

**SREE CHITRA TIRUNAL INSTITUTE FOR  
MEDICAL SCIENCES AND TECHNOLOGY,  
TRIVANDRUM, INDIA**



**LOG BOOK**

SUBMITTED IN FULFILLMENT FOR THE COURSE OF  
( **DAMIT** )  
**DIPLOMA IN ADVANCED MEDICAL IMAGING  
TECHNOLOGY**

PERIOD: JAN 2014 – DEC 2015

**SHYNI B.**

**SREE CHITRA TIRUNAL INSTITUTE FOR  
MEDICAL SCIENCES AND TECHNOLOGY,  
TRIVANDRUM.**



**CERTIFICATE**

This is to certify that **Shyni B** has participated in Interventional cases and Imaging Cases during the period Jan 2014 to Dec 2015 while working as an Technologist student in the Department of Imaging Sciences and Interventional Radiology, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum, Kerala (India).

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*Professor & Head,*

Department of Imaging Sciences and Interventional Radiology,  
**Sree Chitra Tirunal Institute for Medical Sciences and Technology,  
Trivandrum, Kerala INIDA.**

## **PREFACE**

This work book, I have done as part of my training in the dept of radiology for diploma in Advanced Medical Imaging Technology (DAMIT) course includes brief details of the equipment used in the Dept, basic physics and working involved with the equipments, the routine protocols and the procedures followed in our different labs, number of cases which I have individually done in X-RAY,CT, MRI &3D WORKSTATION, and the cases which I have assisted in Neuro and Cardiac Cath Lab, I also have included the seminars and projects I have done.

DAMIT is a two years full time residential programme in advanced medical imaging technology for qualified radiographers to excel and learn the newer techniques in medical imaging. Selection is done by a national level entrance examination. At present institute offers 3 seats.

The students are posted in the department of radiology equipped with all modern medical imaging facilities-State of art and top of the line-MRI system, Spiral CT system, DSA suit, Colour Doppler ultra sound scanner and a radiology network with a central workstation with added 3D software and the division of Interventional Radiology make it a distinguished Radiology Dept .The course schedule contains theory classes, practical training, seminar presentations & projects. Diploma is awarded after successful completion of 2 Year term based on a written examination with viva-voce and internal assessment.



BIOMEDICAL TECHNOLOGY



PATIENT CARE

**The Sree Chitra Tirunal Institute for Medical Sciences & Technology (SCTIMST)**, Thiruvananthapuram is an Institute of National Importance established by an Act of the Indian Parliament. It is an autonomous Institute under the administrative control of the Department of Science and Technology, Government of India.

The Institute signifies the convergence of medical sciences and technology and its mission is to enable the indigenous growth of biomedical technology, besides demonstrating high standards of patient care in medical specialties and evolving postgraduate training programs in advanced medical specialties, biomedical engineering and technology, as well as in public health

It has a 250-bedded hospital for tertiary care of cardiovascular and neurological diseases, a biomedical technology wing with facilities for developing medical devices from a conceptual stage to commercialization, and a center of excellence for training and research in public health.

The Institute has the status of a University and offers postdoctoral, doctoral and postgraduate courses in medical specialties, public health, nursing, basic sciences and health care technology. It is a member of the Association of Indian Universities and the Association of Commonwealth Universities

## **ACKNOWLEDGEMENT**

First and foremost, I would like to thank my Head of the Department Prof. Dr. Kapilamoorthy, Prof. Dr. Kesavadas C, Ad. Prof. Dr. Bejoy Thomas and all other faculty members who had guided me through the different phases of my studies encouraged and helped me on all aspects of my training.

I thank the Director of the institute Dr. Asha Kishore, Dean Prof. Dr. Suresh Nair and the Registrar Dr. A.V. George, for their advices and kind attention towards me.

I extend my heartfelt thanks to all the Radiographers, other staffs of radiology, staff members of different depts, for their help during my stay in the institute. I am thankful to the patients who were the core medium of study.

At last, I would like to acknowledge my sincere thanks to PG residents, senior and junior DAMITS for their co-operation at work place and in studies.

# **COURSE CURRICULUM**

<b>POSTING</b>	<b>NUMBER OF MONTHS</b>
<b>DSA</b>	<b>7</b>
<b>MRI</b>	<b>8</b>
<b>CT</b>	<b>8</b>
<b>CARDIOLOGY AND BME</b>	<b>15 DAYS</b>

**1. Every Thursday 8:00 AM to 9:00 AM – Seminar**

# PRACTICAL DATA SHEET

## A ) Cases done in OPD X-Ray.

Equipment : SIEMENS Heliophos 4M 500mA.-+  
No of Cases : More than 1700 (Chest, Spines, Pelvis, and Extrimities.)

## B ) Portable X-Ray.

Equipment : SIEMENS Simox D 40mA.GE genius 60mA0  
No of cases : About 2500 including chest, abdomen, skull and CV Jn.

## C) CT Scan.

Equipment : Brilliance iCT 256 slice/ Ge light speed dual  
No of Cases : Head - 3000  
Chest - 500  
Abdomen - 300  
CT Angios - 1100  
Cardiac CT - 56

## D) CT Interventional Procedures.

CT Guided Biopsies : 30  
Bone Biopsies : 25  
Stereotactic Studies : 45  
Laser Ablations : 5

## F) Magnetic Resonance Imaging.

Equipment : Magnetom Avanto Tim 76 x 18

No of Cases Done :

Brain - 1900  
Cervical Thoracic,& Lumbar Spines - 1300  
Stereotactic MRI(Pallidotomy & Biopsys) - 23  
Musculo Skeletal System  
(Pelvis, Hip joint, Knee, Shoulder joint Etc.) - 60  
Cardiac imaging - 100  
Abdomen and Chest - 30  
MR Angiograms - 290

### **H) D S A Lab.**

Equipment : **GE innova 3131.**

No of Cases Assisted:

<b>4Vessel Angios</b>	:	450
Aortograms	:	50
IVDSA	:	3
Peripheral Angios	:	30
Spinal Angios	:	60
Coronary angio	:	6
Bronchograms	:	5
PTBD	:	45
WADA Test	:	25
BOT	:	4
Ba Studies	:	17

### **Interventional Procedures :**

Angioplasty	:	140
PTCA	:	5
PDA Coiling	:	6
Embolization (Onyx,Glue& Particle)	:	120
GDC Embolization	:	60
Chemo. Embolization	:	26
Thrombolysis	:	12
Stenting	:	60
Tracheal Stenting	:	1
PLDD	:	6
Vertebroplasty	:	1
TESI	:	20
TGN laser ablation	:	9
Flow diverter	:	4
TEVAR	:	7
EVAR	:	3

## **SEMINARS PRESENTED**

1. Basic Principles Of Ultra Sound - Its Advantage And Disadvantages
2. Computed Radiography & Digital Radiography
3. Echoplanar Imaging and its clinical applications
4. MR Angiogram
5. MR Hardwares & its advances
6. Principles of Digital Subtraction Angiography (DSA)
7. PACS & Teleradiology
8. Hybrid Imaging
9. MR Perfusion Imaging
10. Cath lab Materials.

# **INDEX**

## **Magnetic Resonance Imaging**

### ***Advances in MRI***

- Perfusion weighted imaging
- Diffusion Tensor imaging
- Susceptibility weighted imaging
- MR angiography
- Functional MRI

## **Computed tomography**

### ***Advances in CT***

- Cardiac CT
- CT perfusion

## **Digital subtraction angiography**

- Hardware's in DSA
- 3d Rotation angiography

## **Computer and digital radiography.**

## **Project**

# Magnetic Resonance Imaging

## System Specification

### 1. SIEMENS Magneto Avanto Tim 76x18 1.5T

- Offering full iPAT functionality.
- Utilizes highest SNR.
- Q-engine (33 mT/m)
- SQ-engine (45 mT/m ) with 50 cm FoV.

## Magnet specifications

- Length - 150 cm
- Magnet bore diameter - 90 cm
- Total system length - 160 cm
- Magnet weight - 3,550 kg (approx)
- Super conductor - Ni-Ti
- No of field generating coils - 7

## Gradient specifications

- Max Gradient amplitude - 40 mT/m (X & Y)
- Min rise time - 200 $\mu$ S
- Max slew rate - 200T/m/s

## RF system

- RF transmit coil – Body coil
- Peak power of Transmitter amp – 15 kW
- Receiver band width – 500 Hz- 1MHz

## **Syngo platform**

- *syngo* is the common software for siemens modalities.
- Panoramic Recon Image Processor, reconstructing up to 3226 images per second
- Host Computer - Pentium 4 based, 3 GHz and 2 GB RAM capacity.
- Spectro processing card.

## **2. GE DISCOVERY 750W 3T**

- Offering parallel functionality & multidrive RF TRANSMIT Technology.
- Utilizes highest SNR.

### **Magnet specifications**

- Magnet bore diameter - 70 cm
- Total system length - 130 cm
- Magnet weight - 3,550 kg (approx)
- Super conductor - Ni-Ti
- No of field generating coils - 7

### **Gradient specifications**

- Max Gradient amplitude - 44 mT/m
- Min rise time - 220 $\mu$ S
- Max slew rate - 200T/m/s

### **RF system**

- RF transmit coil – Body coil , Head coil & Extremity coil
- Peak power of Transmitter amp – 15 kW/channel[30kW total] for body & 4.5kW for head
- Receiver band width –  $\pm$ 250kHz

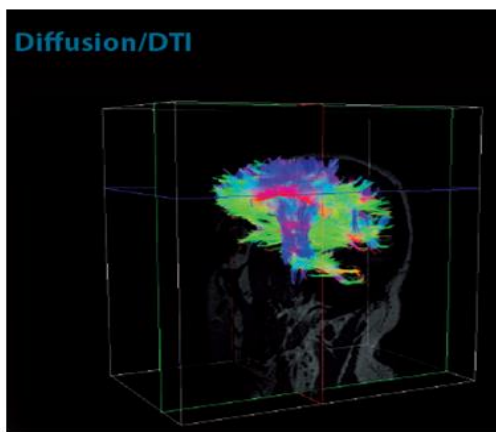
# NEW POST PROCESSING SOFTWARE

## MYRIAN – INTRASENSE

- Module based solution for Diffusion/DTI , Perfusion/DCE imaging
- Windows based software
- Vendor – neutral application , process image from any modality manufacture

## XT- BRAIN nordic ICE

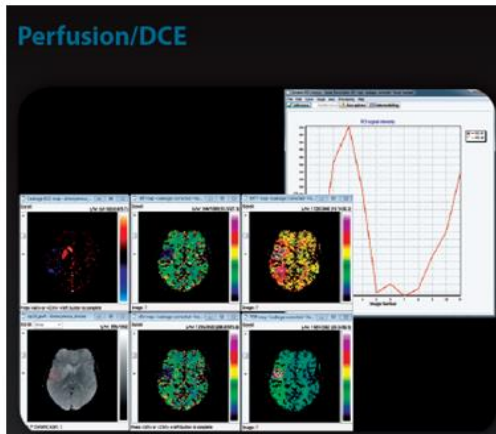
Provide flexibility for research oriented work



**Tools**

**Myrian® XT-Brain Diffusion & DTI:**

- Fast generation of various parametric maps; color-coded DTI, FA, RA, ADC, TraceW & tensor eigenvalues
- Simplified workflow and analysis using an intuitive step-by-step interface guiding the user through the process of data loading, analysis and visualization
- Integrated correction scheme for motion and eddy current artifacts
- Co-registration between DWI data and structural T1/T2 volume
- Fiber Tracking using seed/target approach or exhaustive search
- Optimize tracking results by selection of termination criteria (FA-threshold, tract turning angle)
- State-of-the-art 3D visualization of white matter fiber tracts superimposed on various underlay volumes (e.g. structural T1/T2, FA, color-coded eigenvector map)
- Superimpose 3D BOLD fMRI activation



**Tools**

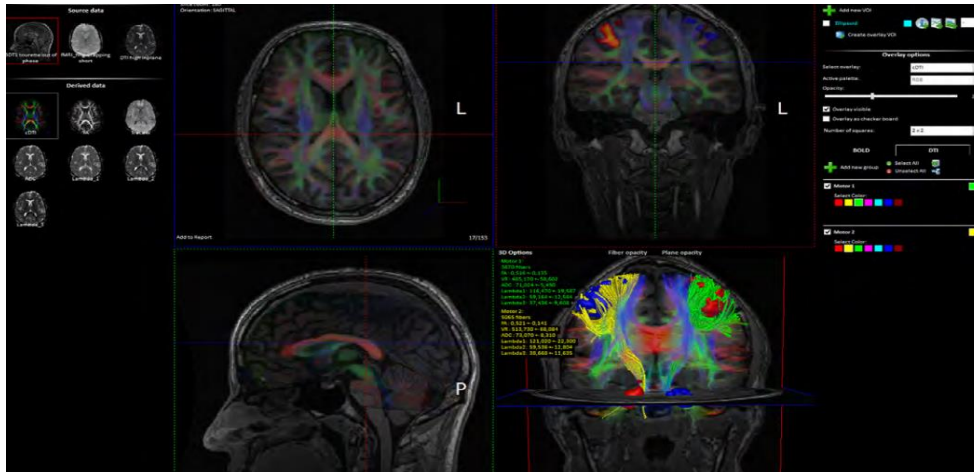
**Myrian® XT-Brain Perfusion & DCE:**

- Fast generation of perfusion maps (BV, BF, MTT, TTP, SVD)
- "One-button" perfusion analysis using pre-defined settings
- Choice of manual or fully automatic selection of arterial input function (AIF) with visual inspection of individual AIF pixels
- Integrated motion correction
- Optimized for tumor perfusion analysis; including advanced processing methods like vessel segmentation and contrast agent leakage correction ("leakage" (Ktrans) maps)
- Optional gamma-variate fitting of input function and tissue curves
- Easy image fusion (drag & drop) of perfusion maps and structural image
- State-of-the art deconvolution techniques for arterial input function (AIF) corrected kinetic analysis
- Fast generation of both quantitative maps (Ktrans, kep, Ve, Vp) and qualitative maps (AUC, Time to peak, Peak enhancement, Wash-in/ wash-out rates)

## nordic Brain EX :

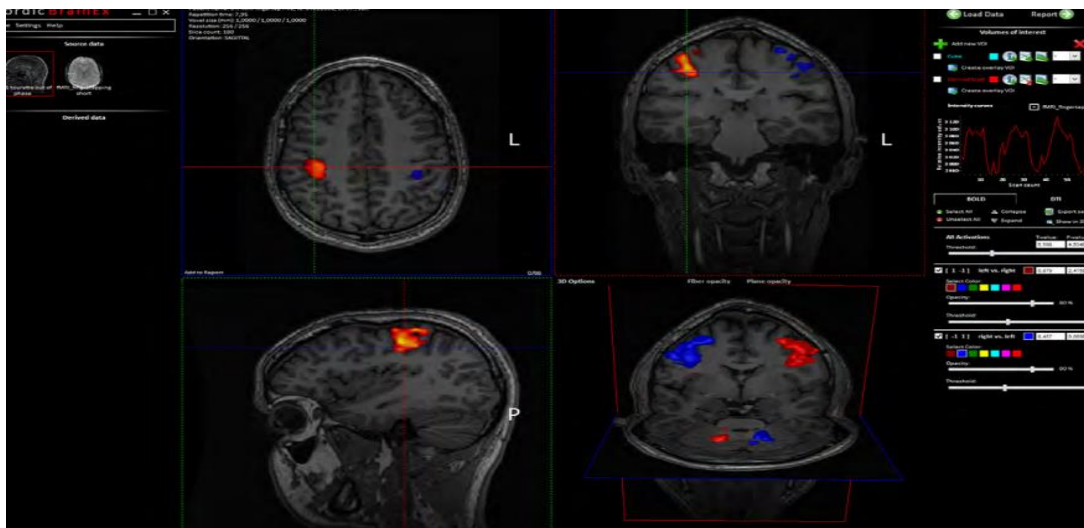
Clinical tool that focus on ease of use and efficiency in clinical setting

- DTI Fiber tracking Module

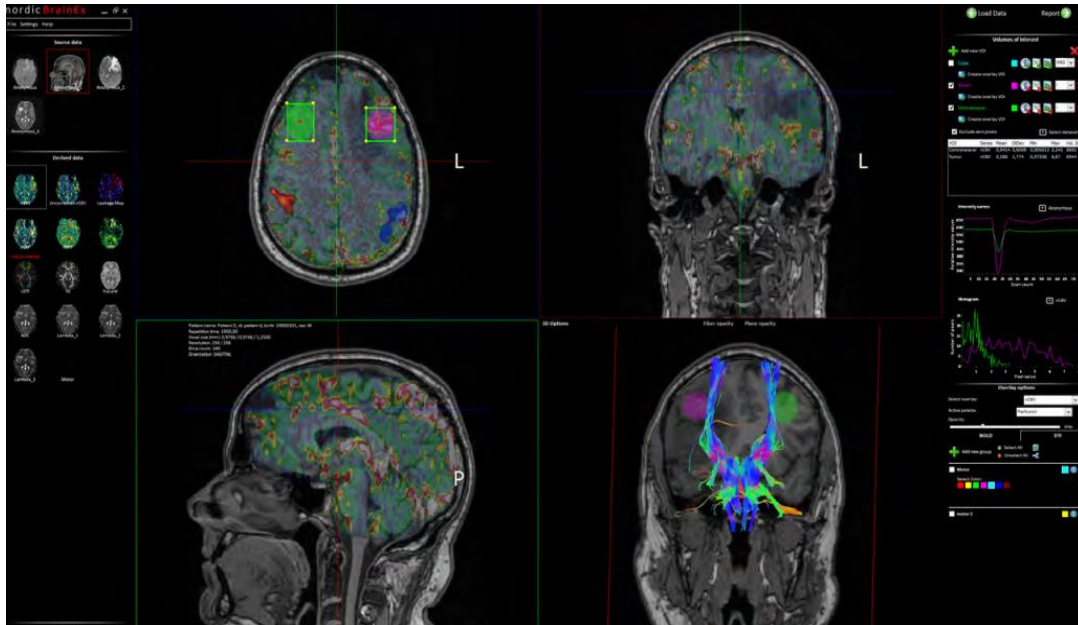


Preprocessing - Motion Correction, Eddy current correction , Smooth , Average ,Adjust noise level  
 Fibertracking – multiple VOI , AND OR & NOT option

➤ BOLD fMRI module



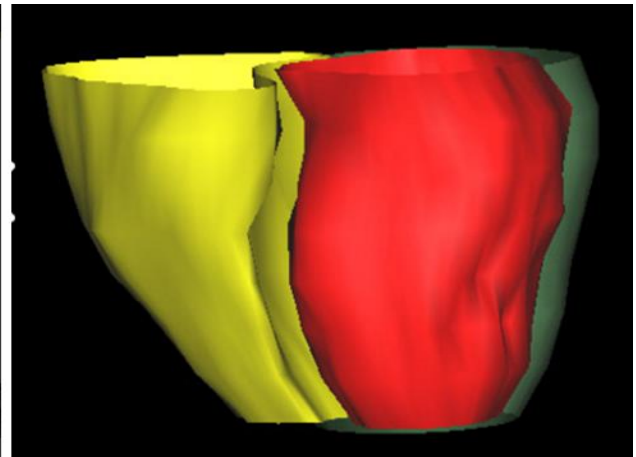
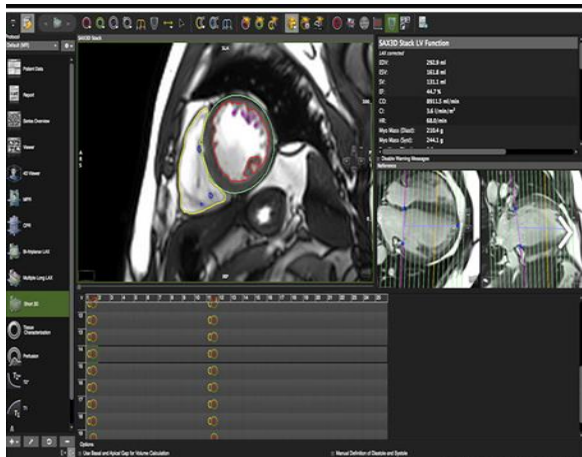
➤ Perfusion/DSC module



- Possible to combine the results from BOLD , DSC PERFUSION and DTI

## CIRCLE CARDIO VASCULAR IMAGING

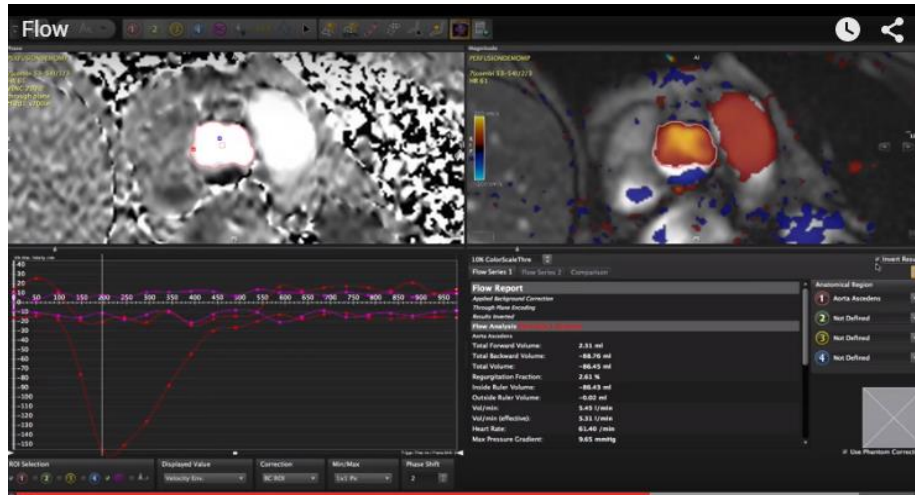
- LV/RV FUNCTION



- Left and right atrial volumetry [disk area summation & area length method]
- Polar maps offering customizable segmentation including AHA segmentation model
- Semi-automatic mitral & tricuspid valve correction
- Optional in- or exclusion of trabeculae and papillary muscles in/from myocardial mass

- Unique threshold based edge detection allows for quick and precise delineation of trabecular structures and/or papillary muscles
- 4D model of left and right ventricle (mesh or solid surface)

## ➤ FLOW



- Color coded flow velocities with adjustable color scale
- Automatic border detection, forwarding and registration
- Automatic synchronization of phase and magnitude images
- Flow and velocity analysis of up to four regions of interest in one series
- Flow analysis of two different series and calculation of flow difference, sum and ratio, etc. (to assess shunt volumina and more)
- Display of flow velocity curves in an interactive diagram
- Background and phantom correction options
- Option of post-hoc flow direction inversion
- Wide range of calculated values including regurgitant volume and fraction, cardiac output, min/max and mean pressure gradients, as well as net positive and net negative volumes

## TISSUE CHARACTERIZATION



### Late Enhancement and T2 weighted imaging

- Qualitative and quantitative assessment of scar and edema
- Infarct core and "grey zone" quantification
- MVO assessment
- Calculation of myocardial salvage
- Existing contours can be derived from other sequences
- Various threshold settings, including an auto-threshold mode (Otsu) and Full-Width-Half-Max
- Polar maps of enhanced area and transmuralty
- Color-coded 4D mesh model display of tissue characteristics

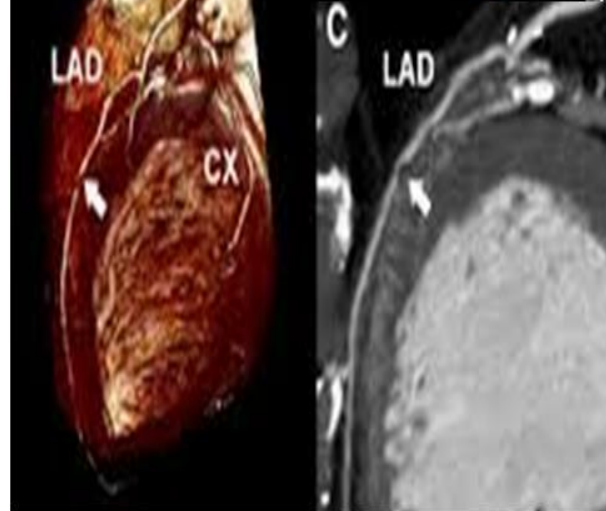
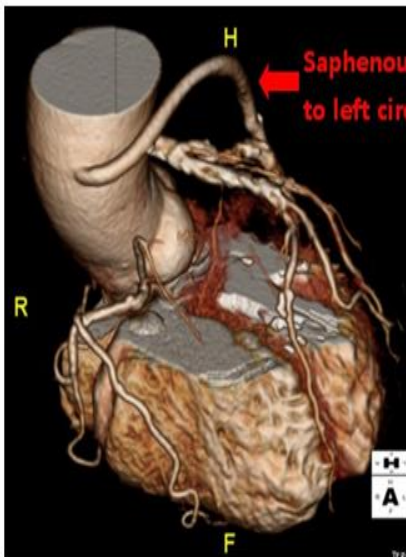
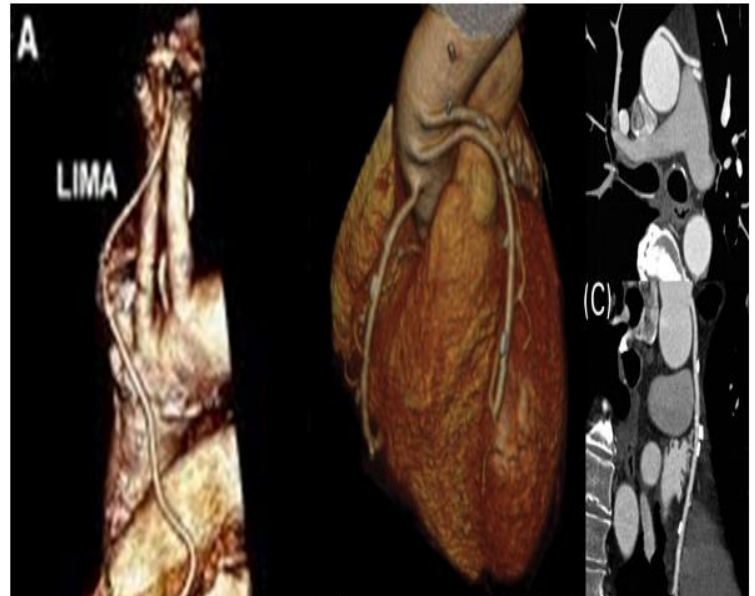
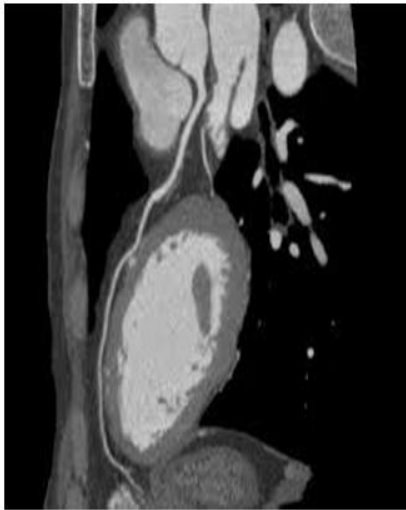
### Early Gadolinium Enhancement

- Assessment of inflammation properties and/or MVO
- Contours are automatically forwarded to the corresponding baseline/post-contrast image
- Calculation and auto-display of myocardial early enhancement and T2 signal intensity ratio (quantitative Lake Louise Criteria for myocarditis)
- Color map of T2 signal intensity ratio

➤ **PERFUSION, T<sub>1</sub> MAPPING . T<sub>2</sub>/ T<sub>2</sub><sup>\*</sup> MAPPING , 4D VIEWER**

## TERARECON – iNtution

- ✓ Volume rendering applications
- ✓ Perfusion
- ✓ Image fusion .....etc



## **Advances in MRI**

Advanced sequences for MRA

Perfusion weighted imaging

Diffusion Tensor imaging

Susceptibility weighted imaging

Functional MRI

## ADVANCES IN MRA

1. TRICKS / TWIST / KEYHOLE
2. INHANCE/NATIVE

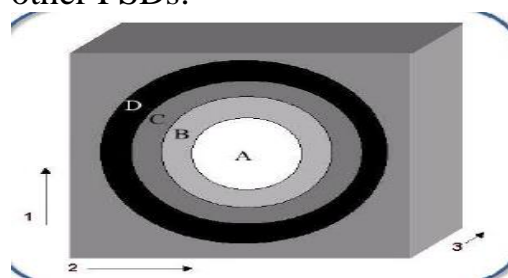
### TRICKS / TWIST

. This can be used in combination with contrast injection to provide dynamic clinical information, including the evaluation of abnormal vascular anatomy as well as vascular hemodynamics, and perfusion measurements. The technique is possible because of the advances in the parallel imaging technique and advances in the k- space coverage scheme because of the higher performance gradients

TRICKS is a CE MRA multi-phase, single station, acquisition technique to visualize dynamic processes, such as the passage of blood with contrast agent through the peripheral vascular system. It eliminates the need for a timed or automatic triggering of contrast.

