’s Disease, Brain Tumors, Depression, OCD, Alzheimer’s Disease, Epilepsy, Hydrocephalus, Multiple Sclerosis, Stroke, Traumatic Brain Injury and Trigeminal Neuralgia |
| Women’s | Uterine Fibroids, Breast Fibro adenomas, Uterine Adenomyosis, Tubal Pregnancy, Fetal Surgery, Cervical Cancer, Ovarian |

| | |
|-------------|---|
| Health | Cancer and Polycystic Ovarian Syndrome |
| Oncological | Bone Metastases, Prostate Cancer, Kidney Cancer, Liver Cancer, Pancreatic Cancer, Soft Tissue Tumors, Head & Neck Cancer, Lung Cancer and Cancer Pain |

9. As per records in FUS Foundation in California, this technology is being designed by 10 manufacturers in North America, by 12 manufacturers in Europe and 10 in Asia
10. As per records in FUS Foundation in California, depicted in Fig. 1, it was in around 1950s when this technology was initially used for treatment of pain. In 1960s, the movement disorder like Essential Tremors or Parkinson’s disease was started to be treated with this technology. Gradually in 1980s, this technology found its ways to treat diseases like Vertigo and Glaucoma. The 1990s saw a great advancement as the outcome of continual research work in this field and chronic diseases like tumors, breast cancer, liver tumor, Pancreatic tumor, Prostate Cancer, BPH found non-invasive treatment procedures using this technology. The 2000s era brought more accomplishments in this field as the brain tumor also found its treatment using this technology. Within past few years, research in this field has just shown wonderful results for treating the diseases like Depression, Alzheimer etc. though these results are yet to be applied on human breed but it has been a great success on animal mammals.[20]

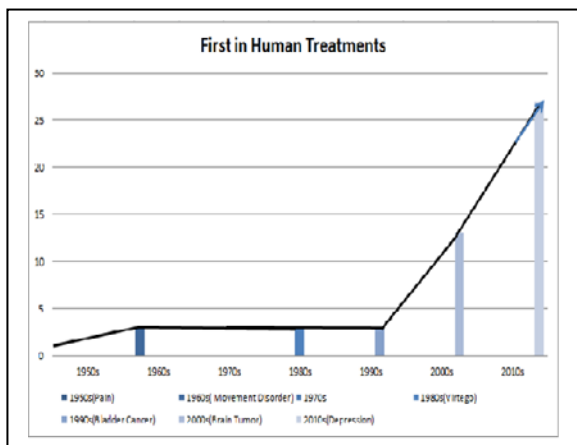


Fig. 1 – Evolution of FUS for Treatment of Various Diseases

4. High intensity focused ultrasound in India

The technology of High Intensity Focused Ultrasound, commonly known as HIFU, has started emerging in India.

It was in July 2010 when Jaslok Hospital in Mumbai claimed its first HIFU surgery which was done successfully on a women namely Ms. Sandhya Dhure who got her treatment using this technology for Uterine fibroids. Dr. Srinivas Desai, Director Imaging and Interventional Radiology of Jaslok Hospital shared with IANS (Indo Asian News Service) that HIFU is being introduced in India as a fast, very cost-effective alternative to hysterectomy or removal of uterus.

The HIFU technology found a gradual entry in the hospitals mentioned below in India:

1. Wockhardt Hospital, South Mumbai
2. Continental Hospitals, Hyderabad
3. Primus Super Specialty Hospital, New Delhi
4. BLK Super Speciality Hospital, New Delhi
5. Seven Hills Hospital, Mumbai
6. Apollo Hospital, New Delhi

Irrespective of being of so much interesting area of research across the globe, it has not been able to gather the attention of all the top most hospitals in India. While trying to understand the reason of this disinterest among different practitioners in India for accepting this technology, it was found that following factors are yet a very big hindrance in its promotion in this country:

1. Lack of awareness – It was observed while talking to chief radiologists in some hospitals in Metro cities that there was a huge gap in their understanding level with respect to the actual interpretation of this technology. Not only the radiologists, but the practioners and of course the patients need to be made completely aware of this technology so that more patients can avail its benefits.
2. Lack of sufficient funds - In some hospitals, it was found that due to its huge cost, many hospitals were not in position of accepting it considering the profit loss scenarios in existing market.
3. Lack of relevant trained practitioners – While some hospitals have started offering the treatment using this technology, still they are not able to cover maximum

cases in single day because of the unavailability of the trained practioners.

4. Bulky Equipment – Though this factor is the least considered factor but it was also mentioned by few practioners mentioning that such equipments are imported from Insightec Company and it takes a long time to make it available for the patients being too much bulky.

Keeping all these factors in mind, and realizing the great potential for treating the deadly diseases with high accuracy levels emphasizes on taking this concept further and making practioners, engineers, governments and researchers across the globe aware about it so that more patients can find ray of hope for their survival from chronic and deadly diseases like tumours etc.

In India, more research is expected to be taken forward in this context so that it can be made available to rural areas also along with urban areas and people can avail the benefits of this technology as much as possible.

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