Volume Assessment of Intracranial Arteriovenous Malformations using Contrast- Enhanced Sliding Interleaved Ky (SLINKY)

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Introduction: Arteriovenous malformations (AVM) of the brain are thought to be congenital vascular lesions that affect 0.01-0.50% of the population and generally present in patients aged 20-40 years. The usual clinical presentations are haemorrhage, seizures, progressive neurological deficit, or headache [1]. At presentation most patients with suspected AVM have conventional catheter angiography (CCA), which is the reference standard by which other methods are judged. Due to its invasive nature there is a role for evaluating less invasive Magnetic Resonance imaging techniques to investigate patients with AVM. We examine the role of Contrast-enhanced Sliding Interleaved Ky (CE-Slinky) [2] in the assessment of AVM of the brain for their classification by the Spetzler-Martin Classification, which uses maximum linear dimension (MLD), eloquence and venous drainage as the criteria [3]. Therefore one aim is to assess the correlation between MLD measured with CE-Slinky against MLD measured with CCA. Treatment of intracranial AVM with Stereotactic Radiosurgery (STRS) needs accurate measurement of the volume of the nidus of the AVM. Therefore another aim of this work is to compare nidus volume measurements made with CE-Slinky against volumes obtained using CCA.

Methods: Sixty patients with cerebral AVM were recruited into this prospective study, which included historical data from thirty patients. In the sixty patients, the mean age was 38.9 years with a near equal sex distribution. Thirty-four patients were being treated for the first time with STRS, 8 patients were retreats, 16 had embolisation and 2 had both embolisation and STRS. A standard MR imaging (MRI) protocol was performed for all patients with a 1.5-T super conducting system (Eclipse; maximal gradient strength 27mT/m; Marconi Medical Systems, Cleveland, OH) used in conjunction with a head coil. Three-dimensional SLINKY time-of-flight data acquisition technique was used after the administration of a bolus of 10 ml of 0.5mol/L gadolinium diethylenetriaminepenta-acetic acid (Gd-DTPA) (Magnevist; Schering A G Healthcare, Berlin, Germany), followed by a 10 ml saline flush. The SLINKY imaging parameters were as follows: TR 29 ms; TE 6.7 ms; flip angle 33 degrees; field of view 22.0 cm; slice thickness 1.0 mm; no gap; 113 images; resolution 512 × 256 (resolution increased acquired matrix factor × 2); phase sampling ratio 0.809; bandwidth 15.6 kHz.

Limited selective, transfemoral, Seldinger CCA was repeated under stereotactic conditions within 24 hours of the MR imaging using a Leksell Model G stereotactic coordinate frame (Elekta Instruments, Atlanta, GA). This was secured to the patient's head using local anaesthetic at four pin sites of pin insertion. CCA was performed appropriate to the known supply to the AVM nidus.

Two observers (S.N. and D.C.) who were blinded to the results of the CCA findings carried out the image analysis. They assessed the diameter *a*, *b*, *c* of the nidus in anteroposterior, craniocaudal and mediolateral planes respectively using the time-of-flight CE-SLINKY data. Volume of the nidus was calculated on the assumption the shape of the nidus being ellipsoid as in current working practice (using the formula, volume = $4/3\pi(a/2 + b/2 + c/2)^3$. The results were compared with the volumes that were acquired from the CCA data that were used to treat the patients. Results of the maximum linear dimension of the AVM were also compared in accordance with the Spetzler-Martin classification to confirm the historical findings.

Results: The Pearson's correlation coefficient for nidus volumes measured with CE-Slinky against CCA was 0.977 (see Fig 1). For maximum linear dimension the Pearson's correlation coefficient was 0.958 (see Fig 2).