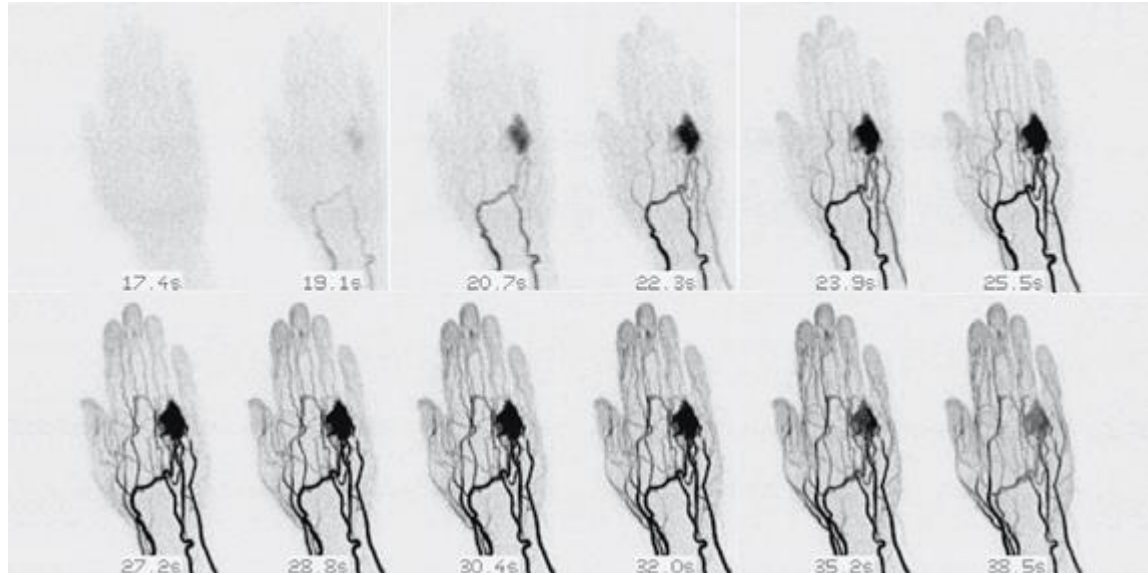
#### **Background:**

Elliptic Centric-TRICKS is a modified 3D Fast GRE pulse sequence that produces CE MRA high spatial and temporal resolution images. A mask acquisition used to produce automatically subtracted source images. Collapsed images from each temporal output phase. TRICKS high temporal resolution is achieved by dividing the 3D k-space into a number of segments from the center of k-space out (A to D). Views are acquired in elliptic centric order and the rate of sampling is varied such that the center of k space is sampled more often than the outer regions. When the center of k space is sampled more frequently than other regions, the time period from one phase to the next is shortened. The end result is that the contrast kinetics/flow is subdivided into more phases with TRICKS than with other PSDs and, therefore, the temporal resolution is shorter than other PSDs.



K – SPACE SCHEME

Basic idea of contrast-enhanced dynamic MRA. a) Conventional measurements with relatively poor temporal resolution. b) TRICKS reduces the time between subsequent 3D data sets to better distinguish between the arterial and venous phase.



Twist image of RT Hand

## Clinical Applications

There are many benefits of using dynamic TRICKS for clinical applications. These include:

- Better detection of vascular diseases such as in arterio venous malformations (AVM) or shunts by providing the dynamic information.
- Better assessment of vascular diseases such as in peripheral obstructive artery disease (POAD) or steal phenomenon by visualizing the hemodynamics.
- Smaller amounts of contrast agent required for the contrast enhancement study.
- Complete elimination of venous contamination even in abnormal hemodynamic states.

## **INHANCE / NATIVE - NON CONTRAST ANGIOGRAPHY**

Advances in MRI is help full to provide non contrast MRA in abdominal and peripheral application. The early techniques of NON CONTRAST MRA include 2D &3D TOF IMAGING , GATED 2D TOF , PHASE CONTRAST ANGIOGRAPY

INHANCE include newer non contrast angiography technique for imaging patient's without contrast medium

### **INHANCE 3D VELOCITY:**

Inhance 3D Velocity is a modified 3D Phase Contrast PSD. It is designed to acquire contrast-free angiography images with excellent background suppression at a shorter scan time in comparison to 3D PC.

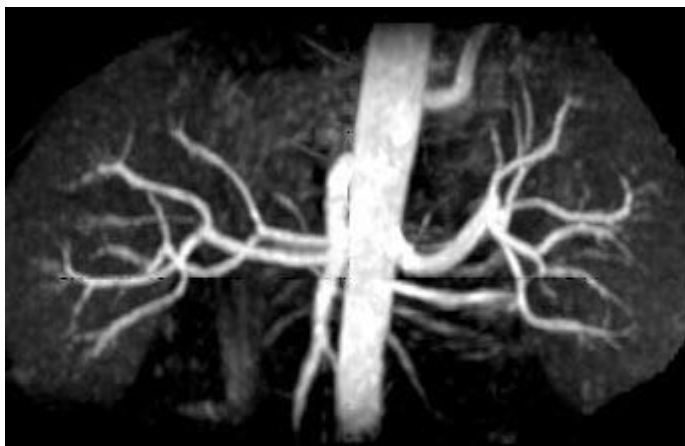
- Shortened scan times through the use of partial k-space filling technique, ASSET compatibility, and dB/dt optimization and RF pulse modifications for shorter TR and TE times.
- A spoiled gradient technique improves SNR and improves background suppression.
- T1-weighted magnitude images can be generated.
- Respiratory trigger compatibility increases 3D PC applications to include abdominal angiography, in particular renal artery visualization.



## **INHANCE INFLOW IR [NATIVE TRUEFISP]**

Inhance 3D Inflow IR1 is a contrast-free angiographic (non-CEMRA) method based on the inherent in-flow effects of blood. This sequence is based on 3D FIESTA, which improves SNR and produces bright blood images. Selective inversion pulses are applied over the region of interest to invert arterial, venous, and static tissue. At the null point of the background tissue, an excitation pulse is applied to generate signal. The net result is an angiographic image with excellent background suppression and free of venous contamination. Inhance Inflow IR can also be used to image venous vasculature. This can be achieved by setting inversion recovery pulses to suppress upstream arterial flow. Respiratory trigger is used to reduce motion artifacts and **SPECIAL** (a chemical saturation technique) is implemented to produce good fat saturation.

The underlying limiting factor in this method is the volume of blood entering the inverted target region within an inversion time. The maximum inversion time which can be used is limited by the recovery of the magnetization of the targeted area – in practice this means a maximum TI of around 1400 ms can be used without in tolerable loss of contrast. The use of this technique has been successfully applied in renal angiography as well as in the assessment of transplanted kidneys to rule out anastomotic stenosis.



## **INHANCE 3D DELTA FLOW [NATIVE SPACE]**

Inhance Deltaflow is a non-contrast agent MRA1 method that is typically used to image peripheral arteries in a run-off exam. Inhance Deltaflow acquires two 3D slabs: one during systolic phase and one during diastolic phase.

A multi-phase SSFSE scan is acquired to determine the diastolic trigger delay for the Inhance Deltaflow acquisition.

### **Background:**

The signal produced from arterial flow is sensitive to the cardiac cycle. During systolic phase, arterial flow is fast resulting in a dark signal. During diastolic phase, arterial flow is significantly slower resulting in a bright signal. Unlike arterial flow, venous and background signal are relatively insensitive to the cardiac cycle.

Subtraction of the systolic slab from the diastolic slab results in the visualization of the arteries with good background suppression. A STIR pulse can be applied to both the systolic and diastolic acquisition for additional fat suppression.

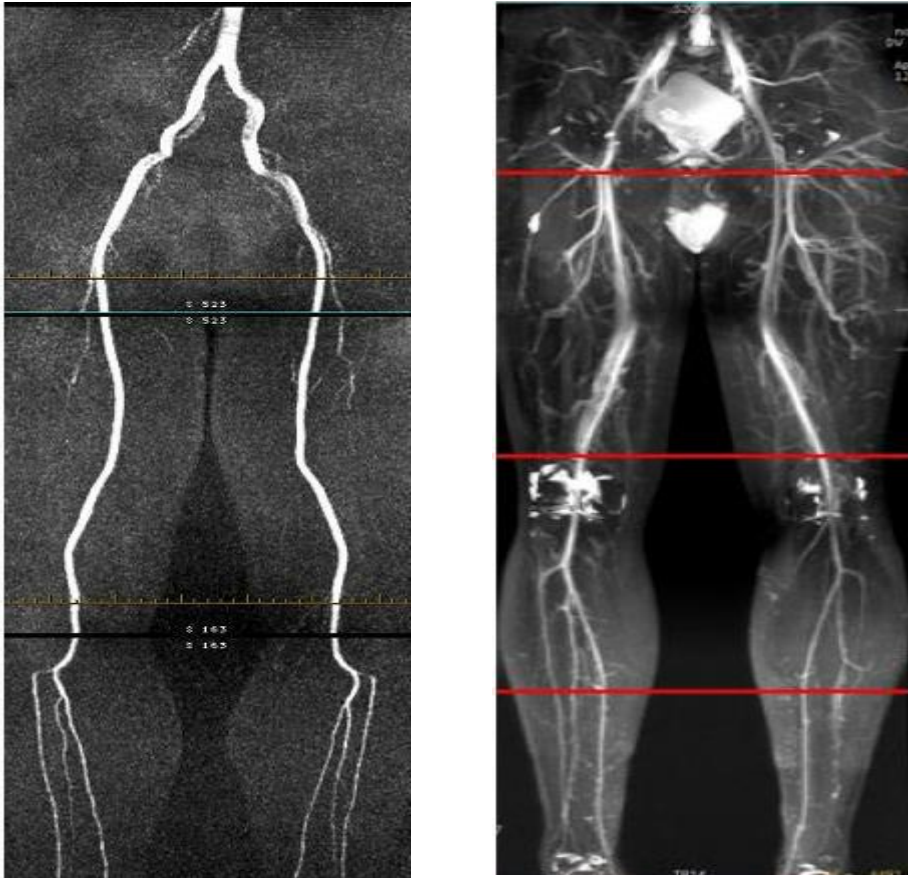
Inhance Deltaflow image results when the diastolic slab is subtracted from the systolic slab



### **Multi-phase SSFSE**

Multiphase SSFSE acquires multiple phase images with increasing delay between each phase. An automatic subtraction of the first phase (corresponding to systolic) from other phase images provide arterial

images, which can be used to estimate the delay that corresponds to the optimum arterial visualization (diastolic start time).



## MR-Echo

The *MR-Echo* application is for cardiac real-time prescription and acquisition. Real time acquisition is particularly useful in patients with irregular heart beats and with patients who cannot perform a breathhold

acquisition. Using real-time images as localizers, the following batch scans can be efficiently performed using MR-Echo Scan and Save:

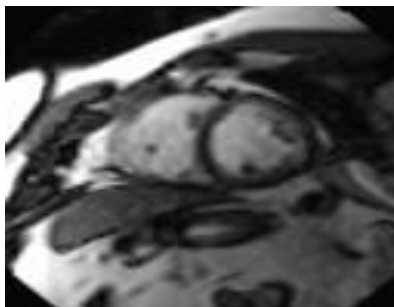
- Function scans, which are typically acquired for wall motion studies
- Time Course scans, which are typically used to evaluate the heart, using a single cardiac phase acquired at multiple locations that are continually repeated over a breath hold

- Myocardial Evaluation scans, which are typically used to evaluate cardiac viability

## Background

The **MR-Echo desktop** has four protocol tabs, each with a unique PSD1 for different applications:

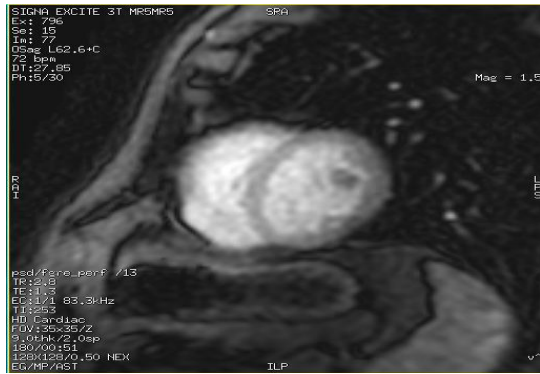
**Realtime** uses a non-gated 2DFIESTA PSD for acquiring real-time images of the heart using a FIESTA (bright blood) pulse sequence. The PSD acquires images at a high-frame rate for localization and qualitative ventricular function assessment.



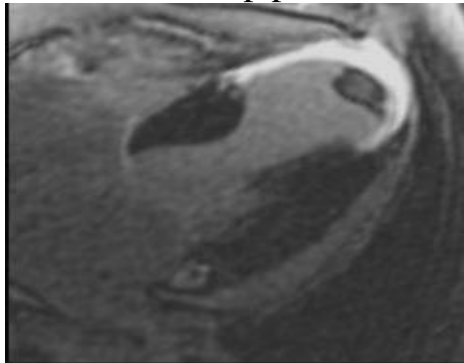
**Function** uses a gated 2D FIESTA PSD. It provides a multi-phase CINE high-frame rate acquisition mode for high-image quality breath-hold cardiac images that are added to the image database. This mode functions with both ECG2 or peripheral gating.



**Time Course** uses a cardiac-triggered 2D Fast GRE or FIESTA PSD with a saturation component. The PSD can be selected when setting up the scan.



**Myocardial Evaluation** uses a single-phase, cardiac-triggered Fast GRE with an IR1-Prep pulse.

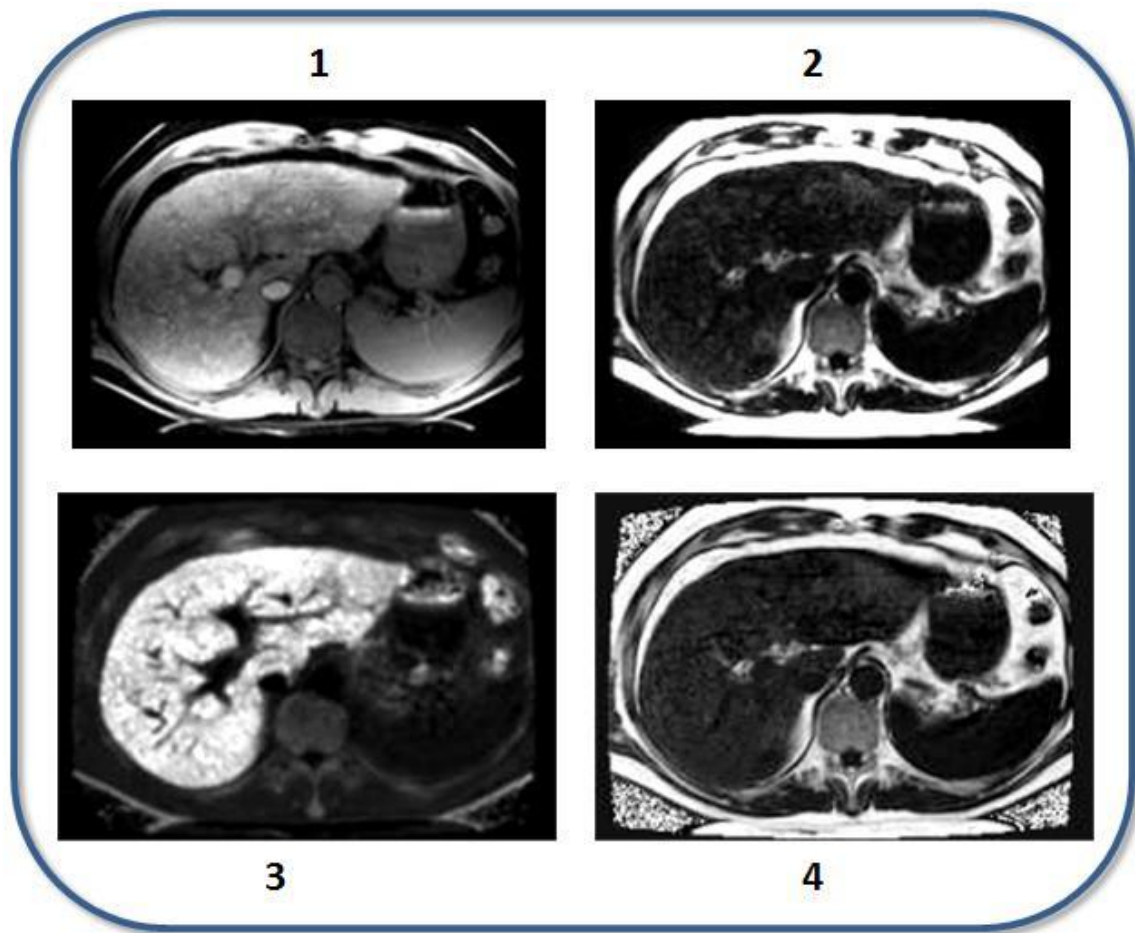


## IDEAL IQ

IDEAL1 IQ is a one-click application that expands on the **IDEAL** technique to produce triglyceride fat fraction images and  $R2^*$  maps in addition to water and triglyceride fat images from the collected multi-echo images of an IDEAL IQ acquisition.  $R2^*$  is the inverse of the  $T2^*$  relaxation rate

The combination of the  $R2^*$  map with the triglyceride fat-signal fraction map enables IDEAL IQ to improve the accuracy of tissue characterization parameters ( $R2^*$  or triglyceride fat) by removing contamination from multiple chemical components.

IDEAL IQ uses ARC, which allows for acceleration in both phase and slice directions for supported coils

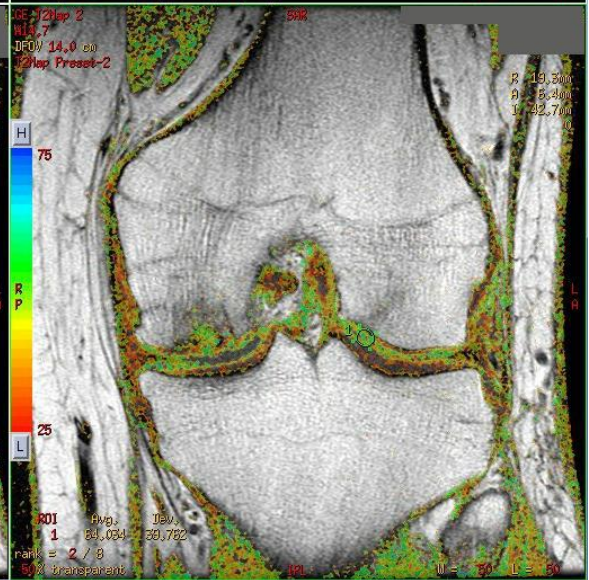
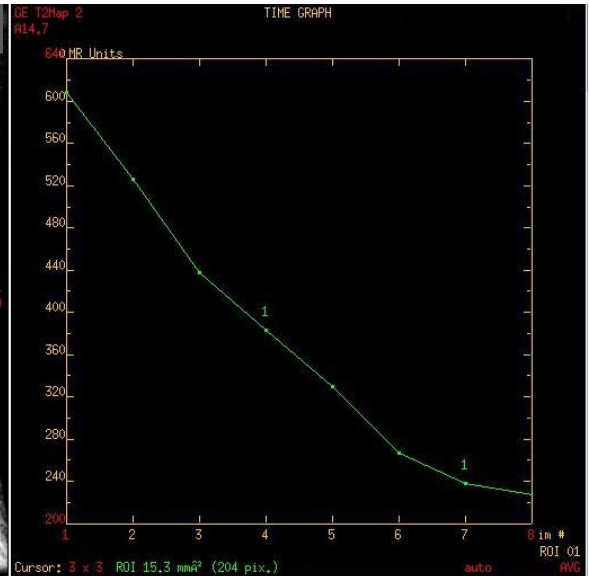


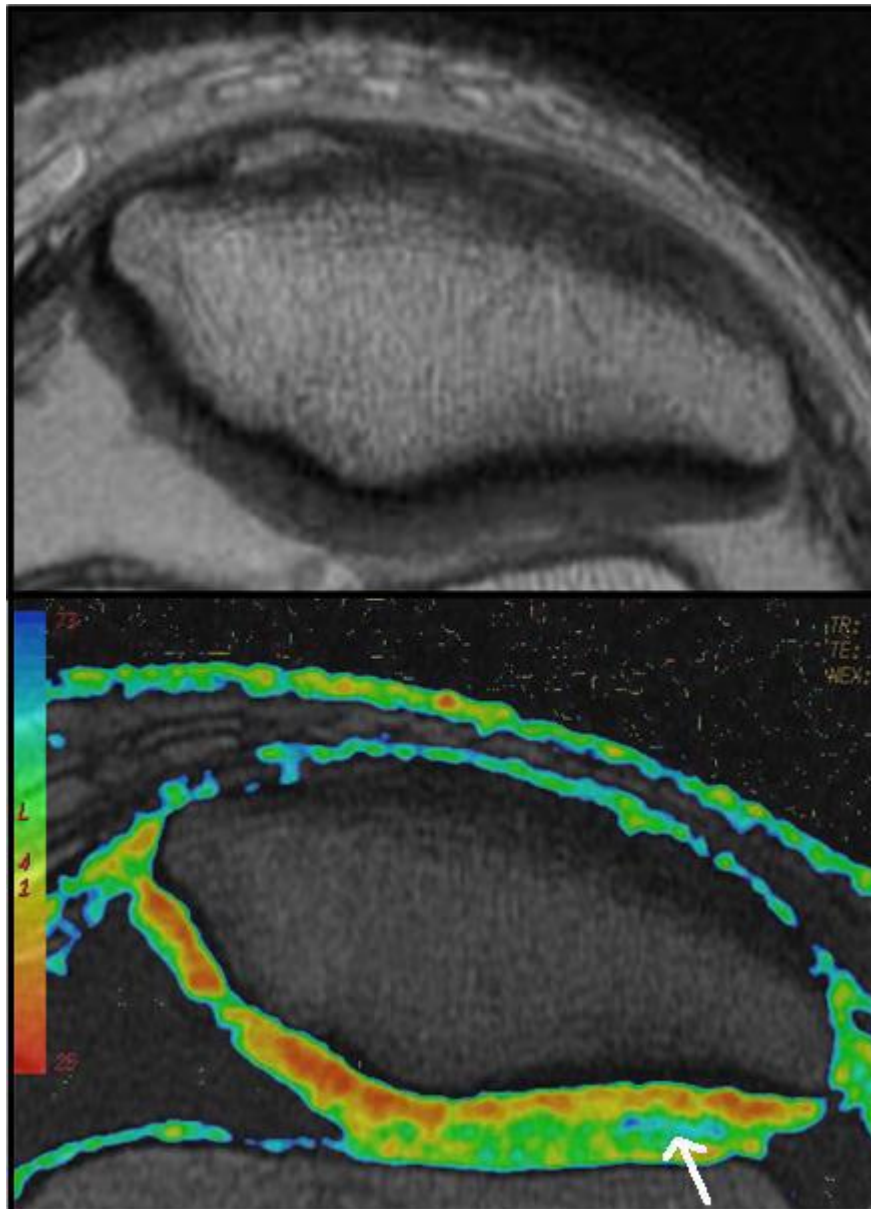
1= T2\* corrected water IDEAL IQ image ,2 T2\* corrected triglyceride fat IDEAL IQ image ,3 R2\* map IDEAL IQ image , 4 Triglyceride fat-fraction IDEAL IQ image

## T2 Map (Cartigram)

*T2 MAP* is used to noninvasively detect changes in the collagen component of the extracellular matrix of cartilage. T2 MAP acquires multiple scans at each location; each set of scans has a unique TE resulting in a set of gray scale images that represent different T2 weighting.

