AVM: Radiosurgery

Debnarayan Dutta, MD
Professor & Head, Radiation Oncology
Amrita Institute of Medical Science, Kochi
Treatment options:
1. Surgery
2. Embolization
3. SRS
4. Observation
Rigid frame based SRS: Work Flow

Fixation of frame

DSA

CT Scan

Image fusion

Planning

QA (LUTZ test)

Treatment

One day procedure
Need admission of patient
Frame fixed >6-8 hours
Frameless SRS: Work Flow

Day 1:

- Thermoplastic mask
- CT Angio
- MR Angio
- CT Scan

- Image fusion
- Planning
- QA

Next day:

- Treatment with mask

2 days procedure
OUT PATIENT
No admission of patient
AVMs

**Epidemiology**
- Account for 10% SAH and 1% of strokes
- Autopsy studies show 4-5% incidence in general population
- Males: Female 2:1

**Presentation**
- Hemorrhage (50%) usually during 2\textsuperscript{nd}-4\textsuperscript{th} decades
- 10-20% risk of death if bleeds
- 10-20% risk of long-term disability
- Increased risk of re-bleed of 6% during first year after initial bleed
- Seizures (25%)
- Headache (15%) migraine-type
- Pulsatile tinnitus

**Treatment**
- Treatment is surgery – early cure, no need to wait for 1-2 years
- Embolization – have it’s issues, may re-canalize/ partial obliterate
- SRS – an effective option, but take 2-3 years to cure
AVM: When to treat

- Deep seated AVMs
- Eloquent area AVMs
- Post-surgery residual AVM
- Post-embolization residual AVM
- Patient refuse surgery

- If AVM Bleeding: wait till blood resolves (usually 3 months)
- Symptomatic AVM (Convulsion, headache)

- Nidus size: usually <3 cm
AVM: NEED to know before treatment

- Post-SRS, need at **least 2 years to completely** obliterate (cure)
- Risk of **bleed is same**, if not more in first 2 years after SRS

- **DSA is the Gold standard** for diagnosis and response assessment
- **MRA** is close second, but usually need a DSA confirmation

- There **is no partial response** in AVM
- Either **completely cured (obliterated)** or **FAILED**

- **FAILURE** may be due to 1) **Inadequate contour** of nidus, 2) **Inadequate dose**
- Nidus coverage should always be **complete**
- As high **marginal dose** possible need to be delivered
- If partial obliteration, higher risk of bleed

- Why we are treating – to **STOP bleeding**
AVM: Why partial obliteration is harmful?

- Higher turbulence with shrinkage of nidus
- Higher risk of bleed
AVM: Prerequisites before Contouring

- **CT scan brain without & with contrast** – see bleed, location, nidus volume, mass-effect
- **Four vessel DSA** (preferable) – Arterial contributions & veinous drainage
- Nidus volume & location

**Examination**-
- Neurological status – Any neuro-deficit
- Any Genetic syndromes – **Sturge Weber Syndrome** etc
- ASK for duration of symptoms, history of any neuro-deficit, convulsion, headache (mass effect)

- Any **history of bleed** or any sign of recent bleed in imaging, withheld SRS procedure till blood gets completely resolved
- Nidus volume will change with blood clot

**TO DO**-
1. ALWAYS study DSA (mostly **2D images**) images with **interventional radiologist & surgeon**
2. Evaluate ALL the **phases** – filling, draining
3. Review the **site of lesion** – eloquent area, motor cortex etc
4. Approximate 2 D volume estimation
5. Inform patients: it will take 2 years at least to respond, may bleed in first 2 years after SRS

Have a **plan in mind** before starting the procedure
AVM: know from DSA

From DSA / MRA / CT scan:
- **Location** of the nidus
- **Feeding vessels** – cerebral circulation or vertebral circulation contribution
  - Anterior circulation / posterior circulation / dual
  - **Supplied by** – anterior cerebral, middle or posterior cerebral artery

NEED to know the supply to locate the nidus & junction of artery & nidus

- **Drainage** – Superficial drainage, deep drainage or dual
- **Flow rate** - High flow or slow flow circulation