Discussion: The obliteration of the nidus is one of the main aims of STRS in the treatment of intracranial AVM. Accurate delineation of the nidus therefore is the prime prerequisite for targeting of intracranial AVM with STRS. Though CCA remains the reference standard due to its high spatial (0.2 mm) and temporal (24 frames/second) resolution it is invasive and is associated with a clinical complication rate of 0.5 – 2% with a risk of silent embolism (23%) [4]. In the sixty cases of this study CE-Slinky clearly demonstrated the nidus (Fig 3) and the measurements were comparable to that of CCA both with regards to maximum linear dimension and volumes. One of the reasons for such a good correlation is that the AVM were preselected, in that all the patients had been referred for STRS with majority of the AVM being moderate in size. With the advent of higher resolution scanners these results are definitely encouraging in non-invasive techniques of intracranial AVM management.

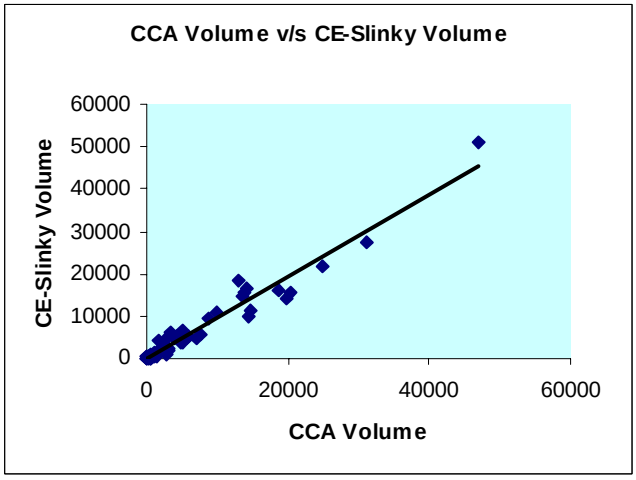

Figure 1. Plot of volumes determined by CCA against CE-Slinky

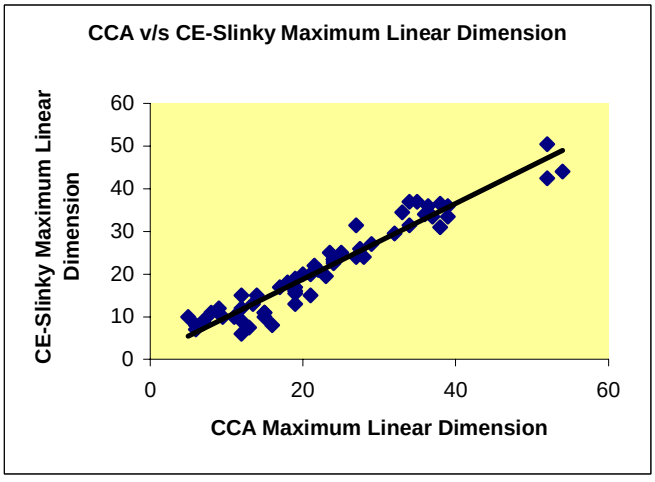

Figure 2. Plot of MLD determined by CCA against CE-Slinky

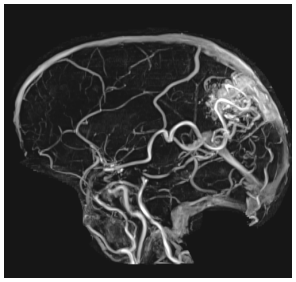

Figure 3: A parietal AVM on CE-SLINKY.

References:

1. *Arteriovenous malformations of the brain in adults.* N Engl J Med, 1999. **340**(23): p. 1812-8.
2. Obuchowski, A., Lefkowitz, DL, Kode, LS, Liu, K, Gullapalli, RP, *Evaluation of cranial MRA using the novel technique SLINKY and comparison with standard 3D time of flight MRA.* Proc. Intl. Soc. Magn. Reson. Med, 1999. **7**: p. 207.
3. Warren, D.J., et al., *Cerebral arteriovenous malformations: comparison of novel magnetic resonance angiographic techniques and conventional catheter angiography.* Neurosurgery, 2001. **48**(5): p. 973-82; discussion 982-3.
4. Mani, R.L., et al., *Complications of catheter cerebral arteriography: analysis of 5,000 procedures. I. Criteria and incidence.* AJR Am J Roentgenol, 1978. **131**(5): p. 861-5.