The acquired data can be processed in FuncTool to produce T2 color maps, which demonstrate more subtle changes in cartilage ultrastructure that are not visible on gray scale MR images. The T2 map and the parametric images produce visible image contrast changes in early stages of cartilage degeneration such as osteoarthritis.



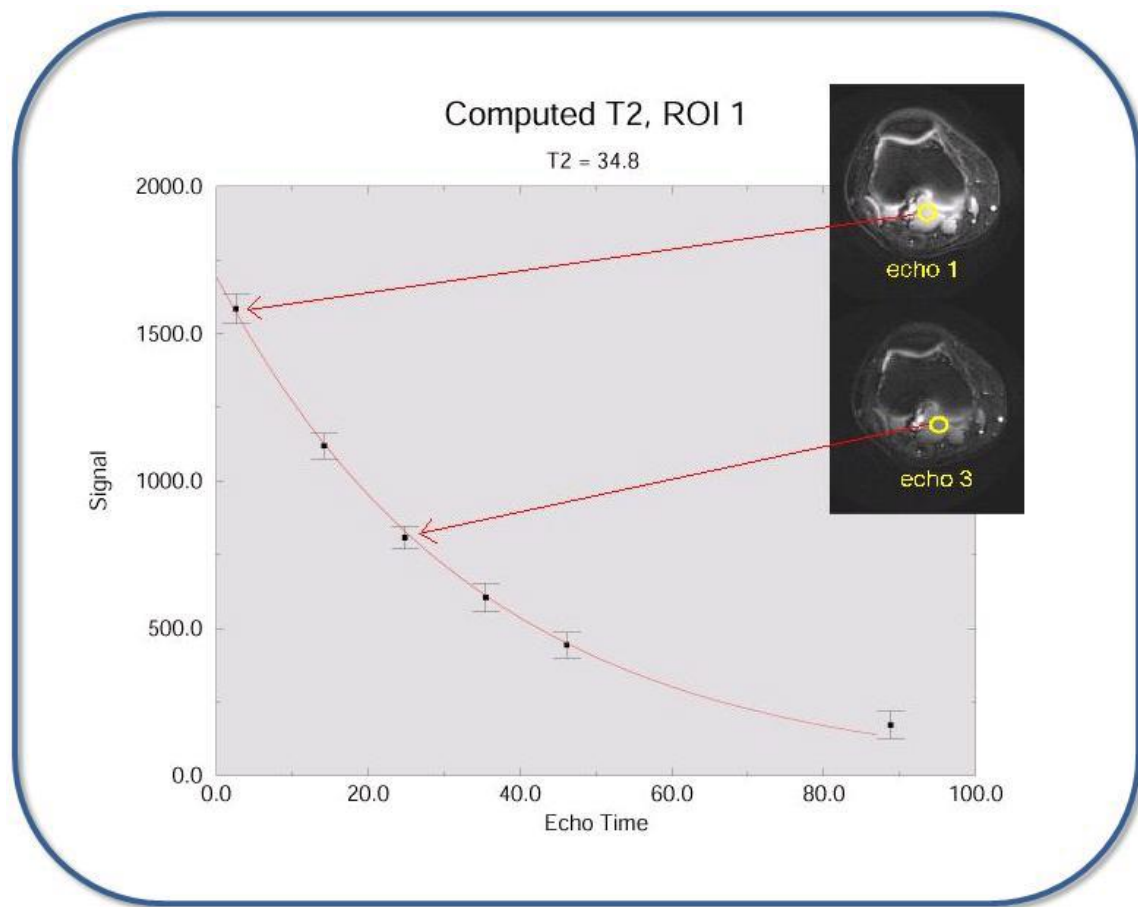


T2 Map knee (top) and color map (bottom) post-processed in FuncTool. Blue signal intensity indicates high T2 value

### Background:

The number of TEs per scan (not selectable) determines the number of images that are acquired at each location. For example, if 10 locations are prescribed and 6 (number of TEs) per scan are prescribed, then there are 10 data sets with 6 images per location. Each image within a data set or location has six unique

T2-weighted images because all lines of k-space are filled with one (each individual) TE. This differs substantially from the traditional Fast Spin Echo sequence.



## Perfusion weighted imaging

Perfusion means the steady state delivery of blood to tissue parenchyma through the capillaries, it derived from the French verb "per fuser" meaning to "pour over or through."

Two type of techniques

- Exogenous contrast
- Endogenous method

### Exogenous method

- Dynamic susceptibility imaging

## **Endogenous contrast**

- ASL

## **Dynamic susceptibility imaging**

Dynamic susceptibility contrast (DSC) MRI, also known as bolustracking MRI, is a well-established technique to measure perfusion (or cerebral blood flow, CBF) and other related hemodynamic parameters. It involves the sequential acquisition of MR images following an intravenous injection of contrast agent. The passage of contrast agent through the brain induces a measurable drop in the MR signal when a T2- or T2\*-weighted sequence is used. This signal–time course is used to compute important haemodynamic perfusion parameters, such as CBF, cerebral blood volume (CBV) and mean transit time (MTT).

### **Steps follow the workflow for the acquisition**

- The contrast agent
- The acquisition of DSC-MRI data).
- Data pre-processing
- The contrast concentration–time course
- Common perfusion parameters
- Post-processing

### **The contrast agent**

MR contrast agents provide additional image contrast by altering the local relaxation times of the protons. In DSC-MRI, gadolinium (Gd)-chelated contrast agents are commonly used. When the blood–brain barrier (BBB) is intact, the strongly paramagnetic Gd<sup>3+</sup> ions remain intravascular, promoting transverse (T2/T2\*) relaxation of tissue water protons via the susceptibility effect. Within the intravascular space, longitudinal (T1) relaxation is also significant. However, when a T2- or T2\*-weighted sequence is used, and the BBB is intact, the susceptibility effect dominates image contrast. Thus, the passage of Gd-based contrast agent through the capillary bed leads to a transient drop in the MR signal.

The injected volume of contrast should be sufficient to promote a measurable drop in MR signal intensity, but not too large. Typically, the injected dose is between 0.1 mmol/kg (so-called ‘single dose’) and 0.2 mmol/kg. Bolus injection speeds less than about 4 mL/s have been

shown to underestimate perfusion (6). A tolerable and safe injection rate is about 5 mL/s. In order to achieve a well-defined bolus, the contrast should be injected into a vein in the right arm (7) and followed by at least 25 mL of saline injected at the same rate (8), which flushes the catheter and veins.

### **The acquisition of DSC-MRI data.**

The susceptibility contrast generated by the passage of a paramagnetic contrast agent through the microvasculature is imaged using T2- or T2\*-weighted sequences (see step 6). Fast acquisition imaging techniques, such as echo planar imaging (EPI), are required to characterize the transient MR signal drop (of approximately 10 s). Single-shot EPI is the most widely available fast imaging sequence on clinical scanners and facilitates whole-brain coverage at reasonable signal-to-noise ratios (SNRs). It has therefore become a popular choice for clinical DSC-MRI.

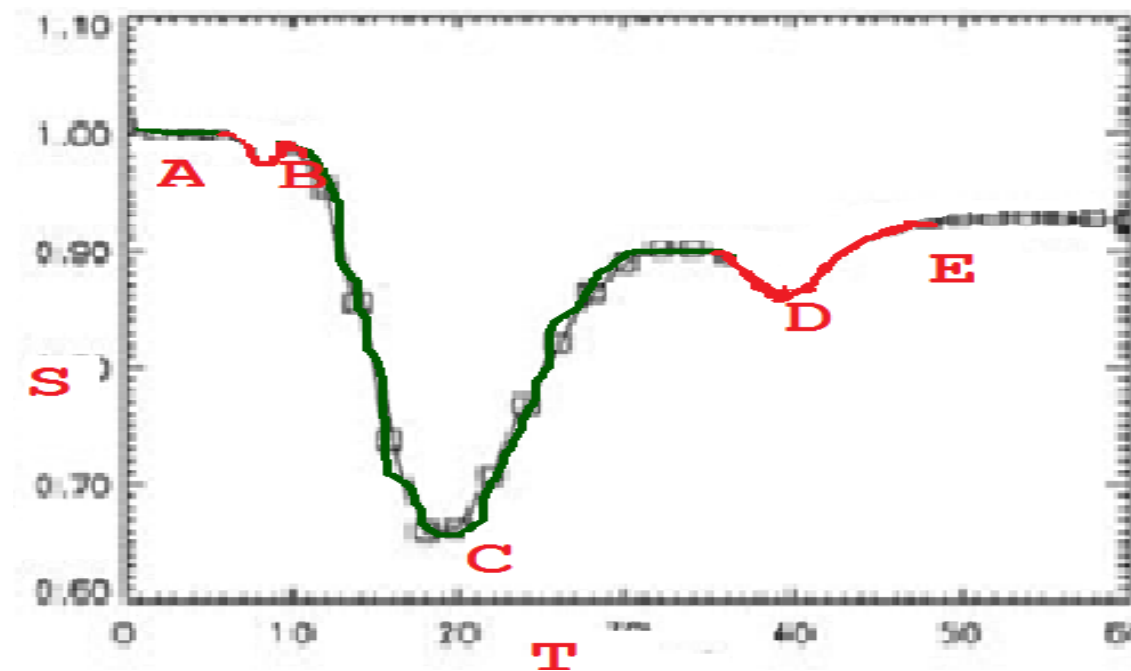
Alternative (less commonly available) acquisition methods have been implemented with a view to reduce EPI artifacts, whilst improving susceptibility contrast, spatial and temporal resolution. Segmented EPI has the advantage of less distortion, but is more sensitive to T1 effects because of shorter TRs. The three-dimensional ‘principle of echo shifting with a train of observations’ (PRESTO) sequence (10) also reduces distortions and can acquire images at very high temporal resolution, thus providing a precise characterization of the MR signal–time course data. However, T1 effects can again be a problem.

DSC-MRI can be acquired using either spin echo (SE) or gradient echo (GE) sequences, which provide subtly different contrasts. The SE DSC-MRI signal drop is largest in the vicinity of capillaries, where the phase accumulation across the diffusion distance is greatest. Consequently, SE DSC-MRI images are sensitive to the microvasculature. In contrast, GE acquisitions do not refocus static field inhomogeneities and are therefore sensitive to changes in T2\*. As a result, the susceptibility-induced signal drop is larger for GE acquisitions than for SE acquisitions across all vessel.

For the more commonly used GE sequence, the optimal signal drop is achieved by setting the MR TE equal to T2\* of the tissue, TR should be no longer than 1.5 s in order to achieve a <25% error in grey matter CBF calculated using standard analysis methods. Good CNR data can be acquired using a flip angle of 60–90° at 1.5-T or 60° at 3-T. However, if a

short TR is used (<1.5 s), particular care must be exercised to minimise the effects of T1 relaxation on the MR signal–time course.

### The Concentration–Time Course



- A : Base line
- B: Arrival point of contrast agent.
- C: Peak signal change
- D: Recirculation of bolus.

## **Common Perfusion Parameters**

- Cerebral blood flow (CBF);
- Cerebral blood volume (CBV);
- Mean transit time (MTT);
- Time to maximum (Tmax).

### Cerebral blood volume (CBV);

- Cerebral blood volume (CBV) is the fraction of tissue volume occupied by blood vessels
- Units: ml / 100 g brain
- 4ml/100g
- Flow x circulation time=CBV  
 $CBF \times MTT = CBV$

### Cerebral blood Flow (CBF);

- Cerebral Blood Flow (CBF)
- Delivery of blood to tissue / unit time
- Units: ml / 100g brain / min
- $CBV/MTT = CBF$
- 50 ml / 100g brain / min

### Mean Transit Time (MTT)

- Mean Transit Time (MTT)
- Average time to flow through capillaries (artery → vein)
- $MTT = CBV/CBF$
- Units: seconds
- 5 S

### Time to maximum (Tmax)

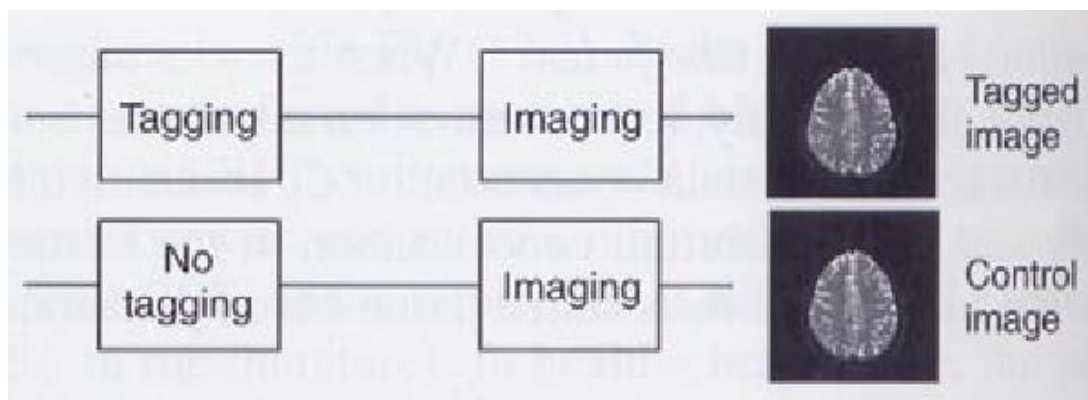
- Tmax is the arrival delay between AIF and the tissue

## **Clinical application**

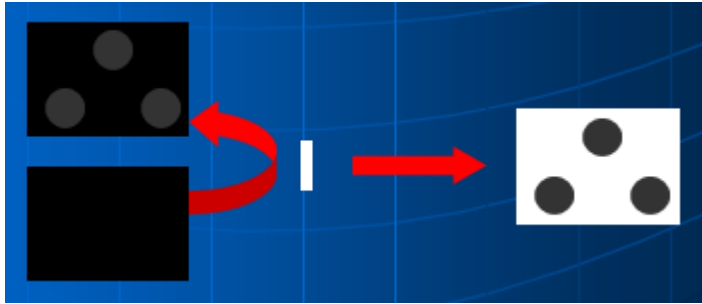
- Evaluation of ischemic penumbra in stroke.
- Classification of brain tumor.
- Grading of brain tumor.
- Cerebral infarction risk assessment
- Selection of patients for extracranial to intracranial bypass surgery
- Moyamoya evaluation
- Assessing risk of hyperperfusion syndrome
- Balloon test occlusion with CVR
- Selection of patients for medical intervention

## ASL

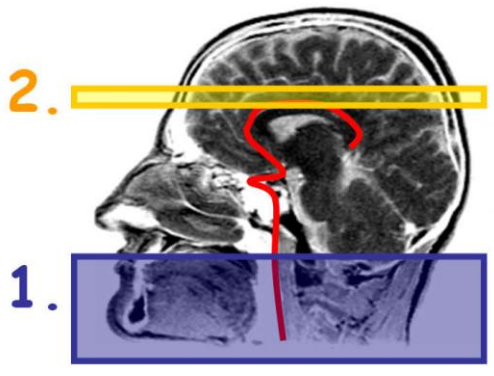
- ASL technique was conceived more than 15yrs ago.
- No exogenous contrast bolus required.
- ASL is based on labeling protons in the blood in supplying vessels outside the imaging plane and waiting for a period called post delay period for reaching the parenchyma.



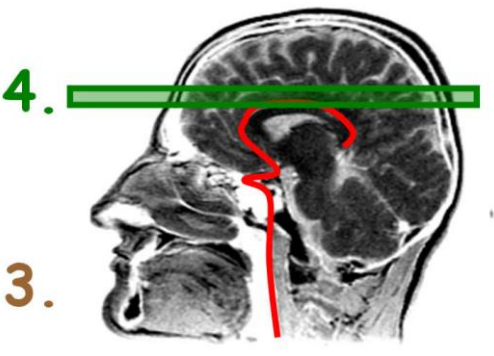
- Images are obtained from the parenchyma in labeled and controlled state.
- Subtracting these two type of images eliminates the static tissue signal will give CBF images.



## Principle of ASL

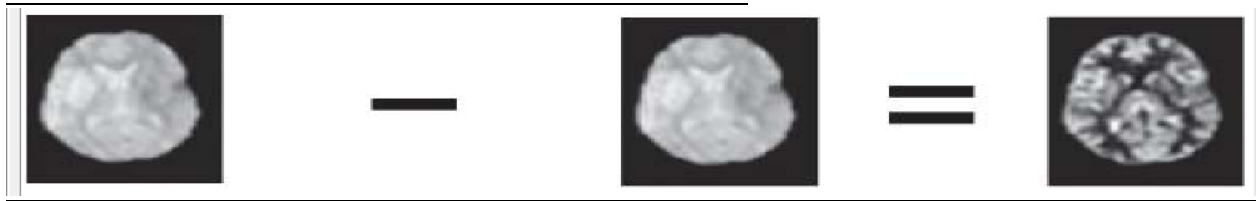


- 1 Tag inflowing arterial blood by magnetic inversion
2. Acquire the **tag image**



3. Repeat experiment without **tag**
4. Acquire the **control image**

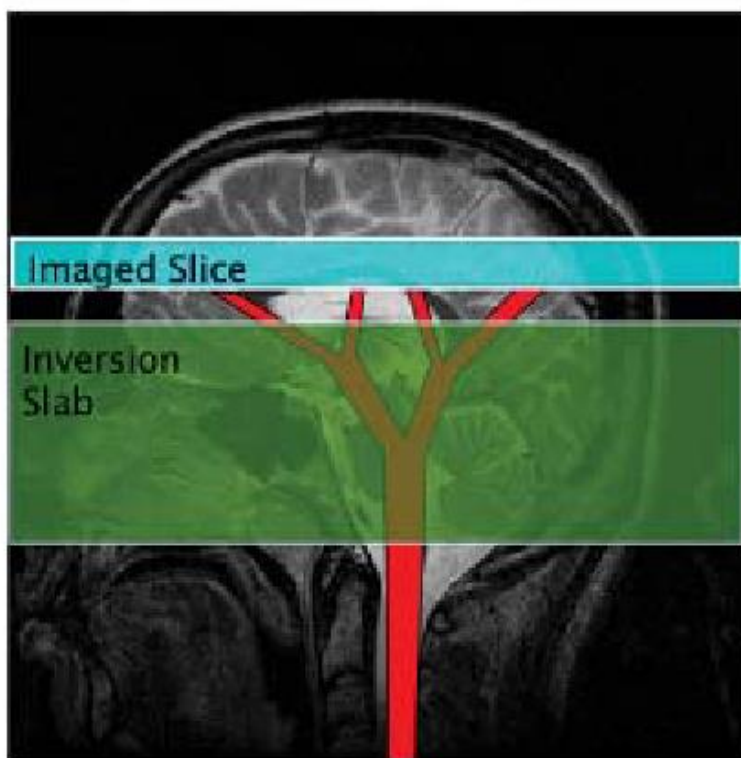
$$\uparrow - \uparrow = \uparrow \propto \text{CBF}$$



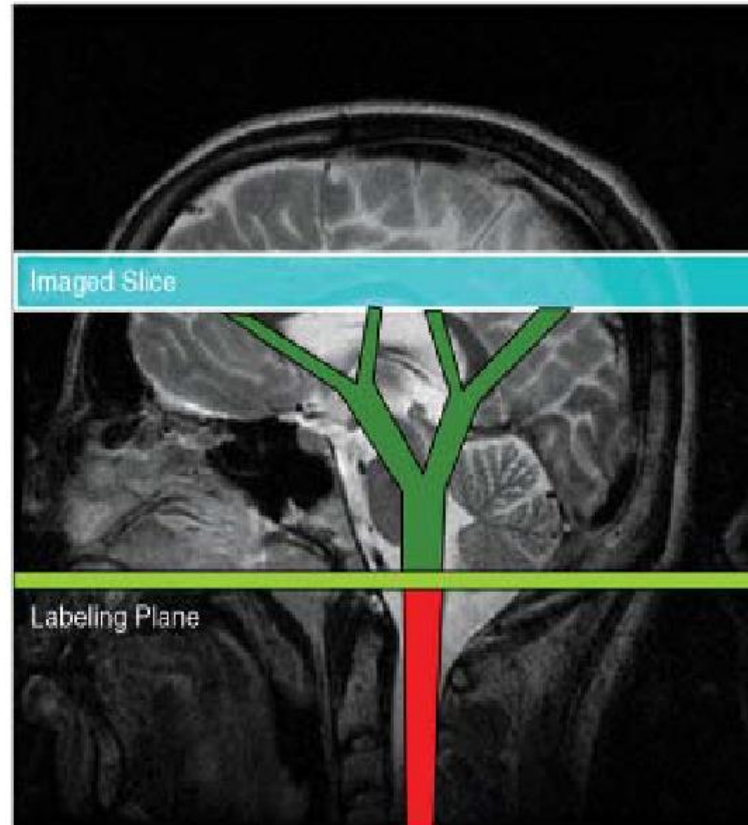
## TYPES OF ASL

- i. Pulsed ASL
- ii. Continuous ASL
- iii. Pseudo continuous ASL
- iv. Velocity selective ASL

### PASL



### CASL

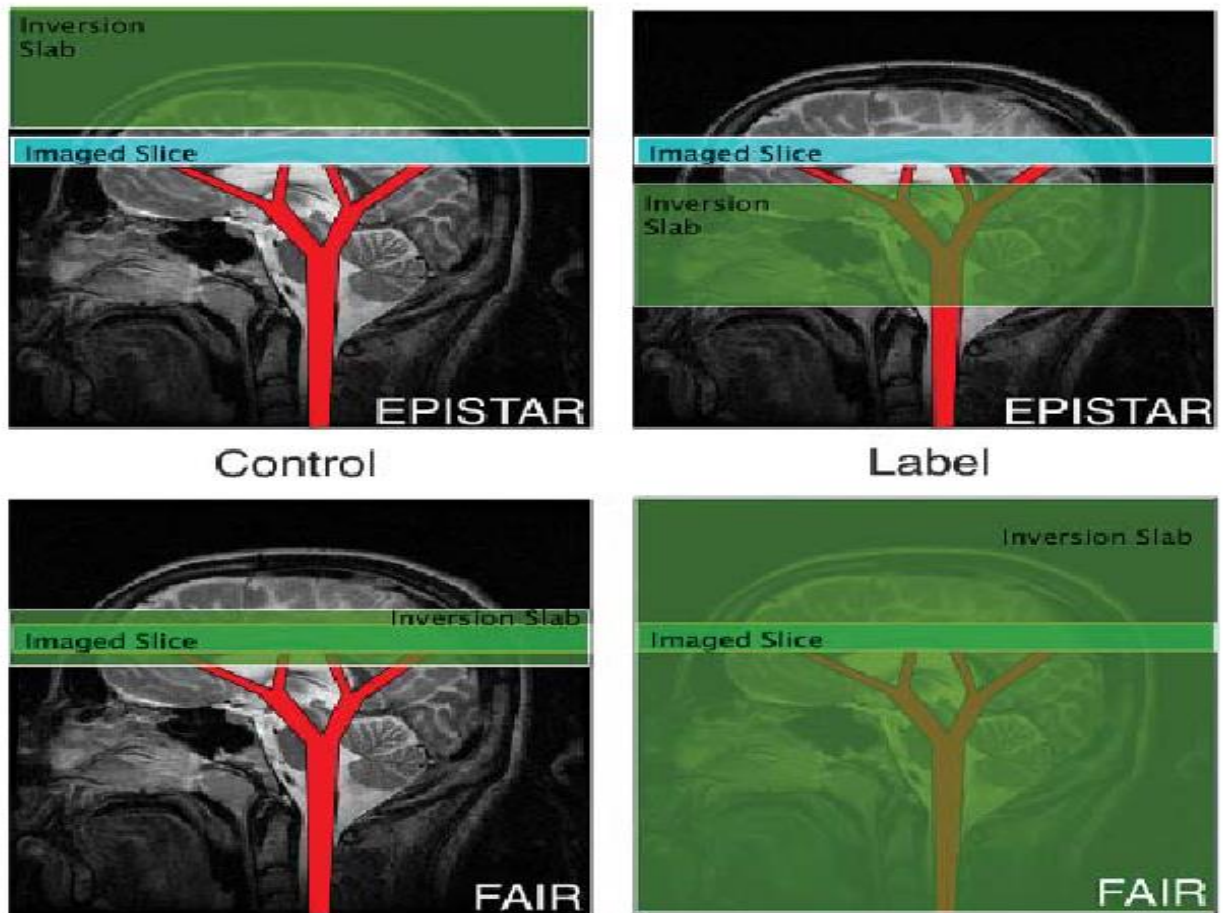


ASL Types	Advantages	Disadvantages
PASL	Higher tagging efficiency Lower SAR	Lower SNR
CASL	Higher SNR than PASL	Lower tagging efficiency Continuous RF transmit hardware required Higher SAR Magnetization Transfer effects
pCASL	Higher SNR than PASL Higher tagging efficiency than CASL	Higher SAR Limited clinical availability.
VS-ASL	Ability to measure low	Lower SNR

### Sequence for ASL

- EPISTAR-Echo planar imaging and signal targeting with all radiofrequency.
- PICOPE-proximal imaging with a control for off resonance effect.
- TILT-transfer insensitive labeling technique.
- FAIR-flow sensitive alternating inversion recovery.
- FAIRER-FAIR with extra radiofrequency pulse.

