Learning Objectives

- To enumerate the clinical rationale for functional radiosurgery
- To discuss the radiobiologic principles of functional radiosurgery
- To describe the application of functional radiosurgery for specific disorders
- To recognize the outcomes and toxicities of functional radiosurgery

Clinical Rationale

Neurologic disorders have a “functional” basis

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Movement disorders stem from disruption in neural networks

Stein et al. Nat Rev Dis Primers 2020

Okun NEJM 2014

Movement disorders stem from disruption in neural networks
Functional Neurosurgery
Targeting neural pathways with modulatory or ablative interventions

Role for stereotactic ablative or radiomodulatory interventions?

Radiobiology

Biological Mechanisms of Radiotherapy
DNA-damage driven response

Augmented response with high-dose per fraction

Mechanisms of Stereotactic Radiotherapy
Unique radiobiology and response?

Targets:
- DNA
- Lipids
- Proteins

Ablative effect
- Immunostimulation
- Vascular sclerosis
- Radiomodulation

Radiosurgery for Functional Neurosurgery

Dr. Lars Leksell developed radiosurgery (1960s) as an alternative to potentially morbid surgical procedures for functional disorders, including:
- Movement disorders
- Psychiatric conditions
- Chronic Pain syndromes
Clinical Applications

- Severe, unilateral electric-like pain
- Medical therapy 90% effective
- Neurovascular compression at REZ
- Surgery for refractory patients
- High potential morbidity from surgery
- Treated with “radiosurgery” in 1951

Trigeminal Neuralgia
A ‘simple’ functional disorder

- Targeting root entry zone (REZ), 80Gy@100% IDL, 4mm shot

GK SRS widely adapted for TN

Clinical Outcomes, University of Pittsburgh

- N=503 patients TN
- 4mm, 80 Gy max dose
- 80% patients had pain relief
- 41% durable relief at 5 yrs
- 10.5% new/incr facial nerve sx's
Trigeminal Neuralgia
Clinical Outcomes, ISRS Guidelines

Movement Disorders: MTLE
Mesial Temporal Lobe Epilepsy
• Chronic, recurrent seizure activity
• Focally originates in the temporal lobe
• Primary treatment is medical therapy
• Surgery is reserved for salvage

Movement Disorders: Rose Trial
SRS vs Anterior Temporal Lobectomy for refractory unilateral MTLE, n=58 pts.
24 Gy@50% IDL
Seizure remission: 58% SRS vs 78% ATL
Barbaro et al. Epilepsia 2016, Narayanasamy et al. JACMP 2019

SRS for Obsessive Compulsive Disorder
Gamma Ventral Capsulotomy (IRRF study, n=40), 120-180 Gy @100% IDL

Radiosurgery for Celiac Plexus Neuralgia
Pancreatic cancer pain disorder
• 70-80% patients with pain
• Treatments:
  • Analgesic medical therapy
  • Chemotherapy
  • Celiac plexus nerve block
• Role for radiosurgery?
Radiosurgery for Celiac Plexus Neuralgia

Pancreatic cancer pain disorder

- Pilot Trial Sheba Med Center
- 25 Gy in one fraction
- T12-L2 aorta plus prox tumor
- Primary obj: 3 wk pain response

Decrease in NRS pain score

Pain was eliminated in 33% of patients during follow-up.

Radiosurgery for Celiac Plexus Neuralgia

Pancreatic pain disorder: Pilot trial n=34 (21)

Lawrence et al. ASCO 2019

Ongoing international Phase II trial (n=100)

Cardiac Radioablation for Arrhythmias

Management of Ventricular Tachycardia (VT) and Atrial Fibrillation (AF)

- Pharmacologic therapy
- Temporary Pacing
- Permanent Pacemaker/Defibrillator
- Cardiac Catheter Ablation


Cardiac Radioablation for Arrhythmias

Radiosurgery for Ventricular Tachycardia (VT) and Atrial Fibrillation (AF)

- Non-invasive high-dose radiation to arrhythmogenic target in heart
- Requires precise image-guidance and motion management strategies

Lydiard et al. IJROBP 2020

- Electroanatomical Mapping
- Motion Management
- Tracking
- Internal Target Volume
- External Pacing
Functional Radiosurgery is safe and effective for non-invasive management of numerous non-malignant conditions. High-dose technique requires precise mapping for ablation. Well-established efficacy and safety for treatment of trigeminal neuralgia. Additional indications include epilepsy and obsessive compulsive disorder. Expanding applications including sites of neuralgia, cardiac arrhythmia.