

## NATIONAL CENTER FOR IMAGE-GUIDED THERAPY

Tmage-Guided Surgery and Interventions in the Advanced Multimodality Image-Guided Operating Suite

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 Precise Localization of Tumor Boundaries for Therapy Clinical Testbed for P41 EB015898 (PI Tempany) National Center for Image-Guided Therapy National Center for Image-Guided Therapy NCIGT.ORG





## **Advanced Multimodality Image** Guided Operating (AMIGO) Suite



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## **1134 Procedures in AMIGO** 08/31/2011-05/13/2016



# **AMIGO Procedures are**

- Standard of Care +
- Under IRB (17 IRB protocols in place)
- Typically one surgery at a time, now 2 IR procedures in parallel
- Physician decides when AMIGO is beneficial
- Gliomas for brain tumor surgery
- Large cervical cancers for gynecologic brachytherapy
- ♦ Repeat negative TRUS biopsy and rising PSA for MR-
- guided prostate biopsy Location of tumor for osteoid osteomas for MR-guided
- cryoablation
- \* Difficult to localize pheochromocytoma for FDG-PET/CTguided resection



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## Some examples

- Brain tumor resection (121)
- Breast cancer surgery (23)
- Gynecologic Brachytherapy (92)

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# **Optimal surgery for brain tumors**

Goal

• Complete resection

• No neurologic injury



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Alexandra Golby, MD Neurosurgeon

## Goals of image-guided neurosurgery

## For the individual patient

#### Surgeon wants to see:

Lesion and define margins Critical structures Relationship between lesion and eloquent areas







Brain tumor resection in AMIGO. Navigation on pre-operative MRI is used to perform a minimal craniotomy with optimized exposure of the lesion



When the dura is exposed, navigated ultrasound imaging is performed prior to making any incisions. Ultrasound provides a fast initial orientation, including the location of major blood vessels.



In a very small subset of cases (now), after the dura is opened and the cortex is exposed, intracranial electrical stimulation testing (ECS) is performed to map important functional areas. This is valuable in confirming and applying preoperative fMRI findings.



Increasingly BOLD fMRI maps are used (without ECS) to delineate the proximity of 'eloquent cortex' to lesion.





White matter tractography provides visualization of the tumor relative to the arcuate fasciculus white matter tract.



Image guidance makes effective tumor resection possible.





A ceiling mounted high field (3T) MR scanner is brought into the OR for intra-operative imaging.



Tumor assessment from pre-op MRI image vs. residual tumor



Post-operative MR scan confirms no intraoperative complications and sets a new baseline. Once conscious, the patient is immediately asked to demonstrate motor control, such as foot movement.



# Why Mass Spectrometry in Neurosurgery?

Many Intra-operative decisions are based on Frozen sections a technology that has been around for the last 150 years. This takes on average 30 minutes.

We want rapid and actionable intra-operative methods for molecular characterization of tissue samples in AMIGO.

Desorption electrospray ionization (DESI) MS can detect 2hydroxyglutarate (2-HG), an onco-metabolite from tissue sections.

2-HG is present in very small amounts in normal cells.

It has been found in large quantities in cells with IDH-1/2 mutations. These include gliomas.

Intra-operative mass spectrometry mapping of an Onco-metabolite to guide brain tumor



Sungata S. Eberlin LS, Norton I, Calligaris D, Feldman DR, Ide JL, Liu X, Wiley JS, Vestal ML, Ramkissoon Sh, Orninger DA, Gill KK, Dunn IF, Dias-Santagata D, Ligon KL, Jolesz FA, Golby AJ, Cooks RG, Agar NY

**80%** of grade II and grade III gliomas and majority of secondary glioblastomas contain IDH1 or IDH2 mutations

Monitoring 2-HG with intra-operative MS could become routinely used for surgeries of primary brain tumors, first to classify the tumor and then, if 2-HG is present, to guide optimal resection.



## **Breast Conservation Surgery**

•Need for re-excision is 20-40% in US

AMIGO

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- intra-procedural supine breast MRI
- for assessment of tumor margins and localization of residual disease

Gombos EC, Jayender J, Richman DM, Caragacianu DL, Mallory MA, Jolesz FA, Golshan M. Intraoperative Supine Breast MR Imaging to Quantify Tumor Deformation and Detection of Residual Breast Cancer: Preliminary Results. Radiology. 2016 Jun

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#### MRI-guided Gynecologic Cancer . 6-Brachytherapy

30% outcome improvement over chemo-radiation

MR is the preferred imaging modality for gyn cancer

Needle artifacts in MR are ambiguous vs. x-ray or CT







- 1. For each needle, use a manually defined tip to iteratively
- search for a short, dark, thin tube
- add this to segmentation if it conforms with the
  "physical model" for the needle; large deflections allowed near the tip and only very small near the base.
- 2. After all needs are individually segmented, identify needle pairs that are physically
- improbable remove the artifact that is causing the errors
- repeat the individual segmentation algorithm for the erroneous needle(s).

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Goal: Find points on the needle path to fit a Bézier curve accurately approximating the catheter shape





# Constrain by Angular Spring Model: large deflections near the tip and only very small near the base



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#### Image-Guided Therapy is the new Surgery Integration of advanced imaging technology in the OR



Augment the eye with imaging Augment the hand with robotics Update images intraoperatively Navigate to delivery site Reduce invasiveness of surgery Apply to multiple procedures







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