BASE-basis image with selective inversion



## Clinical application

- ASL perfusion maps frequently are used to evaluate an intra- or extra-axial neoplastic process.
- Infectious Etiologies.
- Physiologic Quantification.
- Posterior reversible encephalopathy syndrome

# **Diffusion Tensor imaging**

## **Diffusion**

Random transnational molecular motions driven by internal kinetic energy.

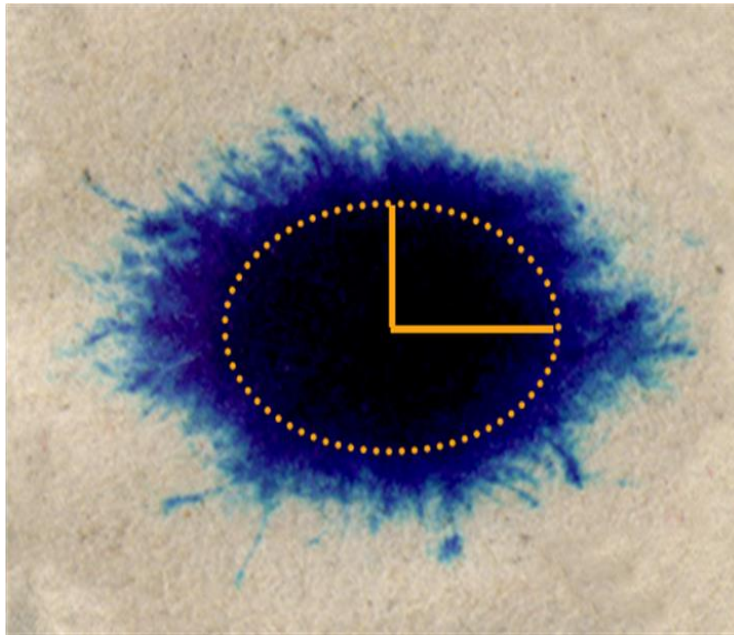
Observed in 1827, by Robert brown.

Diffusion refers to the transport of gas or liquid molecules through thermal agitation randomly, that is, it is a function of temperature above 0 K. In pure water, collisions between molecules cause a random movement without a preferred direction, called Brownian motion. This movement can be modeled as a “random walk,” and its measurement reflects the effective displacement of the molecules allowed to move in a determined period. The random walk is quantified by an Einstein equation: the variance of distance is proportional to  $6Dt$ , where  $t$  is time and  $D$  is the proportionality constant called the diffusion coefficient, expressed in SI units of  $m^2/s$ .

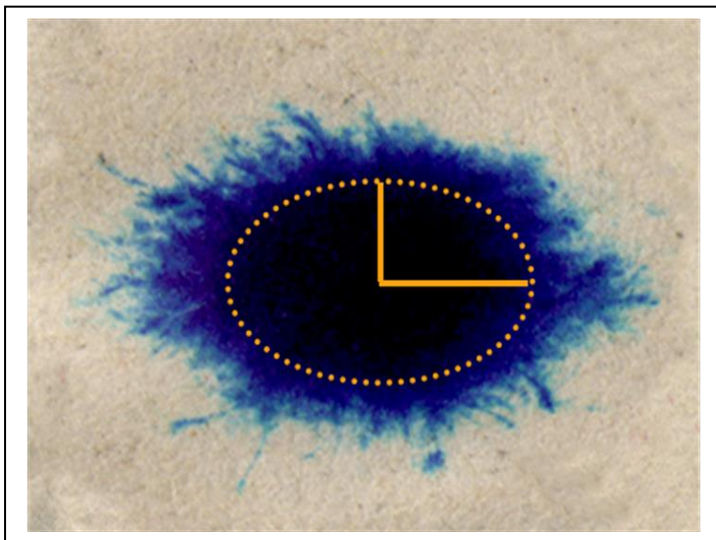
## **Isotropy and anisotropy**

Isotropy means uniformity in all directions. A drop of ink placed in the middle of a sphere filled with water spreads over the entire volume, with no directional preference. If the same experiment is repeated in a sphere filled with uniform gel the restriction is increased as compared with free water, but is still isotropic, as the restriction is the same in all directions.

Anisotropy implies that the property changes with the direction. If a bundle of wheat straw with the fibers parallel to each other is placed inside a glass of water, the ink will face severe restriction in the direction perpendicular to the fibers and facilitated along the fibers. This bundle is highly anisotropic.



Isotropic



Anisotropic

## Diffusion-Weighted Imaging

MR image contrast is based on intrinsic tissue properties and the use of specific pulse sequences and parameter adjustments. The image contrast is based on a combination of tissue properties and is denominated “weighted,” as the contribution of different tissue properties are present, but one of them is more expressive than the others.

Routine acquisitions have some degree of diffusion influence that is actually quite small. Some strategies have been developed to make diffusion the major contrast contributor, and dedicated diffusion-weighted imaging (DWI) sequences are available nowadays on commercial

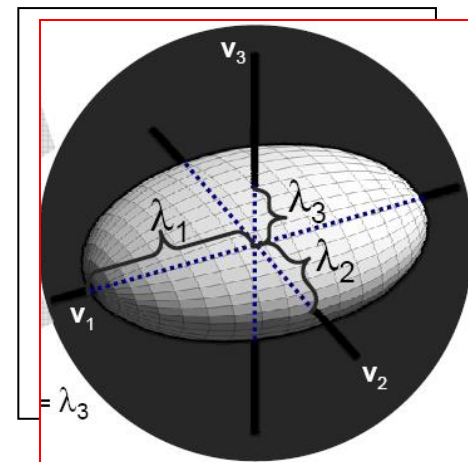
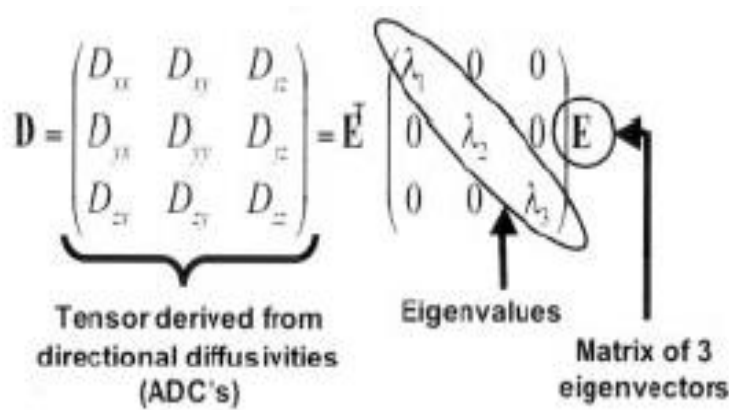
scanners, as well as several others as investigational sequences that may or not be available in clinical practice.

## Diffusion tensor

A mathematical model representing the directional anisotropy of diffusion.

Represented by a 3 x 3 matrix- 6 directional movement

The eigenvalue of the diffusion tensor are the diffusion diffusivity, and the three principal directions of diffusivity, and the eigenvector corresponding to the largest eigenvalue is the main diffusivity direction in the medium



## Diffusion-weighting factors

### Trace

- The most clinically measure is Trace.
- This is the sum of the the eigen values of the diffusion tensor.  
ie  $D_{xx}+D_{yy}+D_{zz}$
- Trace / 3 can be thought as mean diffusivity.

### b-Value

- The b-value provides diffusion weighting
- For DWI images as TE provides T2 weighting for T2 images.
- The higher the b-value, the more diffusion weighted
- The image will be at the cost of signal to-noise ratio (SNR).

## **ADC maps**

- Diffusion always obtain at least 2 diff. B value measurements to characterize ADC

## **FA**

- Degree of anisotropy

## **Protocol**

TR	:	3500 m sec.
TE	:	105 m sec.
THICKNESS	:	5 mm.
DIRECTIONS	:	30.
b VALUE	:	0 &1000

## **Clinical application**

- Early detection of stroke
- Evaluate Prognosis of stroke.
- Tumor classification
- Grading of tumor
- Oncologic applications of DW imaging take advantage of restricted diffusion shown by most tumors.
- As a Tool for Surgical Planning.

## **SWI / SWAN**

Susceptibility-weighted imaging (SWI) is a novel magnetic resonance (MR) technique that exploits the magnetic susceptibility differences of various tissues, such as blood, iron and calcification [1]. It consists of using both magnitude and phase images from a high-resolution, three-dimensional (3D) fully velocity-compensated gradient echo sequence.

Phase mask is created from the MR phase images, and multiplying these with the magnitude images increases the conspicuity of the smaller veins

and other sources of susceptibility effects, which is depicted using minimal intensity projection (minIP).

it has also been referred to as high-resolution (HR) blood oxygen level dependent (BOLD) venography. However, in this text, we use SWI to refer to the use of magnitude or phase images, or a combination of both, obtained with a 3D, fully velocity-compensated, gradient echo sequence. This 3D SWI can be used to visualize smaller veins and other sources of susceptibility effects, such as hemosiderin, ferritin and calcium.

## **Imaging acquisition and image processing**

Imaging was performed using a 12-channel phased array head coil on a 1.5 T clinical scanner. The SWI sequence parameters were: TR (repetition time), 48 ms; TE (echo time), 40 ms; Flip angle, 20°; bandwidth, 80 kHz; slice thickness, 2 mm, with 56 slices in a single slab; matrix size, 512×256. A TE of 40 ms was chosen to avoid phase aliasing, and a flip angle of 20° was used to avoid nulling of the signal from pial veins located within the cerebral spinal fluid (CSF). The acquisition time was 2.58 min with the use of iPAT factor-2.

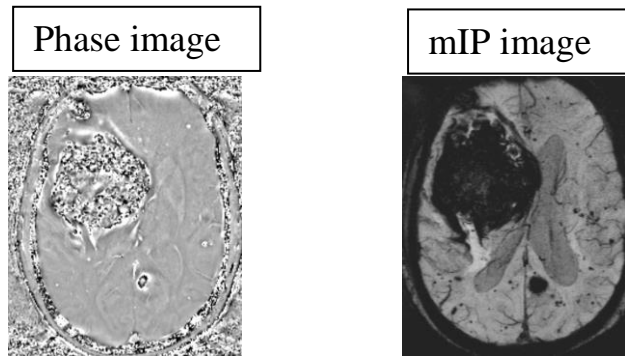
## **Usefulness of SWI phase imaging**

Calcification can be differentiated from hemorrhage based on differences in susceptibility effects – calcium is diamagnetic and blood products show largely paramagnetic susceptibility this makes MR comparable to computed tomography (CT) in calcium imaging.

## **Blood oxygen level-dependent MR Venography / small vessel imaging**

Susceptibility-weighted imaging uses the paramagnetic deoxy-Hb as an intrinsic contrast agent. Deoxyhemoglobin causes a reduction in T2\* as well as a phase difference between the vessel and its surrounding parenchyma. The T1 and T2 properties of blood are dependent on the oxygen saturation of the blood, hematocrit and the state of the red blood cells (RBCs). At 1.5 T, arterial blood has a T2\* of approximately 200 ms, while 70% saturated venous blood has T2\* of 100ms. Hence, Long TEs will help in differentiating arteries from veins [15]. When the phase mask

is multiplied with the magnitude images, the venous data is enhanced; when veins are not present, there is no change in the signal. The resultant images are displayed using the minimum intensity projection, highlighting the signal from veins and minimizing the signal of adjacent brain tissues.



### **Clinical applications**

- detection of hemorrhagic lesions
- Calcification can be differentiated from hemorrhage Iron quantification.
- evaluation of stroke, trauma, vasculitis and epilepsy
- characterization of brain tumors

### **Functional MRI**

Over the last decade, functional MR (fMR) imaging has progressed from a research tool for noninvasively studying brain function to an established technique for evaluating a variety of clinical disorders through the use of motor, sensory, and cognitive activation paradigms.

fMR imaging uses blood-oxygen-level-dependent (BOLD) effects to localize regional cerebral blood flow changes temporally and spatially coupled with changes in neuronal activity. When groups of neurons are active, the blood flow to the active neurons increases in excess of what is needed to provide the additional oxygen consumed metabolically. The net result of increased

neuronal activity is a decrease in paramagnetic deoxygenated hemoglobin in the veins and capillaries within the vicinity of the active neurons. The amount of change depends on many factors including the nature of the task and the region of brain affected. The decrease in deoxy hemoglobin produces a small change in signal intensity, which is typically less than 5% in T2\*-weighted images acquired at 1.5 Tesla. These slight changes in signal intensity (“activation”) are detected by post-processing statistical

analysis techniques that identify the task-related hemodynamic responses.

One clinical application of fMR imaging is the mapping of brain functions in relationship to intracranial tumors, seizure foci, or vascular malformations before surgical excision. The goal of functional mapping procedures is to maximize resection of pathological tissue, spare eloquent cortices, and reduce surgical risk.

- Blood Oxygen Level Dependent (BOLD) is the MRI contrast for deoxy hemoglobin.
- First discovered in 1990 by Seiji Ogawa at AT & T Lab, USA.

### **Hemodynamic response**

- A local increase of neuronal activity immediately leads to an increased oxygen extraction rate in the capillary bed.
- The response of the vascular system to the increased energy demand is called the hemodynamic response.

It thus seems likely that the hemodynamic response primarily reflects the input and local processing of neuronal information rather than the output signals (Logothetis and Wandell 2004)

- Consists of increased local cerebral blood flow (CBF), as well as increased cerebral blood volume (CBV) and CMRO<sub>2</sub>.
- The hemodynamic response not only compensates quickly for the slightly increased oxygen extraction rate but it is so strong that it results in a substantial local *oversupply* of oxygenated hemoglobin.
- About 70% of the BOLD signal arises from larger vessels in a 1.5 tesla scanner, about 70% arises from smaller vessels in a 7 tesla scanner.
- Furthermore, the size of the BOLD signal increases roughly as the square of the magnetic field strength.

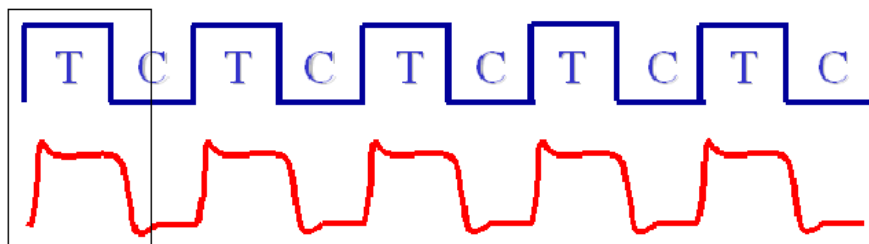
Hence there has been a push for larger field scanners to both improve localization and increase the signal

## **Types of f MRI**

- Depending upon the method of study the f MRI experiments can be categorized in to two :
  - » Block designs
  - » Event related.
  - » Mixed.

### **Block designs**

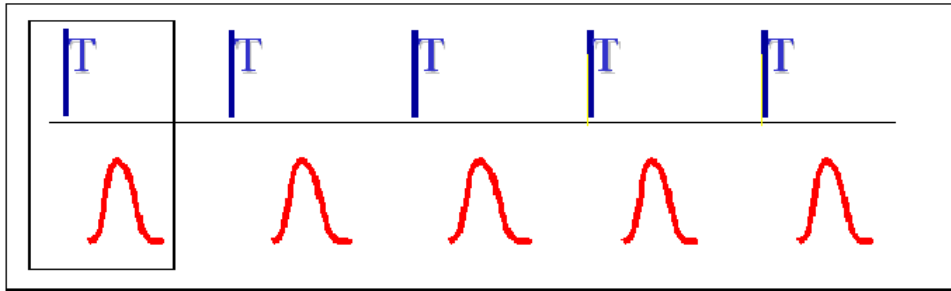
- First used in f MRI and still and the most useful in prevalent neurosurgery.
- It involves subject performs a task, alternated for a similar time with one or multiple control tasks.



### **Event related f MRI**

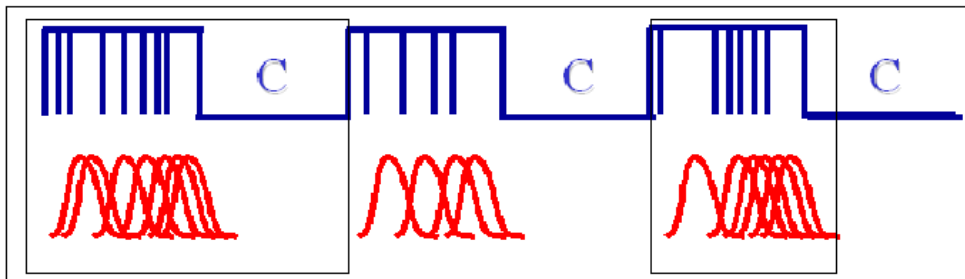
- The individual trials are randomized.

Responses to trials belonging to the same condition are selectively averaged and the calculated mean responses are statistically compared with each other.



### Mixed designs

- A combined attempt gives information about maintained versus transient neural activity.
- This technique is an interesting mixture of the characteristic block design measurement of repetitive sets of stimuli and the transient responses detected by event-related designs.



### Echo planar imaging

- EPI represents the fastest available scanning method.
- Fulfills most of the requirements demands by the f MRI.

### Clinical paradigms

- Certain tasks which are in an arranged fashion for the objectives to map the activity.
- A wide variety of paradigms are developed by the continuous experiments in the field of f MRI.

## Different types

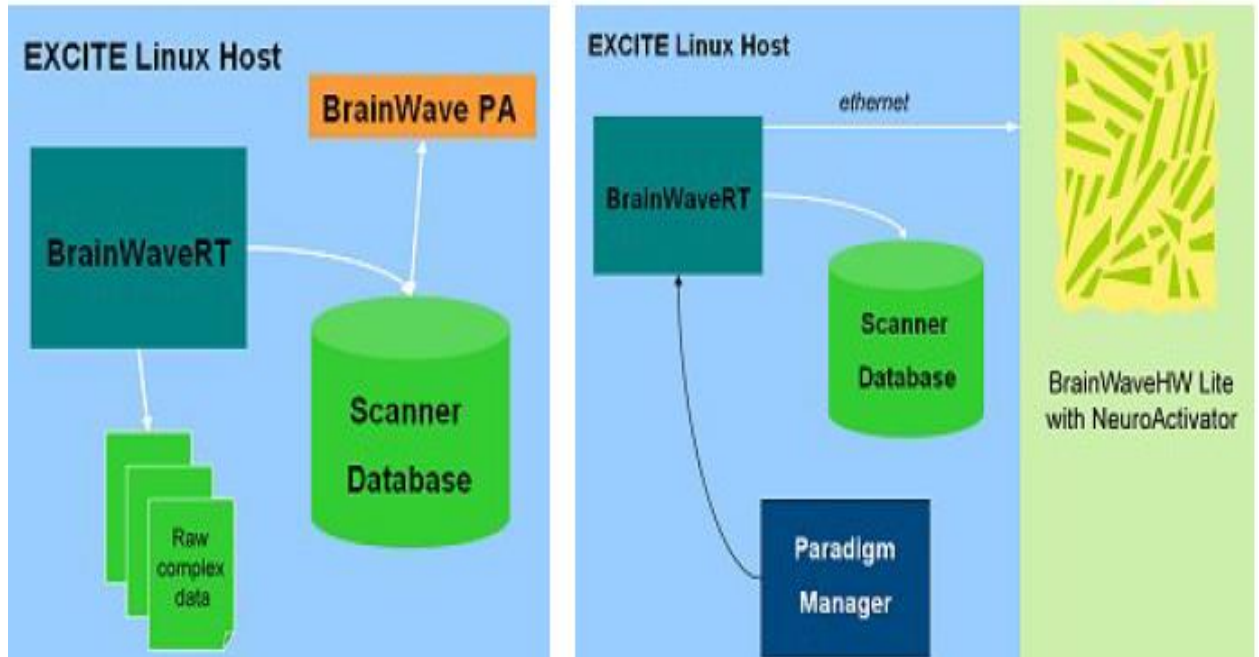
1. Motor paradigms
2. Bilateral finger tapping Vs Rest
3. Lip Pouting vs rest
4. Bilateral leg motor vs Rest
5. Language paradigms
6. Verb generation
7. Word pair
8. Syntax
9. Semantics

## Clinical application

- Epilepsy
- Surgical planning

## BrainWave- Application for fMRI processing in 3T

BrainWave consists of three basic tools to acquire, analyze and generate fMRI data. **BrainWaveRT** is the primary tool. It is protocol-driven, but has an additional paradigm setup step performed by either a small utility tool called the **Paradigm Manager** or by clicking *fMRI* on the Details area of an fMRI protocol. BrainWaveRT is the main interface to use to collect high-quality EPI images during a functional experiment. If you also have the optional **BrainWavePA** is the processing and analysis package that is used to analyze the EPI data set acquired with BrainWaveRT. BrainWavePA determines activation, fuses this activation in color onto a 3D anatomical data



**BrainWaveHW Lite** comprises equipment used to create custom audio, visual, language and motor paradigms and play them out into the patient environment when used with BrainWaveRT. This equipment consists of a stimulus computer mounted in a rack in the MR equipment room. Paradigm Studio software on the stimulus computer is used to create custom audio and visual paradigms. **Paradigm Studio** software is carried to the patient bore using third party equipment (EPRIME)

## COMPUTED TOMOGRAPHY

CT has been called one of the most important advances in radiology since Roentgen invented X-ray. The past decade has witnessed a constant progression of innovations in the modality, leading up to the introduction of multislice CT. High resolution images, ultra-fast scanning speed, a broad range of clinical applications, and sophisticated image postprocessing tools, unimaginable just a few years ago, have placed multislice CT into the radiology spotlight. These advances have led to

important medical insights and opened up dramatic new horizons in the research, diagnosis, and treatment of disease.

Since its introduction in 1972, CT has been an important imaging modality. Recent technological advances have made CT one of the primary diagnostic imaging tools for a wide range of imaging applications. Yet many small hospital radiology departments rely on dated, single-slice scanners or do not provide CT services at all. As the costs of CT scanners decline rapidly, making the move to multislice CT is easier than ever before.

Today, an advanced multislice unit is priced less than a single-slice CT was several years ago. Moreover, with the accelerated exam throughput and a growing repertoire of procedures, many small hospitals have found that a multislice CT can pay for itself in a short time and go on to turn a significant profit, while enhancing the quality of care in the community.. Most radiologists are familiar with the broad-based clinical benefits enabled by new multidetector technologies, from faster and higher quality exams to sophisticated 3D image processing. No longer constrained by a patient's limited breath-hold time, multislice CT has also significantly broadened the clinical applications, allowing advanced techniques such as imaging of the heart and peripheral vessels.

## **System specification**

### **Brilliance iCT**

The Brilliance iCT enable clinical excellence through the optimal combination of speed, power, coverage and dose utility. It sets a benchmark in full coverage whole body scanning while simultaneously setting new standard for advanced cardiovascular imaging.

## X-ray tube

### X-ray Tube

Feature	Specification
Focal Spot – Smart Focal Spot	X & Z deflection
Focal spot (IEC)	Large: 1.1 x 1.2 Small: 0.6 x 0.7
Anode Diameter	200mm
Anode Rotation Speed	10,800rpm
Spiral Groove Bearing	Double supported, direct cooling
Target Angle	8°, Segmented

X-Ray Tube Features	Clinical Value
Spiral Groove Bearing	Anode rotation stability for virtually motion-free, focal spot for better image clarity
Segmented Anode	12 individual anode segments compensate for heating and cooling cycles for higher reliability
Smart Focal Spot	Dynamic focal spot motion doubles the number of projections to yield 256 slices and improves in-plane spatial resolution

## Detectors

### Detector

Feature	Specification
Slices	256 x 0.625
Material	Solid-State GOS with 86,016 elements
Slip Ring	5.3 Gbps transfer rate
Data Sampling Rate	Up to 4,800 views/revolution/element
Collimations Available (Channels x mm)	2 - 128 rows x 0.625 - 1.25mm; fused combinations for axial
Slice Thickness (Spiral mode)	0.625 - 10mm variable
Slice Thickness (Axial mode)	0.625 - 10mm variable
Scan Angles	240°, 360°, 420°

## Collimators

### Collimator

Feature	Specification
Wedge Filters	Small, Medium, Large
IntelliBeam Filters	2
Eclipse DoseRight collimator	Reduces dose up to 30% during helical scans.

## Patient Table

### Patient Table

Feature	Specification
Vertical Range, mm	610 to 1080mm with 1.0 mm increment
Manual Longitudinal Stroke, mm	1900mm
Scannable Range, mm	1750mm
Z Position Accuracy	±0.25mm
Longitudinal Speed, mm/s	0.5 – 185mm/s
Max Load Capacity with Accuracy, lb	450 lbs (204 kg) with 0.25mm Z-axis accuracy 650 lbs (295 kg) with Bariatric Patient Support*
Floating tabletop	Carbon-fiber table top with foot pedal and hand control for easy positioning and quick release.