- Nidus volume & extent
- Overlying vessels

- Critical structure nearby
AVM: Contouring

- **Nidus volume** include: COMPLETE nidus in delayed phase need to be included
- Nidus volume will change with different filling & draining phase, hence **appropriate phase** need to be selected for contouring

- Ideally, **rotational angiogram** in different phase need to be fused with planning CT scan

- If not possible, take CT scan / **CT Angio** in different phase (arterial, veinous, delayed)
- **MR Angio** done & fused with CT scan

- **Eye balling the DSA 2D films** always during contouring
AVM: Contouring

- **Nidus**: lesion seen on DSA
- **NO CTV** margin

- **PTV margin**: 0-2 mm
  (depending upon setup error and treatment accuracy)

**Normal brain**

**OARS:**
- Eye
- Chiasm
- Optic nerve
- Brainstem
- Spinal cord
AVM: NEED to know about Dose prescription

- There is **no dose fixed for AVM**
- In **isocentric technique**, dose prescribed at isocentre and isodose line covering the target is assessed
- **Peripheral (marginal) dose is considered important for obliteration**
- **MAX dose or prescribed dose is NOT important for obliteration**

- In **multiple isocentric techniques** or in volumetric prescription, marginal dose is calculated

- Preferable **marginal dose is 20-24 Gy**
- **Beyond 24 Gy**, no additional benefit
- **Less than 18 Gy**, obliteration rate drops significantly

- **Toxicity** (Persistent neurological deficit) depends upon **12 Gy normal brain volume**

- Dose prescription done with persistent neurological deficit probability **<5% & obliteration rate >80%**
AVMs: SRS dosimetry

Obliteration depends upon: **marginal dose**

Complication depends upon: **12 Gy normal brain volume**

Higher precision RT: rapid dose fall-off – high marginal dose & low 12 Gy volume
Dose response curve: obliteration rate

Obliteration after SRS depends upon marginal dose

Long-term Toxicity

% AVM with Symptomatic Radiation Necrosis

Volume (cc) receiving 12 Gy or more
Long-term Toxicity

% AVM with Symptomatic Radiation Necrosis

Volume (cc) receiving 12 Gy or more
AVM: Isocentric accuracy test (LUTZ Test)
Treatment delivery: Frameless Robotic SRS in AVM

Treatment time: 20-45 min
Thermoplast based SRS
Pts received Dexa/ PPI
No acute toxicity for majority of patients (one pt had brain oedema requiring MDT)
Follow up: Protocol

Follow up:

- MRA/ MRI every 6 monthly / 12 monthly
- After MRA shows complete obliteration, **DSA needed for confirmation**
- Once obliteration is complete: **CURE. No further follow up**
- If **NOT obliterated after 2 years**, follow till **3 years** with MRA
- **Residual AVM need retreatment** – Surgery, embolization or re-SRS
Case 1
Obliteration rate = 85%

\[ \alpha/\beta = -49.3 \pm 5.3 \]
Long-term Toxicity

% AVM with Symptomatic Radiation Necrosis

- Pons/Midbrain
- Thalamus
- Occipital
- Cerebellar
- Intraventricular
- Frontal

Toxicity = <10%

12 Gy Vo: 19.4 cc

Volume (cc) receiving 12 Gy or more
Case 2
Obliteration rate = 80%
Long-term Toxicity

% AVM with Symptomatic Radiation Necrosis

Toxicity = <3%

12 Gy Vo: 6.8cc
Case 3
12 Gy Normal brain vol: 17.9 cc
12 Gy Normal brain vol: 19.3 cc
% with In-field Angiographic or MR Obliteration

Marginal Dose (Gy)

Obliteration rate = 80%

$\alpha/\beta = -49.3 \pm 5.3$
Long-term Toxicity

% AVM with Symptomatic Radiation Necrosis

Volume (cc) receiving 12 Gy or more

Toxicity = <5%

12 Gy Vo: 25 cc
Take HOME

- All cases are different
- Do more cases to learn more
- Individualize treatment accordingly

- Get appropriate imaging
- Excellent immobilization

- Respect OAR Constraints
- Understand required dose

- Discuss
Thank you
duttadeb07@gmail.com