## Image Quality

### Image Quality

Feature	Specification
Spatial resolution - Ultra high mode	24.0 Lp/cm @ cut-off
Spatial resolution - High mode	16.0 Lp/cm @ cut-off
Spatial resolution - Standard mode	13.0 Lp/cm @ cut-off
Noise	0.27%
Low contrast resolution	4.0mm @ 0.3%
Absorption range	-1024 to + 3072 Hounsfield units

## Gantry

### Gantry

Feature	Specification
X-ray tube and Detectors Architecture	Rotate-rotate
Air Bearing Rotor	Whisper quiet and stable operation at 220rpm.
Rotation Times	0.27* & 0.3*, 0.33, 0.375, 0.4, 0.5, 0.75, 1, 1.5 seconds for full 360° scans; 0.18* seconds for partial angle 240° scans.
Gantry Aperture, mm	700mm
Intercom System	Two-way connection between the gantry and console areas.
Breathing Lights	Visual patient communication to improve study compliance.
Operator Controls located on Gantry (left and right, front and back)	Front side LCD with touchscreen activation of Couch In/Out, Couch Up/Down, Emergency Stop, X-Ray Indicator and visual display of ECG wave and heart rate.
Controls located at Operator's Console	Couch In/Out, Couch Up/Down, Emergency Stop, X-ray Indicator, Start Scan, Pause.
Eclipse DoseRight Collimation	Lowers patient exposure during helical scanning.
Integrated ECG	Eliminates ECG monitor & Cart
Focus-detector distance	1040mm
Focus-isocenter distance	570mm

\*0.18, 0.27 & 0.3 optional

## Advances in CT

- Cardiac CT
- CT perfusion

## **Cardiac CT**

Cardiac CT imaging makes high demands to the CT scanner in temporal and spatial resolutions due to cardiac motion and breathing. High spatial resolution is required, because the cardio vascular system to be examined has vessels, for example coronary arteries, in the millimeter or sub millimeter range. Small lesions of diagnostic value must be identifiable. High temporal resolution is needed, because the heart is in periodic motion. In order to virtually freeze the heart in the diastolic phase of the heart cycle (which is usually used for reconstruction) the temporal resolution has to be better than the length of this diastolic phase. Temporal resolution is the time needed to acquire one image. A short scan time is required because breathing and patient motion reduce the image quality. It also reduces the amount of contrast agent needed for visualizing the cardio-vascular system.

High image quality in cardiac imaging therefore requires sophisticated technical solutions: To visualize the complex anatomic structures of the heart, a collimation smaller than 1 mm is recommended to reconstruct voxels in the submillimeter range.

To acquire cardiac images, the heart motion has to be virtually frozen during the diastolic phase. Therefore a high temporal resolution of about 100 ms up to 200 ms is possible with PHILIPS BRILLIANCE iCT 256-SLICE CT scanners.

To make it easier for the patient to hold her breath and not move, a short scan time of about 10 s is favorable, which also reduces the total amount of contrast agent needed.

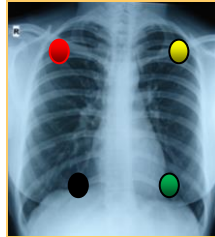
To acquire data over several heart cycles, scanning has to be done in relation to the heart beat. Retrospective ECG gating is therefore useful.

## **PHILIPS BRILLIANCE iCT 256-SLICE CT SCANNER**

High temporal resolution is achieved by scanning of up to 256 slices simultaneously with a minimum gantry rotation time of 0.27 s. This results in a temporal resolution of about 135 ms. High spatial resolution is achieved by scanning with up to 0.625 mm collimated slice width (adaptive detector system). Voxels of 0.35x0.35x0.625 mm resolution are reconstructable. A short examination time is achieved by scanning up to 8cm in one gantry rotation.

## **ECG CONNECTING TO PATIENT**

The correct placement of the ECG electrodes is essential in order to receive a clear and robust ECG signal with marked R-waves. Incorrect placement of the electrodes will result in an unstable ECG signal which is sensitive to movements of the patient during the scan.



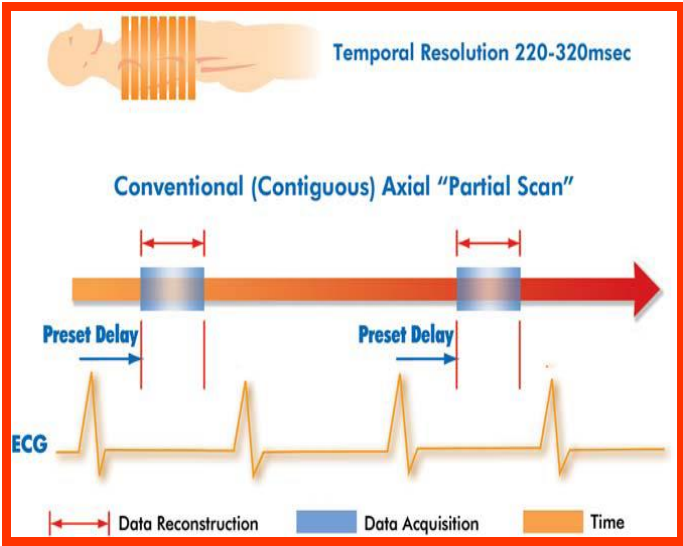
- Red electrode: on the right mid-clavicular line, directly below the clavicle
- Yellow electrode: on the left mid-clavicular line, directly below the clavicle
- Black electrode: right mid-clavicular line, 6 or 7 intercostal space
- Green electrode : on the left mid-clavicular line, 6 or 7 intercostal space

## **TWO MODES OF ACQUISITION**

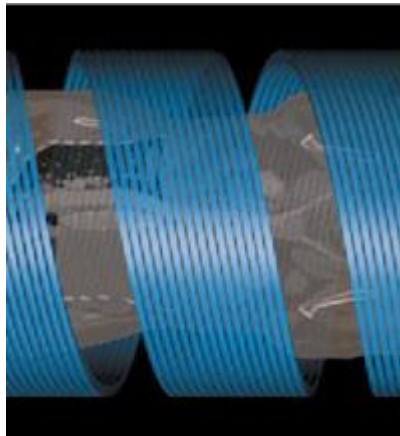
- i. PROSPECTIVE
- ii. RETROSPECTIVE

### **PROSPECTIVE SCANNING ( AXIAL )**

This mode is also called step and shoot method. In this method, the system detects the ECG from the patient's body and calculates the diastolic phase where the heart is at the least motion. It then exposes only the predetermined R-R interval phase after that the table moves to the next region and exposes.

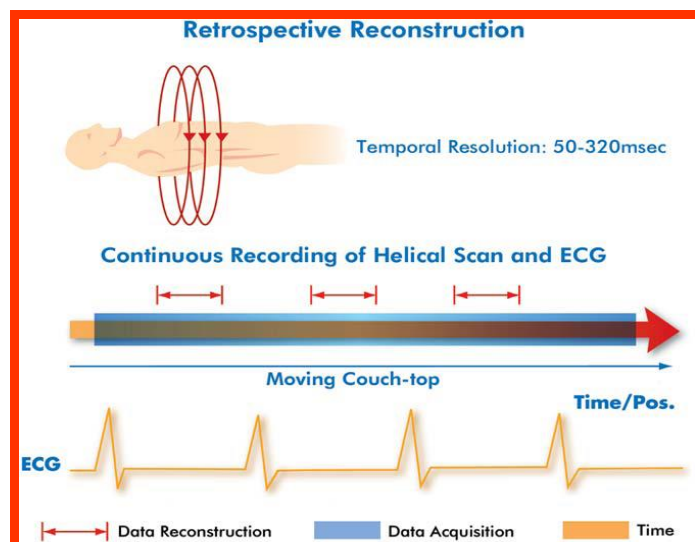


## RETROSPECTIVE SCANNING ( SPIRAL )



The recommended scan mode for cardiac CT is multi-slice spiral scanning. In this mode, the gantry rotates with constant speed during acquisition while the patient table moves through the gantry. This results in a spiral movement rendering a complete volume data set over the scanned volume (i.e. the patient's heart). The image on the left hand side schematically shows multi-slice CT acquisition.

Because the acquisition time spans several heart cycles, the spiral is measured in parallel with the patient's ECG signals. Acquired volume data is later reconstructed according to these ECG signals (retrospective ECG gating). See the illustration below for a schema of retrospective gated multi-slice CT:



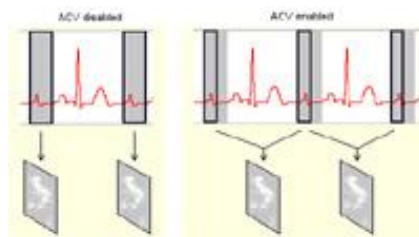
## **IMAGE RECONSTRUCTION**

During scanning, single slices of the volume data are reconstructed in RT mode in full resolution but with reduced diagnostic usability because they originate from different phases of the cardiac cycle. High image quality is reached by reconstructing the volume data set (the spiral) especially from the diastolic phase of least heart motion in post-processing steps:

Shifting the delay time within the diastolic phase of the heart's cycle allows to define an ideal scan box to be used for reconstruction. Slightly instable heart rates and arrhythmias may be compensated. Preview series can be reconstructed until the best delay is selected.

Synchronizing pulses over the R-peaks allow to edit the ECG and to skip extrasystole, for example.

The Adaptive Cardio Volume algorithm increases the temporal resolution by reconstructing images with raw data of two adjacent heart cycles (RR cycles). Motion artifacts are reduced.

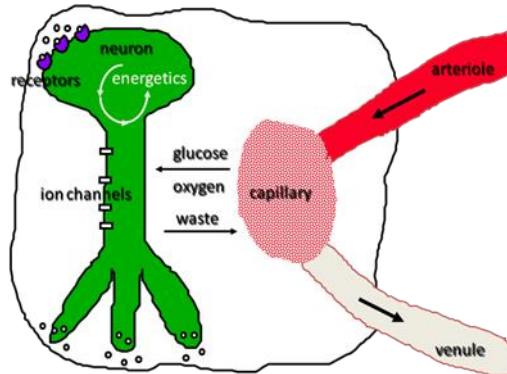


With the collimated slice width used (0.625 mm), images of nominal slice width of 0.625, 1, 2 and 3 mm can be reconstructed. We recommend to use slice widths of 1 mm to increase image quality by reducing artifacts.

The reconstructed images can be used for 3-D imaging such as MPR, Thin MIP or VRT.

# PERFUSION CT

It means steady state delivery of blood to tissue parenchyma through the capillaries. Derived from the French verb "per fuser" meaning to "pour over or through."



## CERBRAL HEMODYNAMICS

### CBV

- Cerebral blood volume (CBV) is the fraction of tissue volume occupied by blood vessels
- Units: ml / 100 g brain
- 4ml/100g
- Flow x circulation time=CBV
- CBF X MTT=CBV

### CBF

- Cerebral Blood Flow (CBF)
- Delivery of blood to tissue / unit time
- Units: ml / 100g brain / min
- $CBV/MTT=CBF$
- 50 ml / 100g brain / min

### MTT

- Mean Transit Time (MTT)
- Average time to flow through capillaries (artery → vein)
- $MTT=CBV/CBF$
- Units: seconds 5 sec

## Historical aspects of perfusion imaging

- I. 1980-Leon Axel determined the cerebral blood flow from rapid – sequence contrast enhanced CT.
- II. Groothius et al created BBP Parametric images of human brain in 1991.
- III. Ken miles implement perfusion CT on spiral CT

### **Applications of CTP**

- I. Vascular pathology
  - Acute ischemic stroke
  - Chronic ischemia
  - Vasospasm
- II. Tumours

### **Protocol of CTP**

- I. NCCT-Non contrast CT
- II. CTP-CT perfusion
- III. CTA-CT angiogram

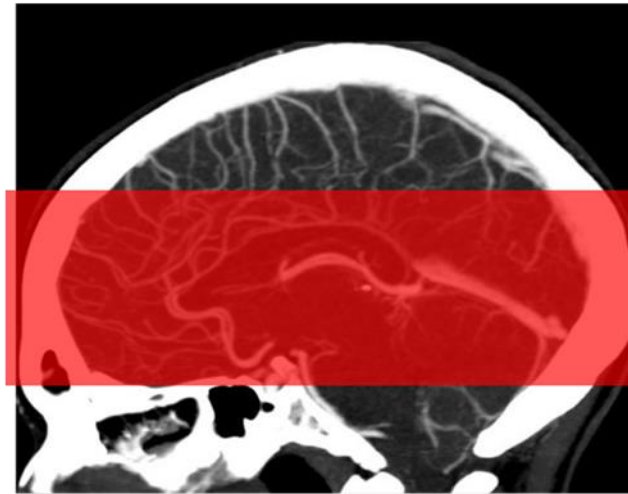
### **Steps of CT Perfusion Scan**

1. Place patient on the table
2. Put an appropriate size IV catheter (18/20 gauge)
3. Center patient for head scan
4. Perform a routine Non contrast study of head
5. Consult with Radiologist for exact location of perfusion scan.
6. Select perfusion protocol
7. Start perfusion scanning and injector at the same time.

We have a 256 slice PHILIPS brilliance iCT scanner which has two type of perfusion methods.

1. Jog mode
2. Non-jog mode

## ➤ NON-JOG MODE



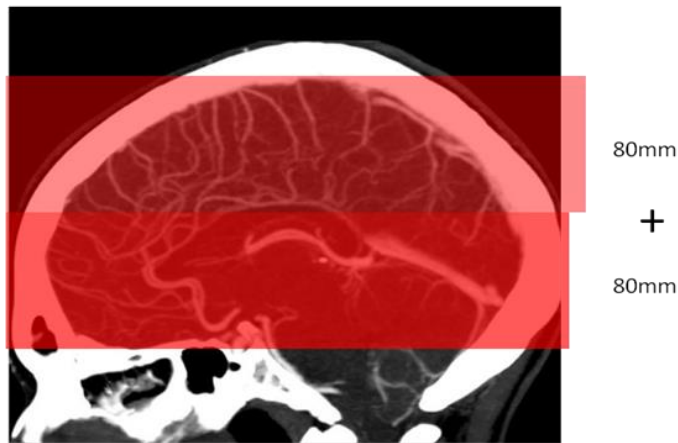
Collimation: 128x0.625 mm  
•Coverage: 80 mm

Jog mode is simply axial scanning .System will perform dynamic scanning while administration of contrast agent with constant table position.

### Non-Jog Mode.

	Brilliance 16 slice	Brilliance 40/64 slice	Brilliance iCT SP	Brilliance iCT
Rotation Time (s)	0.5	0.5	0.4	0.4
Collimation	16 × 1.5 mm	32 × 1.25 mm	32 × 1.25 mm	64 × 1.25 mm
Coverage (mm)	24	40	40	80
kVp	90	80	80	80
mAs	125	125	100	100
ACS/DOM	OFF	OFF	OFF	OFF
Cycle Time (s)	2.0	2.0	1.5	1.5
Cycles	30	30	40	40
Thickness (mm)	6.0	5.0	5.0	5.0
Increment (mm)	0.0	0.0	0.0	0.0
Resolution	Standard	Standard	Standard	Standard
FOV (mm)	250	250	220	220
Filter	UB	UB	UB	UB
WC/WL	80/40	80/40	80/40	80/40
CTDI-vol (mGy)	240	132	160	148

## ➤ JOG SCAN



Total Scan Area: 160 mm (16cm)

Multiple axial scans at two couch locations with minimal inter-scan delay with single scan at each location between “jogs”.

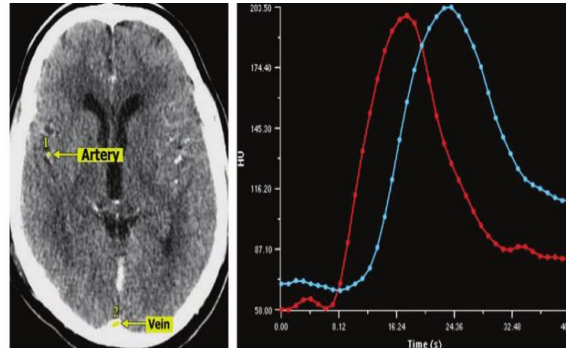
- I. Table Scanner obtains images from a single 360 degree rotation at location A
- II. increments by 4 cm to reach position B
- III. Scanner obtains Images from a single 360 degree rotation at location B
- IV. Table travels 4 cm in opposite direction to return to position A
- V. “Jogging sequence” continues for a total of 40-60 seconds.

**Jog Mode (Table moves back and forth between two positions).**

	Brilliance 16 slice	Brilliance 40/64 slice	Brilliance iCT SP	Brilliance iCT
Rotation Time (s)	0.5	0.5	0.4	0.4
Collimation	16 × 1.5 mm	32 × 1.25 mm	32 × 1.25 mm	64 × 1.25 mm
Coverage (mm)	48	80	80	160
kVp	90	80	80	80
mAs	125	125	100	100
ACS/DOM	OFF	OFF	OFF	OFF
Cycle Time (s)*	4	4	4	4
# of Jog Cycles	15	15	15	15
Thickness (mm)	6.0	5.0	5.0	5.0
Increment (mm)	0.0	0.0	0.0	0.0
Resolution	Standard	Standard	Standard	Standard
FOV (mm)	250	250	220	220
Filter	UB	UB	UB	UB
WC/WL	80/40	80/40	80/40	80/40
CTDI-vol (mGy)	120	66	80	72

## Workflow for processing Perfusion scanned data

1. Load all images into Brain perfusion
2. Select the best artery to do an ROI. Do not use an artery that feeds the affected side.



3. Select the best vein to do an ROI.
4. Calculate for the perfusion images.

# Digital Subtraction angiography

## System specification

### **Innova 3131**

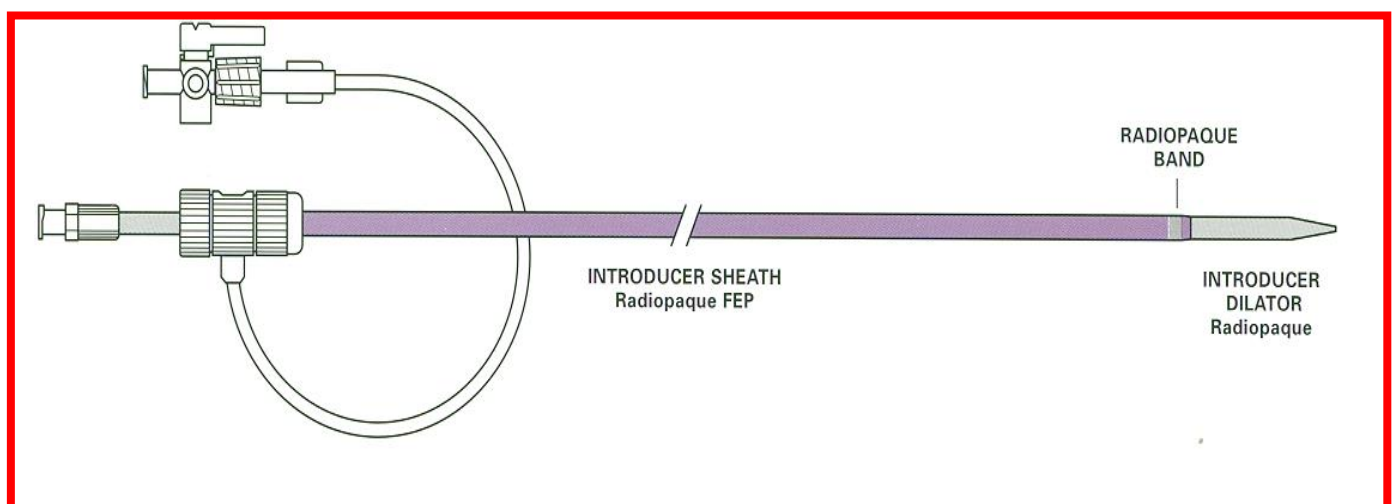
<b>Company</b>	GE Healthcare
<b>Model</b>	Innova 3131
<b>Type</b>	Biplane digital flat panel fluoroscopic system
<b>Acquisition zoom</b>	Yes
<b>Other imaging software options</b>	Fluoro, DSA, instant mapping, cine, Innova Breeze runoff, Innova Chase, Innova Sub 3-D and CT, stenosis & vent analysis
<b>Minimum room size to accommodate system</b>	19.8 x 24 feet, 6 in. procedure system
<b>PATIENT TABLE</b>	
<b>Motion</b>	8-way horizontal float
<b>Length x width, cm (inches)</b>	Omega V table: 333 (131) x 46 (18)
<b>Vertical range, cm (inches)</b>	Omega V table: 30 (12)
<b>Lateral range, cm (inches)</b>	Omega V table: 14 ( 5.5)
<b>Longitudinal, cm (inches)</b>	All tables up to 170 (66.9)
<b>Tilt</b>	NA
<b>Maximum patient weight, lb.</b>	All tables 450
<b>X-ray density</b>	Omega V table < 1 mm AI
<b>Swivel</b>	NA

**Rotational angiography features** A fast rotational 200 rotation at a 40sec spin speed, using a frame rate of 30 FPS provides approximately 150 views in a 5 second acquisition

**Time from acquisition to 3-D display** 25 sec 256 x 256 x 256; 58 sec 512 x 512 x 512; 50 sec Fast 512

## Hardware's

### **INTRODUCER SHEATH**



Sheaths provide smoother and safer catheter introduction during procedures that require multiple catheter exchanges or arduous manipulation of the catheter. Sheaths usually come with a sideport for heparin and or contrast installation and for obtaining pressure measurements. There should also be a hemostasis valve to prevent air aspiration and blood backflow. Sheath also come with a interlocking dilator to aid in the insertion of the sheath, once the sheath dilator is in the artery, the interlocking hub can be detached and the dilator portion can be removed

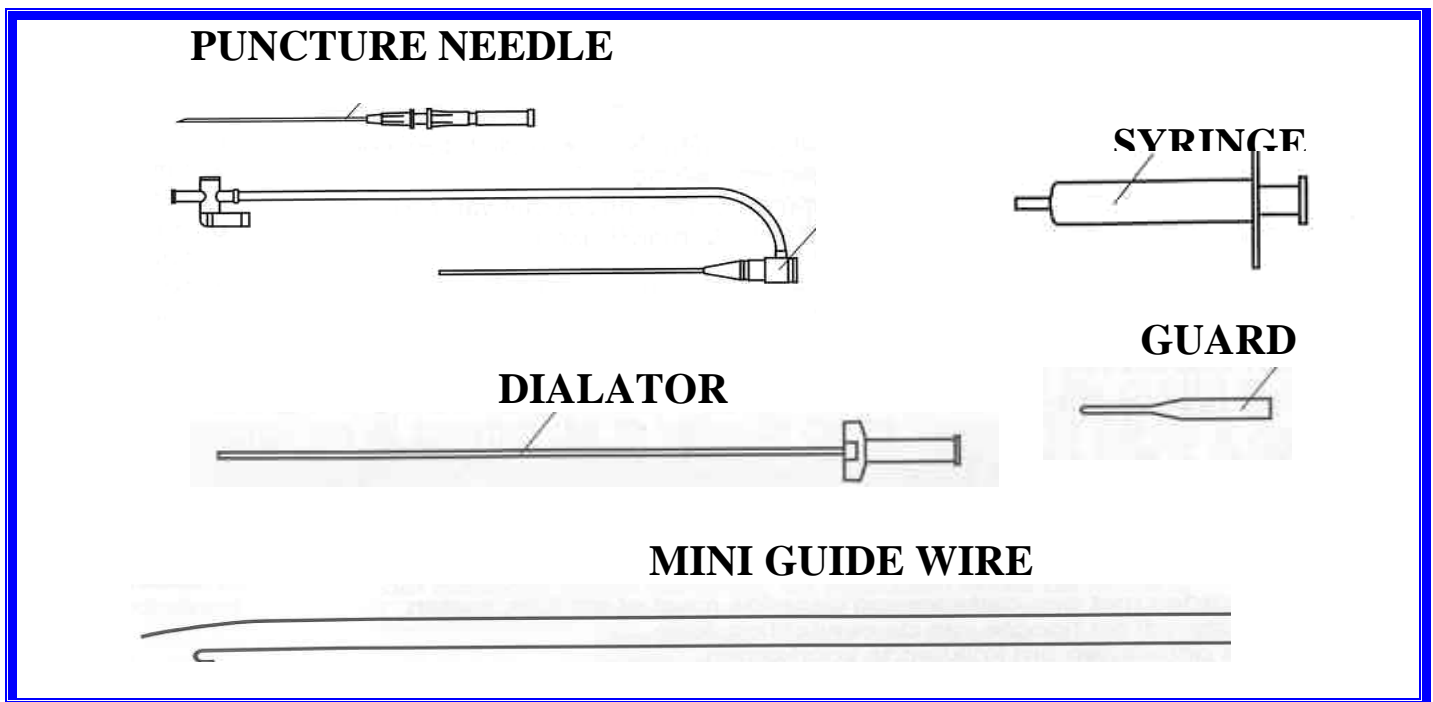
Advantages:

1. Repeated access to the artery
2. Ease of catheter maneuverability.
3. Lessened bleeding.

The placement of a sheath of appropriate length may also allow the operator to negotiate tortuous anatomy only once. There are numerous sheaths available in from various manufactures.

### **INTRODUCER SET**

Introducer set contains puncture needle,syringe,dilator,guard and mini guide wire



### **DILATORS**



Dilators are thick-walled plastic tubing with a tapered end that provide a tract from the skin surface to the vessel, assuring smooth catheter entry. The dilator is most commonly used when a guide wire is in a vessel but catheter placement is difficult, when a vessel is heavily scarred, when plaque is present at the puncture site, or in the presence of a graft.

## **CONTRAST**

The contrast material used for interventional procedure should be non-ionic for several reasons.

**Omnipaque 350mg/ml**

**Visipaque 320mg/ml**

Diluted contrast—50 ml contrast 30 ml saline.

## **CATHETERS**

Catheters are long, hollow tubes that supply an avenue or passageway for contrast media, embolizing materials or therapeutic medications or instruments. Catheters come in a variety of sizes that are measured in the term called French as general rule: 3F to 5F for children and 4F to 9F for adults. This term French refers to the outer diameter of the catheter.

Catheters also have a variety of shapes which include single and multiple curves. Catheters are designed to be either radiolucent to view bubbles or radiopaque for better visualization. Memory refers to a catheters ability to retain its shape. Torque refers to the catheters ability to twist and turn. Another term use to discuss catheters is Tractability this refers to how well a catheter can track over a guide wire Ordinary catheters cannot normally be directed into a CC-fistula or into the most distal external and internal carotid artery branches that may be supplying an AVM. So micro catheters are used they range in the order of 2.5fr. to 3.5fr. These are made of highly flexible silicone. These catheters may be either flow directed or may require the use of a guide wire.

Units Useful for Angiographic Catheters & Guide wires

1" = 25.4mm

1mm = 3F = 0.039"

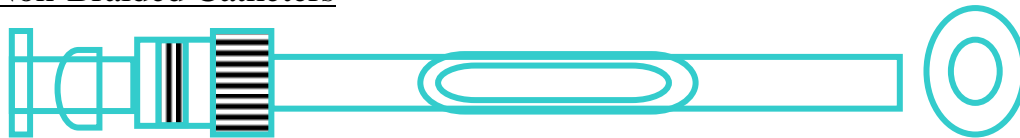
1F = 0.013"

French FR	Sizes mm
1F	1/3mm
2F	2/3mm
3F	3/3mm

Example 9F catheter = 3mm Diameter

### Angiographic Catheter

#### Non-Braided Catheters



Catheter Construction

Cross section

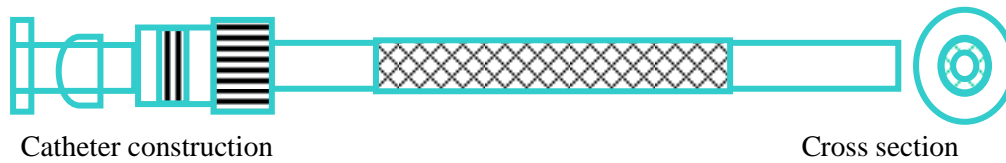
Types:

Radio opaque Polyethylene – has a medium coefficient of friction and less stiffness than TFE. It does absorb some moisture. Polyethylene tubing contains Bismuth Salts for radio opacity. Suitable for selective and super selective angiographic studies.

Thin wall radio opaque Nylon – has low friction coefficient and is kink resistant. Bismuth salts for radio opacity. Suitable for maximum high – flow administration of contrast medium.

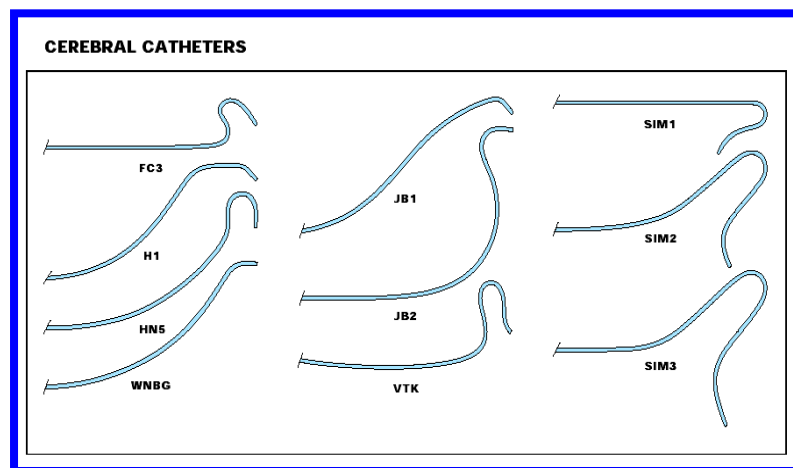
Radio opaque TFE – has a lower coefficient of friction and higher burst point than polyethylene of similar wall thickness and out side diameter. TFE is stiffer than polyethylene. It doesn't absorb moisture. Bismuth salts are used for radio opacity. Suitable for non-selective angiographic studies. (! Never sterilise TFE by irradiation; complete disruption results. Radio opaque vinyl – is more flexible than standard polyethylene material. Suitable for selective and sub selective angiographic studies when standard catheter can't be advanced over wire guide to desired position.

## Braided Catheters



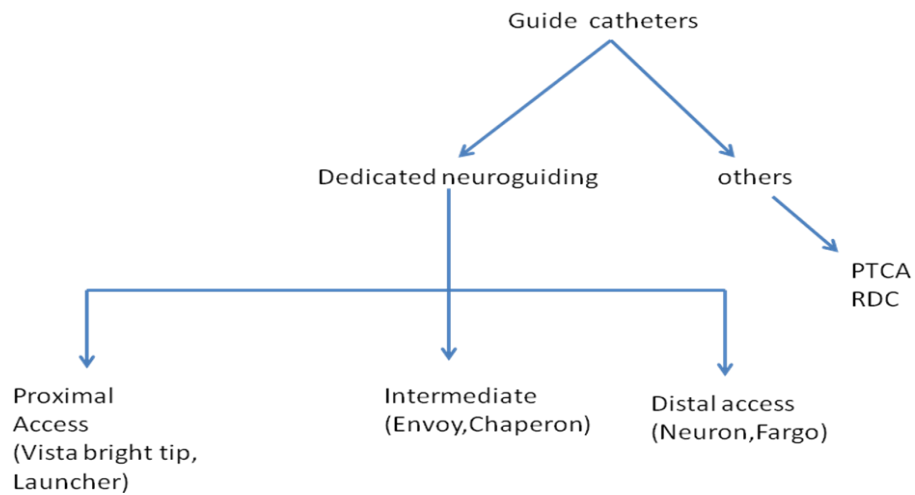
Types:

Thin wall radio opaque polyethylene with torque control – has stainless steel braided construction within catheter shaft which imparts torque control to catheter tip. Bismuth salts are used for radio opacity. Suitable for high flow administration of contrast medium in selective angiographic studies.



## GUIDE CATHETERS

Used in interventional procedures for introducing microcatheters. In selecting the size of the microcatheter, the operator must always remember the goals of the procedure. This requires matching of the guide catheter inner lumen with the outer diameter of the microcatheter. In addition one must also keep in mind the inner lumen of the microcatheter, so that appropriate embolics can be delivered. The length of the guide catheter is important in very tall individuals, in whom a 90-cm length may be inadequate for appropriate positioning of the guide catheter.



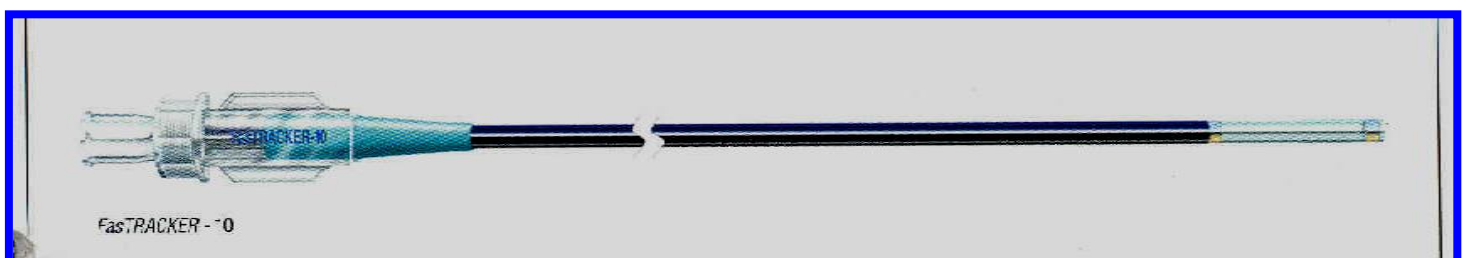
Fargo

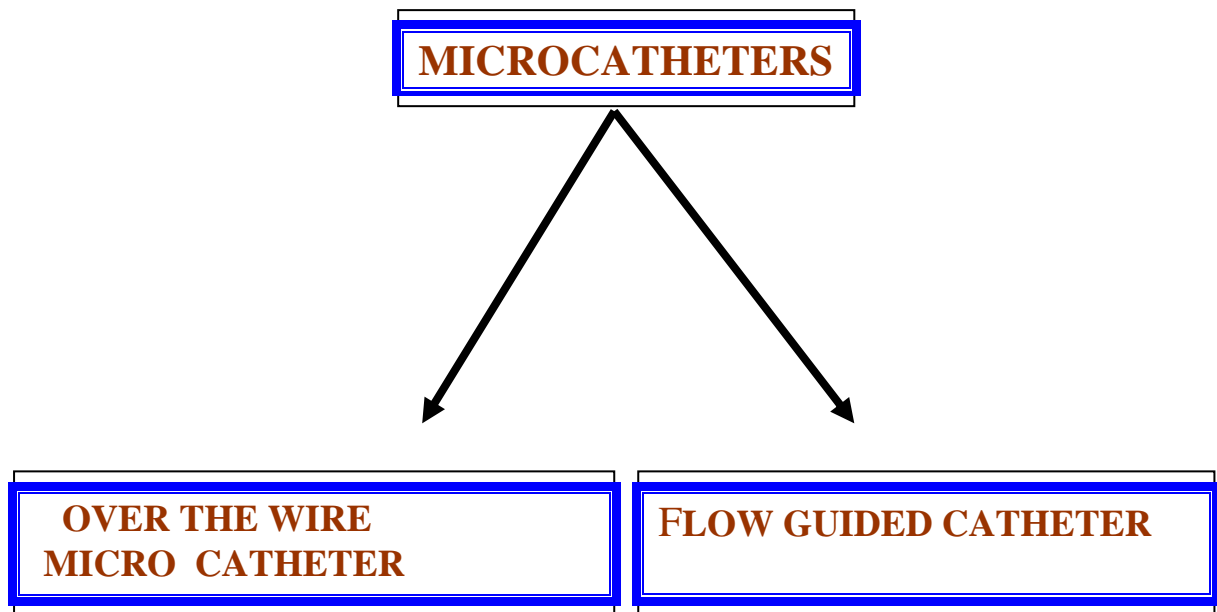


## MICRO CATHETER

**MICROCATHETERS:** - All of the commercially available micro catheters are constructed of polyethylene and are hydrophilically coated. Many micro catheters will contain braided materials, which improves flexibility, pushability, and trackability of the microcatheter. The braided construction lessens the incidence of micro catheter kinking or ovalizing as it traverses bends. This braid feature can also cause the microcatheter to move forward and suddenly to retract as the guide wire is removed. Most Currently available micro catheters have similar performance characteristics. All the catheters have a marker at the tip, and most are available in a two-marker variation for the deployment of coils.

### FasTRACKER-10





## **OVER THE WIRE MICROCATHETERS**

Used for the infusion of thrombolytic agent.

### **Echelon™ Micro Catheter**

These micro catheters provide straightforward access and stability. Proprietary nitinol braided design offers more proximal push with soft distal navigation. Four specific zones utilizing nitinol variable braiding provides control along the length of the catheter with shaft support, tip flexibility and smooth transitions. The large ID of the Echelon microcatheter allows a greater flow rate than competitive microcatheters. The small OD of the Echelon allows more flow in the guide catheter which can be useful for angiographic injections. Echelon pre-shaped microcatheters offer the best tip shape out of the package and after simulated use.

### **Rebar™ Micro Catheter**

The Rebar™ Micro Catheter is an endhole, single-lumen catheter. The proximal end of the catheter incorporates a standard luer adapter to facilitate the attachment of accessories. The catheter has a semi-rigid proximal shaft which transitions into the flexible distal shaft to

facilitate the advancement of the catheter in the anatomy. Single or dual radiopaque markers at the distal end facilitate fluoroscopic visualization.



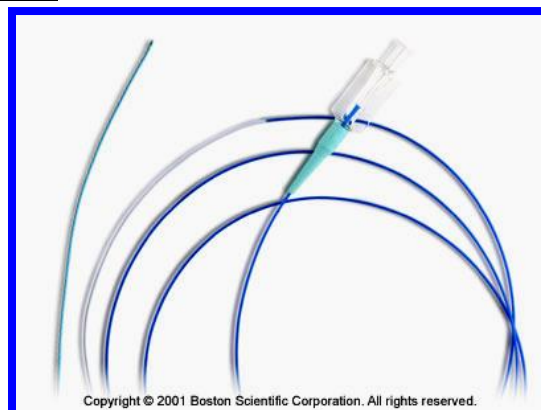
### **Prowler microcatheter(braided )**

The prowler micro catheters are also available in a preshaped 45-degree, 90-degree angle, J-tip. The preshaped curves keep the operator's fingers from the steam, and the microcatheter seems to maintain their shape longer .At times, as mentioned earlier, the braided catheter will retract as the guide wire is removed. Similarly braided catheters have a tendency to suddenly move forward.

## **FLOW GUIDED MICROCATETHERS**

These are very flexible hydrophilic-coated catheters that are primarily designed to deliver liquid embolics such as glue, onyx, and dehydrated alcohol, PVA (less than 500 $\mu$ m) can be administrated through these microcatheters as well.

### **SPINNAKER ELITE**



Developed specially for flow directed applications, the spinnaker elite flow directed microcatheter might be used for regional infusion of diagnostic agents and vascular occlusion with berenstein liquid coil-10. The flow-directed spinnaker elite (Boston) is not approved for use with glue or other liquid agents, which would seem to be its purpose.

### **Marathon™ Flow Directed Micro Catheter**



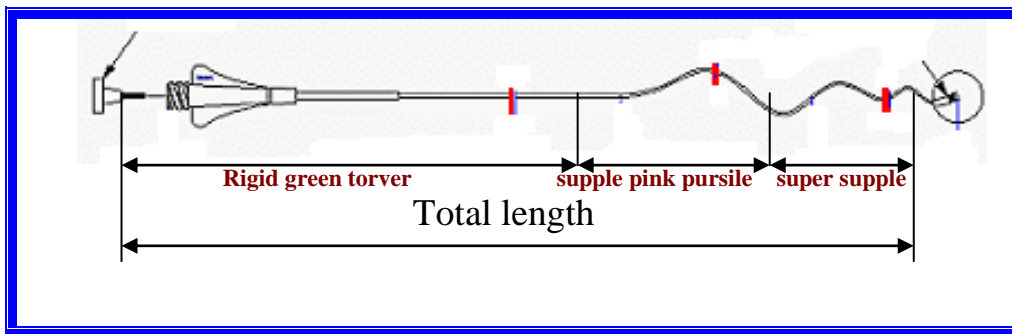
Developed as an Onyx Delivery Catheter, the Marathon offers the user the lowest available tip profile while providing unmatched burst and tensile strength, making it the ideal catheter for the treatment of Brain AVMs. It has proximal pushability due to the stainless steel coil reinforcement in proximal shaft. Soft flow-directable distal segment. Distal tip of 1.3F, marker band profile of 1.4F and robust reinforcement Nitinol braid reinforcement in distal "floppy" segment and has lubricious (PTFE) ID liner - from hub to tip for excellent guidewire interaction

### **BALT MAGIC**



MAGIC catheters are designed for general intravascular use. They may be used for the controlled, selective regional infusion of therapeutic agents or embolic materials into vessels. The MAGIC catheter is intended to

facilitate access through distant,tortuous vasculature. Progressive suppleness ranging from a super supple distal shaft to a rigid proximal shaft allows the catheter to be advanced by the physician. The rigid proximal shaft allows torque control to facilitate the advancement of the catheter.The MAGIC catheter tip(ring)and shaft are radiopaque.



## MICRO THERAPEUTICS

Rebar-10

Rebar-14

Rebar-18

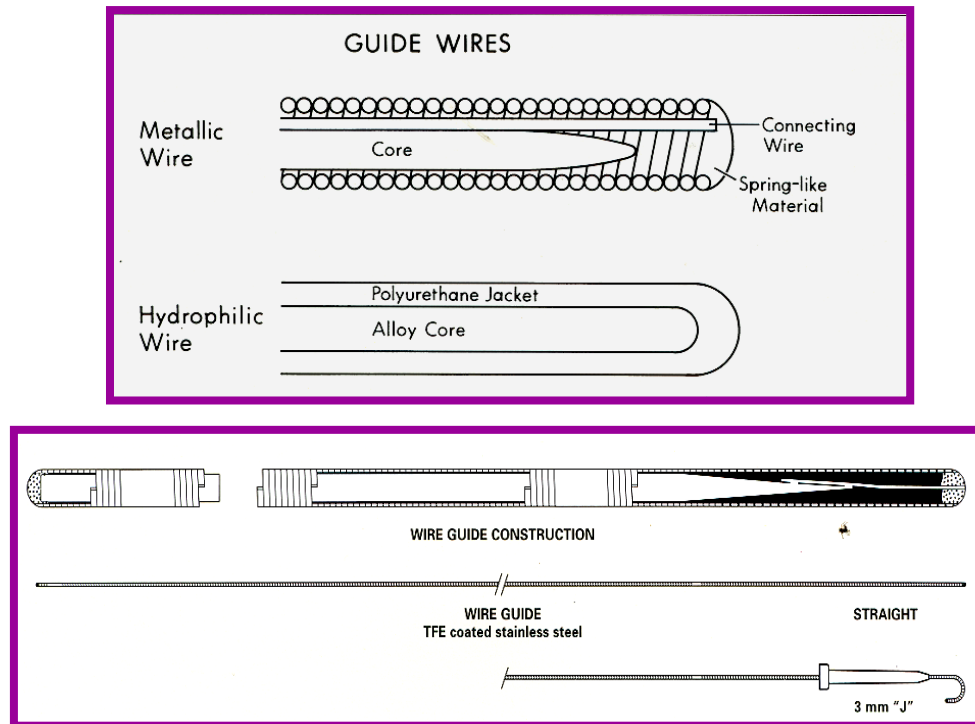
Working length	153	153	153
Distal flexible segment	170	170	170
Proximal O.D French	2.3	2.4	2.8
Proximal ID(INCH)	0.015	0.017	0.021
Braid material	Stainless steel	Stainless steel	Stainless steel
Distal OD French	1.7	1.9	2.3
Distal ID(INCH)	0.015	0.017	0.021

Tip marker OD French	1.7	1.9	2.3
Markers	2	2	2
Minimal guide(inch)	0.035	0.035	0.035
Maximum wire OD(in..)	0.012	0.014	0.018
Inner lumen construction	PTFE	PTFE	PTFE
Dead space	?	0.27	0.27

## TARGET

	Excelsior	Excel	Renegade	FasTracker-10
Working length	150/6	150/15	150/10	150/3
Distal flexible segment(cm)		150/7.5	150/20	155/15
Proximal OD French	2.6	2.4	3.0	2.6
Proximal ID(IN.)	0.019	0.017	0.021	0.016
Braid material	Stainless steel	Stainless steel	Fiber Weave	None
Distal OD French	2.0	1.9	2.5	2.0
Distal ID(IN.)	0.019	0.017	0.021	0.015
Tip marker OD French	2.0	1.95	2.5	2.6
Markers	1or2	1or2	1or2	1or2
Minimal guide(in.)	0.042	0.035	0.038	0.038
Maximal wire OD(IN.)	0.016	0.014	0.018	0.010
Inner lumen construction	PTFE	PTFE	PTFE	PP/EVA proximal PE/EVAdistal
Dead space(cc)	0.35	0.30	0.47	0.30

## Guide Wires:



- Guide wires are thin and are constructed of stainless steel wire.
- Guide wires are very flexible and vary in size and length.

## GUIDEWIRE USED FOR DIAGNOSTIC ANGIOGRAPHY

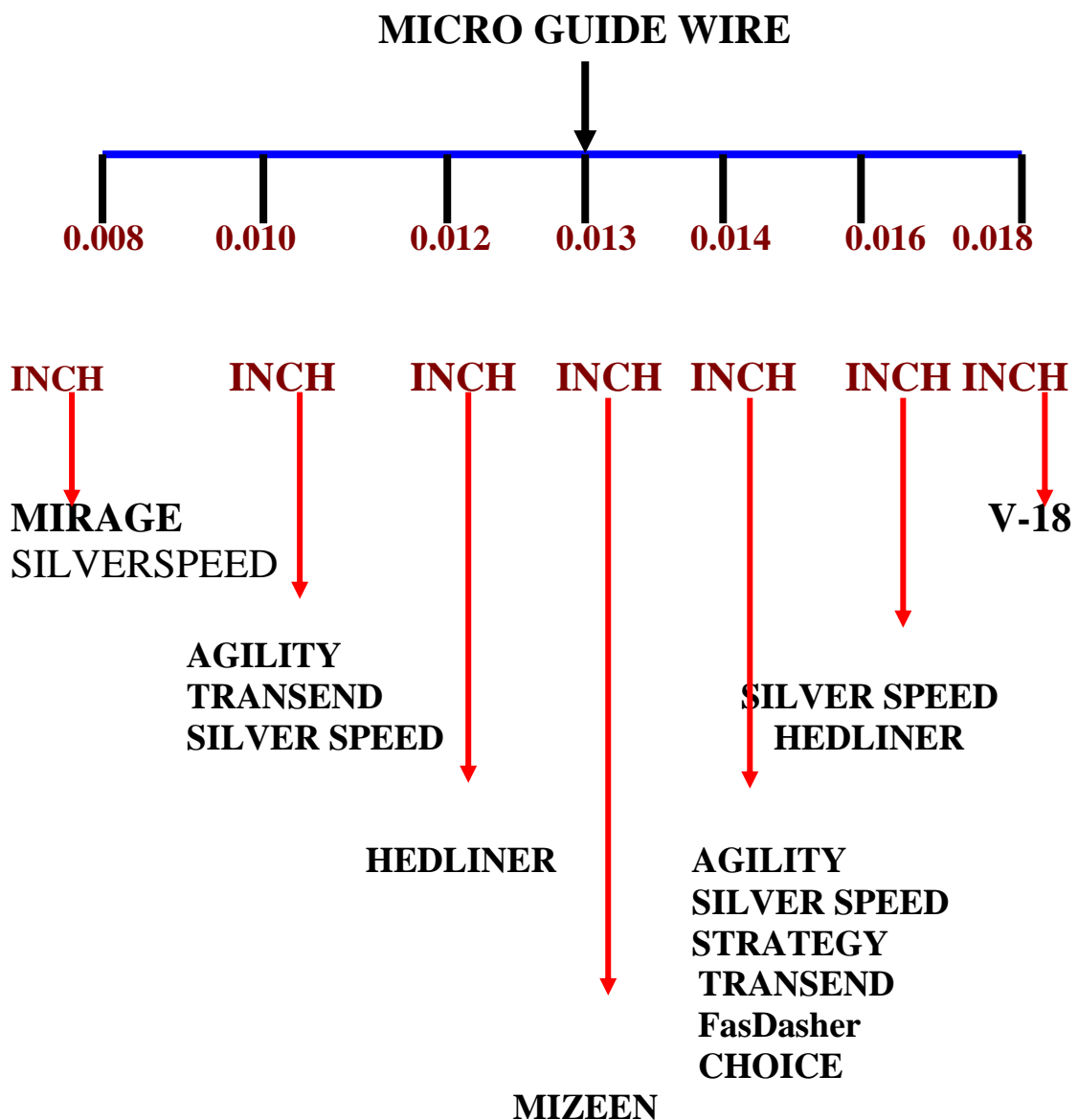
The length of guide wires vary from 100 to 300 cm and sizes range from 0.025 " to 0.045 " in diameter. Guide wires may be coated with Teflon, polyurethane, polyethylene or a hydrophilic coating (Glide Wires) to lower the friction coefficient and prevent damage to the vessel walls. Guide wires may also treated with heparin to reduce the chance of blood clotting and emboli formation.

### **Types**

Guide wires basically are of two shapes, straight and J curve and may have either a movable core or a fixed core.

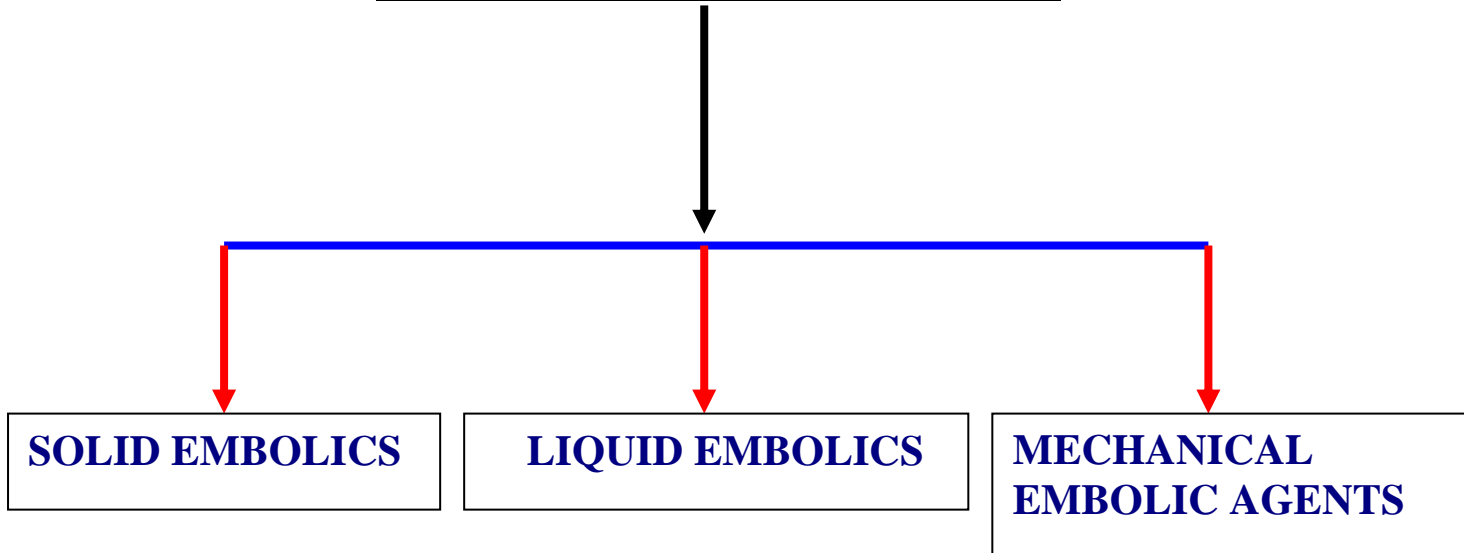
## MICROGUIDE WIRE

Most microguide wires have a stain less steel core; a few have a nitinol core .This core provides most of the torquing.A few have a polymer outer coatings and nearly all have hydrophilic coatings. The core diameter is so small that microguidewires are not radiopaque unless the manufactures have added platinum coils to the distal segments, distal radiopaque polymer coatings, or gold-tipped ,markers. Some microguidewires tip are shapeable, and others are pre shaped by manufactures.



## EMBOLISATION MATERIALS

### EMBOLISATION MATERIALS



#### Solid embolic agents

Solids that have been used as embolic agents include

1. POLYVINYL ALCOHOL ( PVA) PARTICLES
2. SILK SUTURES
3. EMBOSPHERES
4. AVITENE
5. GEL FOAM

All of these agents mechanically obstruct the vessels, which leads to slowing of the flow and eventually clot formation within the embolised vessel.

#### Polyvinyl alcohol

These are artificial embolisation devices. These devices are intended to provide vascular occlusion upon selective placement via an angiographic catheter. It is a nearly water-insoluble polymer made by the reaction of foamed PVA with formaldehyde. The polymer is not linear but composed of cross-linked chains that determine the physical properties such as swelling, suspension in contrast material, and viscosity. They are available in different sizes and different brand names.

**BRAND NAME      MANUFACTURES**

<b>PVA</b>	<b>COOK</b>
<b>CONTOUR</b>	<b>BOSTON</b>

**COOK**

<b>SIZE RANGE</b>
<b>50-100<math>\mu</math></b>
<b>100-200<math>\mu</math></b>
<b>200-300<math>\mu</math></b>
<b>300-500<math>\mu</math></b>
<b>500-700<math>\mu</math></b>
<b>700-1000<math>\mu</math></b>
<b>1000-1500<math>\mu</math></b>
<b>1500-2000<math>\mu</math></b>
<b>2000-2800<math>\mu</math></b>

**BOSTON**

<b>SIZERANGE</b>
<b>45-150<math>\mu</math></b>
<b>150-250<math>\mu</math></b>
<b>250-355<math>\mu</math></b>
<b>355-500<math>\mu</math></b>
<b>500-710<math>\mu</math></b>
<b>710-1000<math>\mu</math></b>
<b>1000-1180<math>\mu</math></b>

**INDICATION FOR USE**

Embolic agents are used for the embolisation of hyper vascular tumours and arteriovenous malformation.

When the PVA particles used for embolisation of the AVMs, the choice of particle size is based on the flow through the lesion. For PVA embolisation of tumors, the particles are as small as possible to occlude as distally as possible. Epistaxis embolisation usually is performed with 200 $\mu$ m- sized PVA particles, which lessens the risks of mucosal slough that can occur when smaller particles are used.

**GELFOAM**

It is a water insoluble, porous, pliable product that is absorbed by the body in 7-21 days with little tissue reaction. It is prepared from

purified pork skin and should not be used in patients with known allergies to porcine collagen. The haemostatic properties are not fully understood but seem to be due to the formation of an artificial clot as matrix forms for platelets that are damaged by contact with the gelfoam. This cause release of thromboplastin, which reacts with thrombin and calcium to produce thrombin, which acts on the fibrinogen in the blood. Gelfoam has the ability to absorb and hold up to 45 times its weight of blood and other fluids. This capacity makes it a very effective vascular occlusive agent

## **LIQUID EMBOLICS**

Liquid agents for neurointerventional use consist of

### **CYANOACRYLATES (GLUE)**

- Histoacryl-(n-butyl 2-cyano acrylates) is commonly used
- Need skill full& care full handling.
- Capable of reaching distal small vessel.
- Exposure of glue to the ionic solution cause polymerization.
- Polymerization can be slowed by addition of iophendylate or glacial acetic acid.
- Tantalum, bismuth or lipidol gives better radiopacity to the glue.
- Speed of the polymerization can controlled by addition of lipidol.

### **HISTOACRYL CONCENTRATION CHART**

<b>NO</b>	<b>CONCENTRATION</b>	<b>HISTOACRYL</b>	<b>LIPIDOL</b>
<b>1</b>	<b>15%</b>	<b>0.5ml</b>	<b>2.8ml</b>
<b>2</b>	<b>17%</b>	<b>0.5ml</b>	<b>2.4ml</b>
<b>3</b>	<b>20%</b>	<b>0.5ml</b>	<b>2ml</b>
<b>4</b>	<b>22%</b>	<b>0.5ml</b>	<b>1.7ml</b>
<b>5</b>	<b>25%</b>	<b>0.5ml</b>	<b>1.5ml</b>
<b>6</b>	<b>33%</b>	<b>0.5ml</b>	<b>1ml</b>
<b>7</b>	<b>40%</b>	<b>1ml</b>	<b>1.5ml</b>
<b>8</b>	<b>50%</b>	<b>0.5ml</b>	<b>0.5ml</b>
<b>9</b>	<b>60%</b>	<b>1.5ml</b>	<b>1ml</b>
<b>10</b>	<b>66%</b>	<b>1ml</b>	<b>0.5ml</b>
<b>11</b>	<b>75%</b>	<b>1.5ml</b>	<b>0.5ml</b>
<b>12</b>	<b>80%</b>	<b>2ml</b>	<b>0.5ml</b>

## **DEHYDRATED ALCOHOL**

It is a liquid agent used in the same way as cyanoacrylates for the treatment of AVM's and some tumors. In the past the alcohol was opacified by dissolving metrizamide powder in it, and the solution was injected under fluoroscopic control. Because metrizamide powder is no longer available, operators opacify the alcohol with a small amount of concentrated nonionic contrast material.

Alcohol injures tissue by denaturing proteins of the cell wall, particularly the endothelial cells, and causing precipitation of the protoplasm. This leads to the thrombus formation and a coagulative necrosis. Alcohol injection is very painful, general anesthesia is usually required. The maximum volume of alcohol used in a treatment session is 1cc/kg body weight and this is usually well tolerated. The alcohol may cause a significant rise in pulmonary vascular resistance and pulmonary arterial pressures.

## **ONYX/SQUID**

This liquid is a proprietary ethylene alcohol copolymer suspended in DMSO and opacified with tantalum powder. It stays in liquid form until it contacts blood or other aqueous solutions. The onyx then begins to precipitate, quickly changing from a liquid to a solid from the outside to the inside. Its major advantage is that it adheres to itself but not to the delivery catheter, so that slow injections with slight reflux along the microcatheter tip can be used without fear of adherence of the cast to the microcatheter. However, if significant reflux occurs, catheter retrieval may be impossible.

## **HYDROGEL**

- Available in either liquid or particle form.
- It forms soft shapeless mass when exposed to water and not produce inflammatory response.

## **MECHANICAL EMBOLIC AGENTS**

- They are platinum microcoils.
- It is soldered to one end of an insulated stainless steel guide wire, a short segment of the soldered end is exposed

- After coil positioning, low voltage current employs electrolysis to detach coils.
- Advantage is withdrawal of the coil before final placement.
- Available in two systems
  1. GDC-18 SYSTEM
  2. GDC-10 SYSTEM
    - They are available in various size and shape.
    - » STANDARD COILS
    - » 2D-COILS
    - » 3D-COILS
    - » SOFT COILS
    - » ULTRA SOFT COILS
    - » STRECH RESISTANT COILS
    - » THROMBOGENIC GDC COILS

### GDC-10,18 & DELIVERY WIRE

The GDC coils are manufactured from a platinum alloy, which permits them to conform to the often-irregular shape of saccular aneurysm. The delivery wire has been designed to provide two important benefits of the GDC technology:

1. CONTROLLED DEPLOYMENT.
2. ELECTROLYTIC DETACHMENT.

The GDC system is a fast, accurate and effective endovascular approach to treating high surgical risk intracranial aneurysm. At the heart of the GDC system is a soft, platinum coil that is attached to a stainless steel delivery wire. The softness of platinum allows the coil to conform to the often-irregular shape of intracranial aneurysm. And because the coils are available in a variety of helical diameters and lengths, the interventionalist can deploy and release the optimal combination of coils necessary to occlude the aneurysm sac.

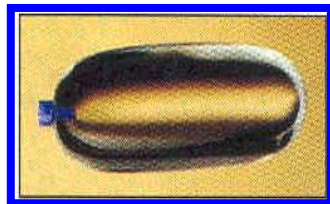
### MATRIX COIL

Matrix detachable coils are platinum coils covered with an absorbable polymer and attached to a stainless steel delivery wire. Matrix detachable coils are designed for use with Boston scientific target 2 tip infusion catheters and a GDC power supply.

Matrix detachable coils:-

- Increased the amount of mature connective tissue present with aneurysm at 14 days.
- Increased neck tissue thickness of aneurysm at 14 and 90 days.
- Reduced cross sectional area of the aneurysm at 90 and 180 days as measured from angiograms and histological sections.

## **DETACHABLE BALLOONS**



## **FLIPPER™ DETACHABLE EMBOLIZATION COIL DELIVERY SYSTEM**

Detachable balloons are designed to occlude the entire vessel with one application. Balloons can sometimes deflate and migrate causing a stroke; they can cause embolus formation and release, vessel rupture and hemorrhage, or infarction. They may also cause Neurological or functioning deficit, vasospasm, ischemia at an undesirable location and death.

Contraindications to balloon occlusion are the patient intolerance to temporary occlusion procedures. Vascular anatomy or blood flow that precludes stable catheter placement. The presence or likely onset of vasospasm. Friable vascular constriction that may cause rupture of a blood vessel and clips, bone fragments, calcifications or any irregularities which may cause damage to the balloon.

## **PART B. Procedures**

Radiological Interventions can be broadly classified into

- I. Vascular Techniques
- II. Non-vascular Techniques

### **I. Vascular Techniques**

These procedures are done to correct diseases originating in the blood vessel system of the human body by obtaining arterial or venous vascular access. Basically these procedures are divided into: Diagnostic & Therapeutic .Diagnostic procedures include all kind of angiograms such as cerebral angiography, peripheral angiography, bronchography etc.

Therapeutic procedures again divided into restoration and obliteration procedure

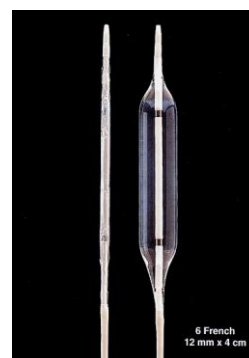
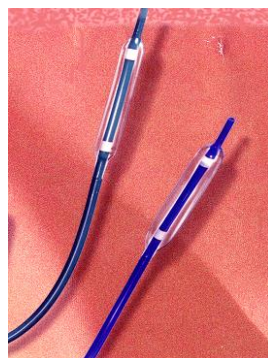
#### **RESTORATION PROCEDURE**

- Angioplasty and stenting
- Thrombolysis
- TEVAR(Thoracic Endovascular Aortic aneurysm Repairment)
- EVAR(Endovascular Aortic aneurysm Repairment)
- FEVAR(Fenetrated Endovascular Aortic aneurysm Repairment)

#### **OBLITERATION PROCEDURE**

- Embolization
- Sclerotherapy
- Chemo embolization

#### **PERCUTANEOUS TRANS LUMINAL ANGIOPLASTY**



This procedure helps to open up occluded blood vessels using small catheters with distensible balloons attached to it, via intravascular access made through small percutaneous needle punctures. As compared to more extensive and difficult surgical approach this proves definitely beneficial in most instances.

## **INDICATIONS FOR USE**

Balloon dilation catheters are recommended for percutaneous transluminal angioplasty of the iliac, femoral and renal arteries and for the treatment of obstructive lesion of native or synthetic arteriovenous dialysis fistulae.

## **STENTS**

### **Desirable stent characteristics**

1. Biocompatibility.
2. Metallurgic properties
  - \* LOW THROMBOGENICITY
  - \*CORROSION RESISTANCE
3. High radiopacity
4. Physical properties
  - \*High expansion ratio
  - \*Predictable expanded size.
  - \*Stable after delivery
5. Inexpensive.

Basic types – Self expanding / Balloon expanded  
Covered / Uncovered.

### **SELF EXPANDING STENT**

Works by

1. Spring action triggered by unloading the device from delivery catheter.
2. Thermal shape memory - Stent assumes configuration when warmed to body temperature

### **SELF EXPANDING STENTS**

1. Wall stent (Schneider)  
Flexible available in varying length

2. Nitinol spring coil stent: Made of nickel-titanium alloy; thermally triggered shape.

3. Giaturco Z stent (Cook)  
Stainless steel; zig zag wire

4. Fluency (Bard): Nitinol stent encapsulated with ePTFE, it has four radiopaque tantalum markers length of uncovered portion is ~2mm

.

### **BALLOON EXPANDABLE STENTS**

1. Palmaz stent (Johnson & Johnson).  
made of stainless steel.

Advantages: Ease and accuracy of delivery and more radiopaque than Wall Stent. Excellent compression resistance.

Disadvantages:

Lack of flexibility. Needs large sheath for introduction

2. Strecker stent.

High radiopacity, Non ferromagnetic; so MR compatible

3. Cordis stent

Made of Tantalum; flexible in undeployed state

4. Express SD Renal

5. Formula 418 - COOK

**COVERED STENTS** : Stents with a sleeve (cover) of thin expandable material.

Uses:

\*To exclude aneurysms, both true and false.

\*To exclude traumatic vessel disruption

\*In esophagus / trachea to cover fistulae

## **COVERED STENTS**

1. Fluency – Bard
2. Wall Graft Covering sleeve made of polyethylene terephthalate.
3. Bifurcated stent system also available for AAA repair.
4. medtronics and cooks covered stent grafts with excellent and captivia delivery system

### **Contraindications:**

1. Lesion within 0.5 cm of bifurcation or essential branch.
2. Patients in whom antiplatelets, anticoagulants or thrombolytic drugs are contraindicated.
3. Connective tissue disorder .
4. Mycotic vascular lesion.
5. Where lesion crosses a joint, Wall Graft cannot be used.

## **OBLITERATION PROCEDURE**

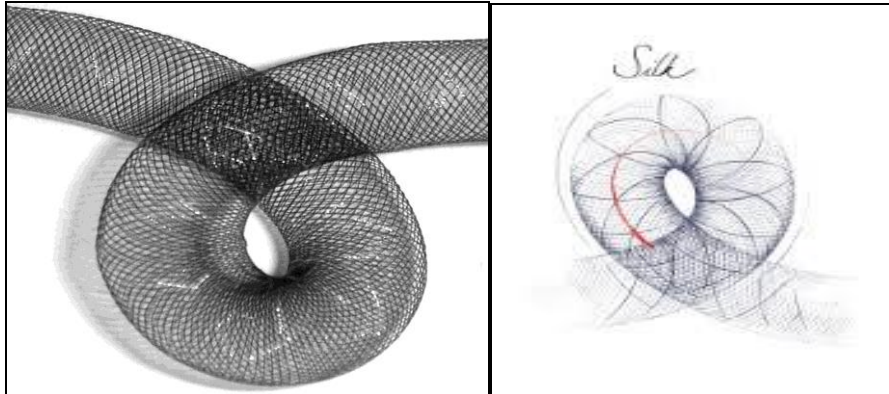
Otherwise referred to as ‘Therapeutic Embolisation’, using particulate materials delivered through micro catheters can be used in settings of acute bleeding from tumor vessels, vascular malformations, Aneurysms, Vascular tumors. Embolic materials in use include alcohol, metallic coils, gel foam,vascular plugs flow diverter etc.

### **Flow Diverter:**

New Endovascular treatment option for complex intracranial aneurysms. The endo-vascular management of intracranial aneurysms include coil embolization techniques, such as balloon assisted and stent assisted coiling, are targeted towards the aneurysm sac, but flow diverters are endovascular devices placed within the parent artery rather than the aneurysm sac Presently available flow diverters are

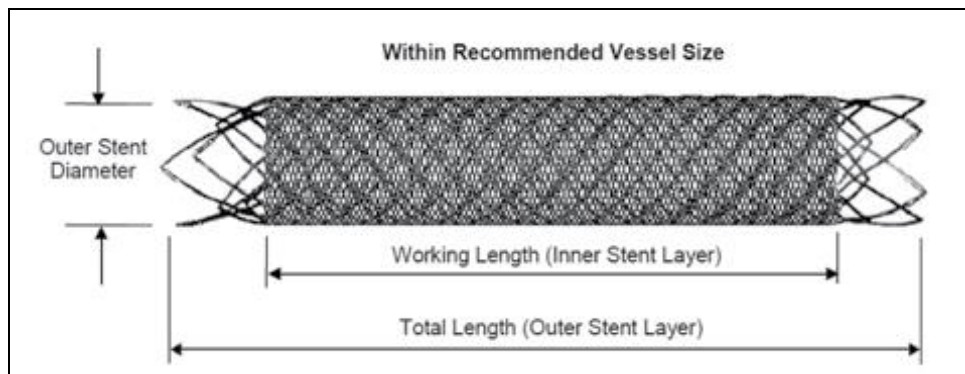
- **Pipeline embolization device** (PED ev3/ Covidien, Irvine, California)
- **Silk flow diverter** (SILK; Balt Extrusion, Montmorency, France)
- **Fred flow diverter**(FRED, Microvention, Terumo)

- **Surpass flow diverter**(SURPASS; Stryker Neurovascular, Fremont)

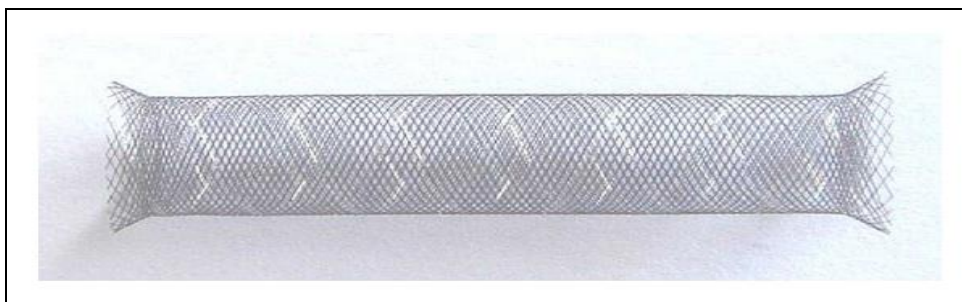


Pipeline flow diverter

Silk flow diverter



Fred system



Surpass flow diverter

### **Vascular Therapy**

This includes ‘thrombolytic therapy’ - meaning lysis of clotted blood inside important vessels and ‘Selective Chemotherapy’ - designed to administer ideal therapeutic concentrations to a tumor.

## **II. Non Vascular Interventions**

### **1. Biopsy Procedures**

Samples can be taken even from inaccessible sites of human body using special needle systems, under imaging guidance for diagnostic purposes.

### **2. Percutaneous Drainage Procedures**

Drainage of abscesses and collections can be done by percutaneous needle placement, which would otherwise need open surgery.

### **3. Percutaneous decompression**

Obstructions of stomach, Intestine, Renal System, etc. can be relieved through guided procedures

### **4. Removal of Foreign Bodies**

Metallic and non-metallic foreign bodies can be located and removed under X-Ray screening

## **ROTATIONAL ANGIOGRAPHY**

### **History**

- The first 3D image—Charles wheatstone-1830s
- The first 3D Cinema –Bwana Devil & House of wax-1952
- 3D Angiography –Cornelius -1972
- Its advanced clinical practice by Voigt in –1983

Rotational angiography (spin) is an acquisition mode designed to allow multiple views to be recorded from a single contrast injection, which saves in contrast, time and dose. Patient is situated in the isocenter of the C-arm of the angiographic unit C-arm rotates in continuous 200\* arc around the patient head in a period of 5sec 3D-RA can be of particular value to the neuroradiologist,

It can acquire and display three-dimensional volumes of the cerebral vessels during interventional procedures. An improved understanding of

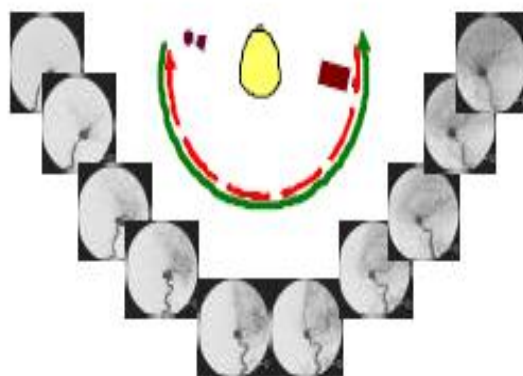
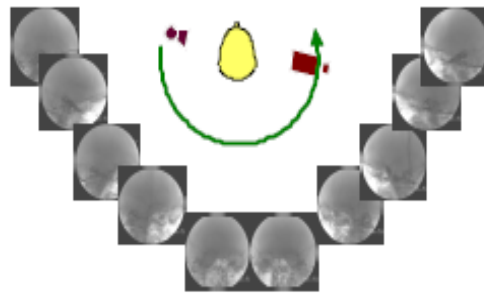
the three-dimensional vascular morphology positioning of catheters, coils, balloons, stents and glue.

A series of images is acquired while the C-arm performs a continuous rotation around the region of interest. In this way, a complete series of images is obtained in a range of projections. The projections may be obtained in the axial plane, or with cranial or caudal angulation.

The first sweep of the C-arm act as the mask-200\*

The return sweep of the C-arm in an arc of 200\* is performed While contrast is injected during the entire period of data acquisition.

The rotating C-arm is calibrated for correction of distortion as a result of deviations in the rotational path



## **Cerebral angiography**

Injection rate 2.5-3ml/S –Total 30-35 ml

## **Abdominal imaging**

Injection rate 10 ml/s-Total 150 ml

Speed of rotation Rate selected & Area of interest

Rotational speed-- 5,8,14 sec

Total number projection images is depend on the speed & frame rate

## **Acquisition**

Images are acquired in the rotational angiography mode over an angle of  $180^\circ$ . The run may be performed in one of three different angulations of the C-arm:  $-30^\circ$  cranial,  $0^\circ$  axial, or  $+30^\circ$  caudal, depending on the orientation of the object of interest.

Images are acquired at a frame rate of 12.5 frames per second, and a rotation speed of up to  $30^\circ$  per second. Allowing for the C-arm coming up to speed at the beginning of the run, and reducing speed at the end, The whole acquisition takes eight seconds, resulting in an average of 100 images per run.

# FEW EXAMPLES OF INTERVENTIONAL PROCEDURES ASSISTED

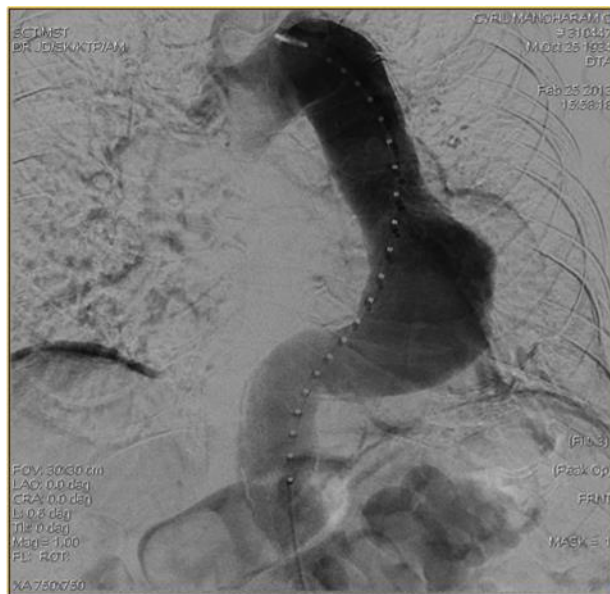
## Mechanical thromboctomy



Pre procedure

post procedure

## TEVAR



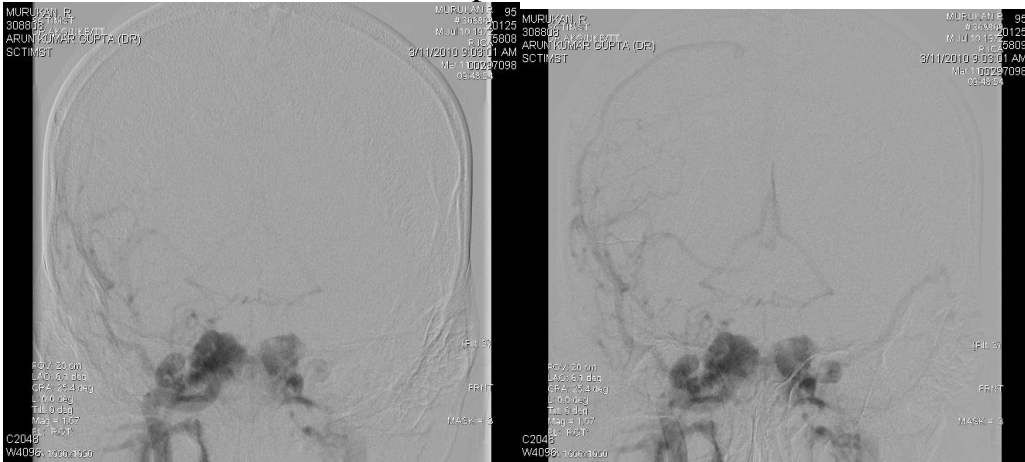
Before



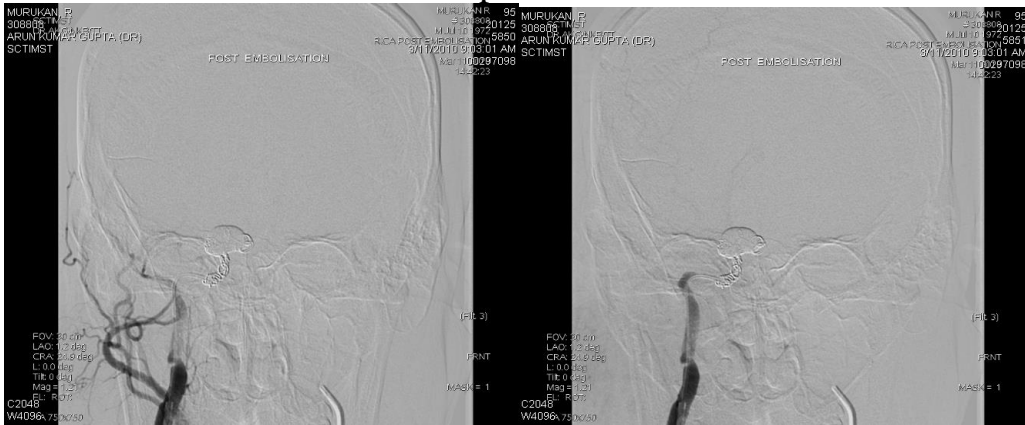
After

# CCF embolization

## Pre procedure



## Post procedure



## Angioplasty



Pre procedure

post procedure

# ANEURYSM COILING



Preprocedure

post procedure

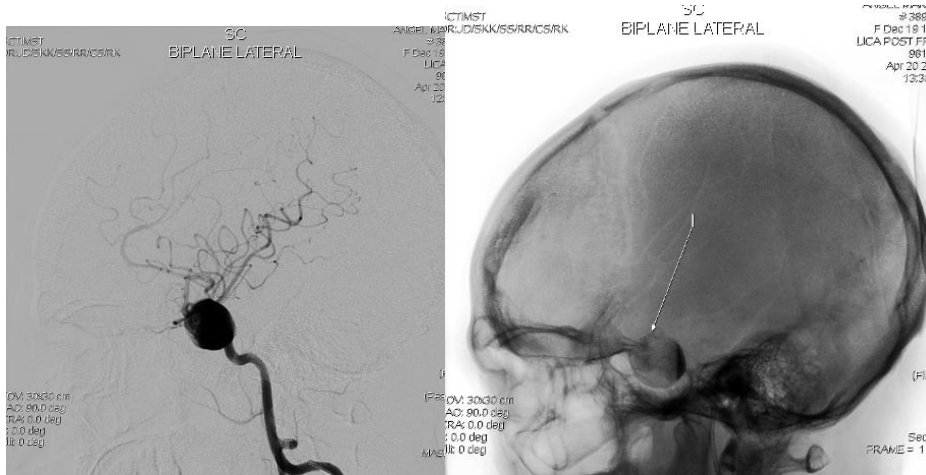
# EVAR



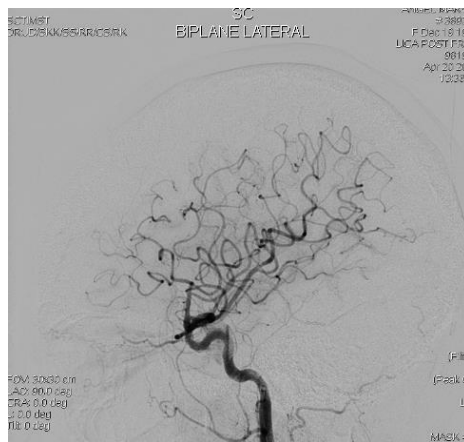
Pre procedure

post procedure

## FRED Flow diverter



**Pre procedure**

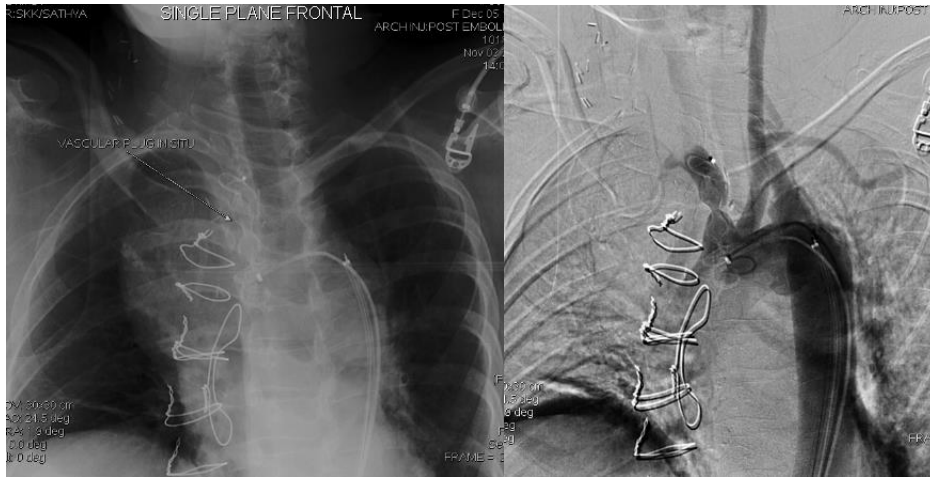


**Post procedure**

## Vascular plug

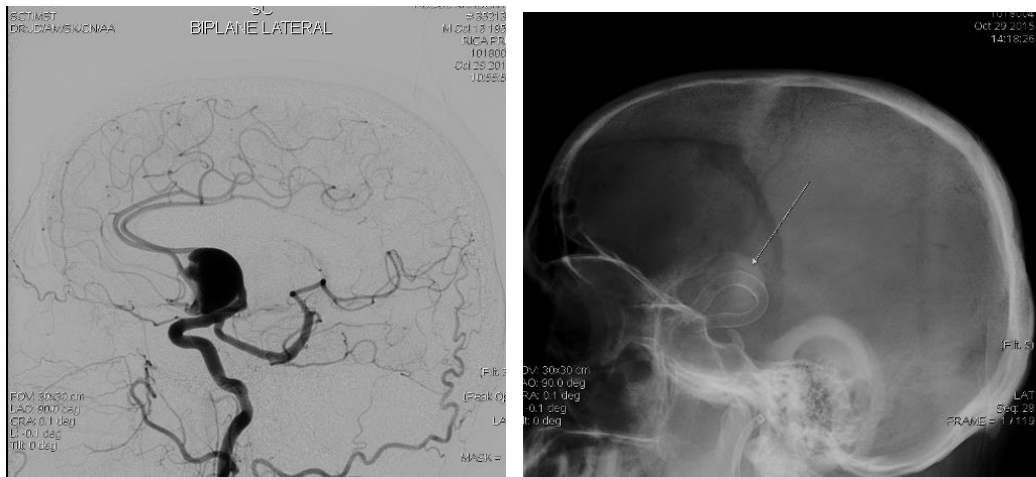


**Pre procedure**

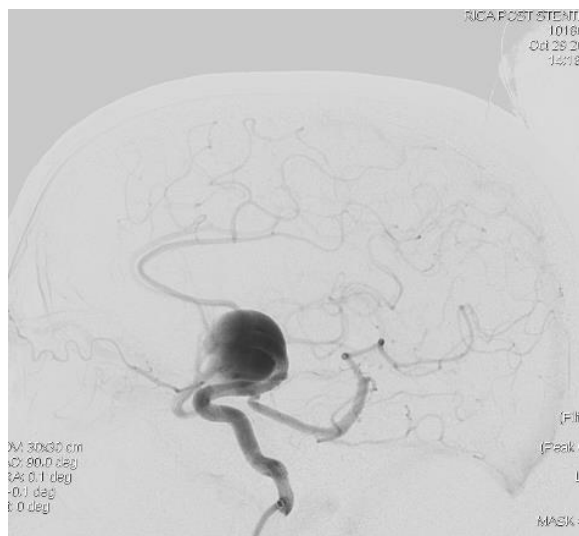


**Post procedure**

**Pipeline flow diverter**



**Pre procedure**



**Post procedure**

*PROJECT*

*Comparative study of perfusion analysis in tumor(HGG &LGG) cases with different softwares LEONARDO Multi Modality Workstation and Myrian soft wares(nordicICE)*

# **INDEX**

- Aim of the study
- Basic science and review of literature
- Materials and methods
- Results
- Discussion
- Conclusion
- References

### **AIM OF THE STUDY**

Comparative study of perfusion analysis in tumor(HGG &LGG) cases with different softwares LEONARDO Multi Modality Workstation and Myrian soft wares(nordicICE)

## **BASIC SCIENCE AND REVIEW OF LITERATURE**

Perfusion describes the circulation of blood through a vascular bed within living tissue, so that oxygen, nutrients, and waste products may be exchanged via capillary walls. MR perfusion imaging refers to several recently developed techniques used to noninvasively measure cerebral perfusion via assessment of various hemodynamic measurements such as cerebral blood volume, cerebral blood flow, and mean transit time. These techniques have great potential in becoming important clinical tools in the diagnosis and treatment of patients with cerebrovascular disease and other brain disorders. Potential applications include the evaluation of tissue at risk after acute stroke, noninvasive histologic assessment of tumors, evaluation of neurodegenerative conditions such as Alzheimer's disease, as well as assessment of the effects of drugs used to treat these conditions.

## **DYNAMIC SUSCEPTIBILITY CONTRAST ENHANCING MRI**

DSC is based on the detection of the first passage of a bolus of non diffusible paramagnetic contrast media DSC MRI approach offers a window on tissue perfusion. Specific pulse sequence have proven to be sensitive to tissue perfusion and blood volume ,permitting the functional aspects of tumor neovascularity to be assessed invivo in a non invasive and repeatable way .The contrast in such MR images is largely based on local magnetic field

inhomogeneities generated in extra vascular space by the passage of the contrast material through the vasculature. These changes in the local magnetic field can be measured as signal changes on MR imaging. Ultrafast imaging techniques, such as echoplanar and spiral MR imaging enable the accurate measurement of rapidly varying signal changes that are due to the first pass of the bolus with adequate temporal resolution (<2 sec for coverage of the entire brain). Signal–time course data can then be converted to relative tracer tissue concentration–time course data. Tracer concentration–time curves can then be analyzed to determine various tissue hemodynamic parameters, such as tissue blood volume, (CBV) blood flow (CBF), transit time (TTP), and mean transit time (MTT).

### Cerebral Blood Volume

Cerebral blood volume refers to the volume of blood in a given region of brain tissue, commonly measured in milliliters per 100 g of brain tissue.

### Cerebral Blood Flow

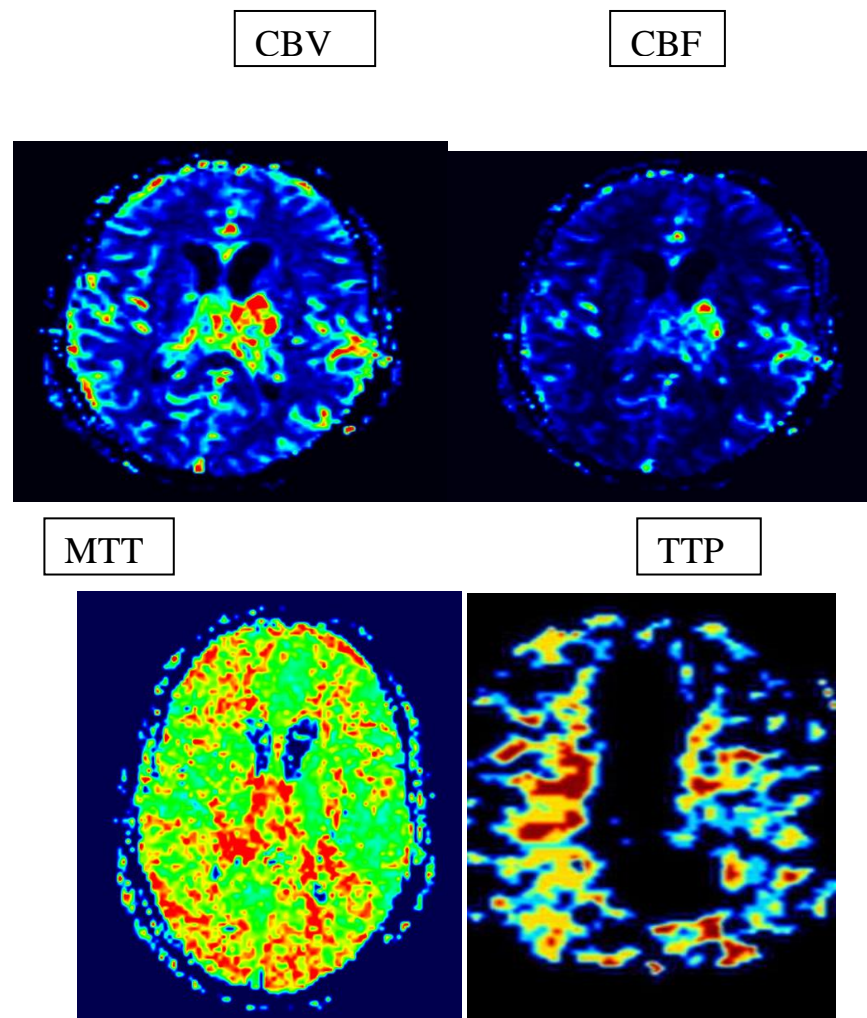
Cerebral blood flow refers to the volume of blood per unit time passing through a given region of brain tissue, commonly measured in milliliter per minute per 100 g of brain tissue.

### Mean Transit Time

Mean transit time refers to the average time it takes blood to pass through a given region of brain tissue, commonly measured in seconds.

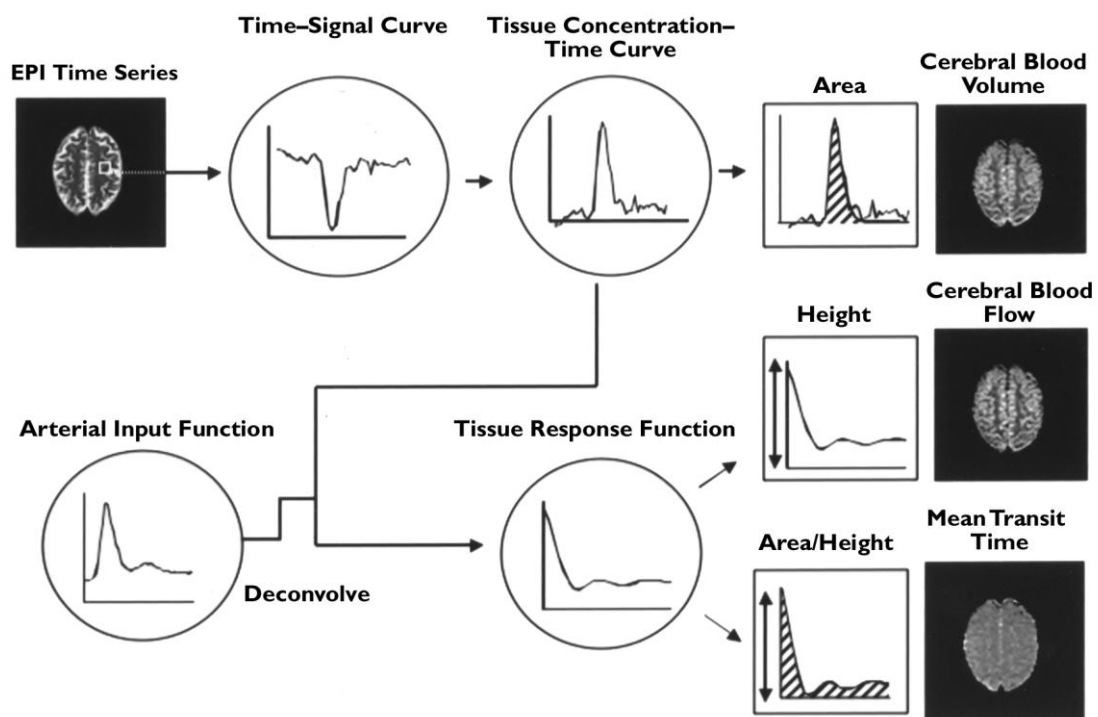
### Time To Peak

Time to peak refers to the time it takes for an IV-injected bolus of contrast material to arrive at a given region of the brain, also commonly measured in seconds



These parameters are dependent on the specific features of the bolus injection, including the amount of contrast material injected, the injection rate, and the paramagnetic properties of the contrast agent. Determination of relative cerebral blood volume from tracer concentration–time data is straightforward and robust, accomplished by integrating the area under the tracer concentration-time- curve. This integration may be performed on the curve data points themselves or on an analytic fit of the data points. The processing techniques

require deconvolution of an arterial input function from tissue concentration–time data to the true brain clearance, or mean transit time through the cerebral capillary bed (mean transit time). Cerebral blood volume, calculated by integrating the area under the deconvolved tissue concentration–time curve, is then divided by mean transit time to obtain cerebral blood flow. Alternatively, the initial height of the deconvolved tissue concentration–time curve may be taken as the cerebral blood flow, and the mean transit time may then be calculated as the ratio of cerebral blood volume to cerebral blood flow.



## CEREBRAL GLIOMAS

Cerebral gliomas are the most common and devastating primary brain tumors. Although these tumors are traditionally considered to be arising from normal glial cells, the origin of the tumors remains undetermined. The World Health Organization (WHO) published a classification system of central nervous system tumors in 1979 and subsequently revised the system in 2000 and 2007. In 2007 system, the major neuroepithelial tumors include astrocytic, oligodendroglial, oligoastrocytic, ependymal, and choroid plexus tumors. The grading of gliomas mainly relies on histological features, including cellularity, nuclear atypia, mitotic activity, vascularity, and necrosis, observed on light microscopy with the aid of immunohistochemistry. Among the gliomas, astrocytic tumors are the most common and usually divided into circumscribed and diffuse tumors. The circumscribed tumors are generally in lower grade occurring in young patients while the diffuse tumors are the most common cerebral tumors in adults belonging to WHO grades, II, III, and IV. As the names imply, circumscribed tumors, such as pilocytic astrocytoma (WHO grade I), are localized with distinct margin and diffuse tumors are notorious in their propensity to infiltrate surrounding parenchyma, irrespective of the grades. The WHO grade II astrocytomas consist of diffusely infiltrative and well-differentiated fibrillary, protoplasmic, or gemistocytic astrocytes with increased cellularity and nuclear atypia but without mitoses, endothelial proliferation, or necrosis. The WHO grade III astrocytomas, anaplastic astrocytomas, show higher cellularity and nuclear atypia than the WHO grade II tumors with mitoses but without endothelial proliferation or necrosis. The WHO grade IV

astrocytomas, glioblastoma (formerly, glioblastoma multiforme), are the most common form of astrocytic tumors occurring in the sub cortical white matter of the cerebral hemispheres. Perfusion MRI is useful in the preoperative assessment of the histopathological grade of gliomas by analyzing rCBV and rCBF

## MATERIALS AND METHODS

21 perfusion data collected retrospectively from our institute out of this 11 where HGG and 10 cases are LGG within the age limit of 20 to 60 years These datas are transferred into leonardo and myrian soft wares and post processed. Data acquisition by 1.5 T MR system – MAGNETOM Avanto Total Imaging Matrix(76x18); Siemens, Erlangen, Germany) using a 12-channel phased-array head coil.

MAGING PARAMETERS: Name: ep2d\_perf  
Sequence type: GRE-EPI

<i>TR: 1850ms</i>	<i>TE: 43ms</i>	<i>TA: 1.40min</i>
<i>Number of slices: 21</i>	<i>Slice thickness: 5mm</i>	<i>Distance factor: 30%</i>
<i>FOV read: 230mm</i>	<i>FOV phase: 100%</i>	<i>Voxelsize: 1.8x1.8x5mm</i>
<i>Base resolution: 128</i>	<i>Phase resolution: 100%</i>	<i>Average: 1</i>
<i>Phase encoding direction R&gt;&gt;L</i>	<i>Phase oversampling: 0%</i>	<i>Concatenation: 1</i>
<i>Sequence type: GRE-EPI</i>	<i>Multi-slicemode: Interleaved</i>	<i>Echo spacing: 0.77ms</i>
<i>Coil elements: HE1-4</i>	<i>Fat sat</i>	<i>EPI factor: 128</i>
<i>Relative SNR: 1</i>	<i>Noise level: 40</i>	<i>Measurement: 50</i>
<i>Measurements: 50</i>		<i>Fat Sat.</i>

## Objectives:

- Analysis of rCBV and rCBF values of LGG&HGG in Leonardo and nordicICE by Myrian

➤ Comparison between Two different soft wares

### SOFTWARES DETAILS

- SIEMENS SYNGO – MULTIMODALITY WORKSTATION  
Perfusion processing module:PERF MR
- Nordic ICE(nordic image control and evaluation)-  
version:2.3.12

### **PROCEDURE**

All patient underwent conventional MRI with T1, T2 and post-contrast T1 sequences. Perfusion imaging was performed using the T2\* weighted gradient echo planar imaging sequence In order to obtain a pre-contrast baseline,the first 10 acquisitions were performed before the administration of the contrast agent. At the end of the 8th image volume acquisition, an intravenous bolus injection of 0.2 mmol kg of body weight of gadolinium–diethylene triamine penta-acetic acid at a flow rate of 5-ml s followed by a 20-ml saline flush was applied.

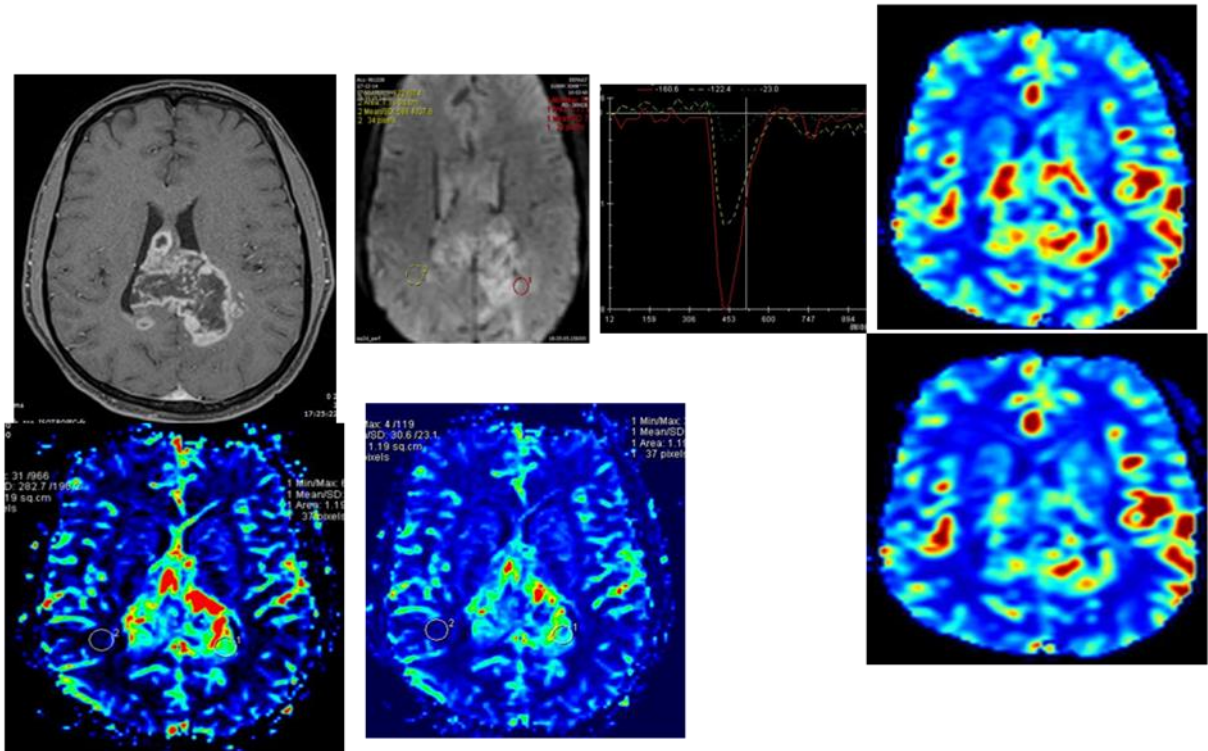
T2\* weighted DSC-MR images were transferred to separate MRI workstation (Leonardo; Siemens) & myrian for generating CBV,CBF maps.Circular ROIs were drawn on the solid tumor area and measured CBV values were also calculated from the contra lateral normal-appearing white matter.rCBV was calculated as the ratio of maximum CBV from the tumorarea to CBV from the contra lateral normal area.Similarly measure CBF value from the tumor area and corresponding contra lateral white matter rCBF is calculated as the ratio of this two

## **RESULT**

COMPARISON B/W LGG AND HGG IN TWO  
SOFTWARES

# Case 1 HGG

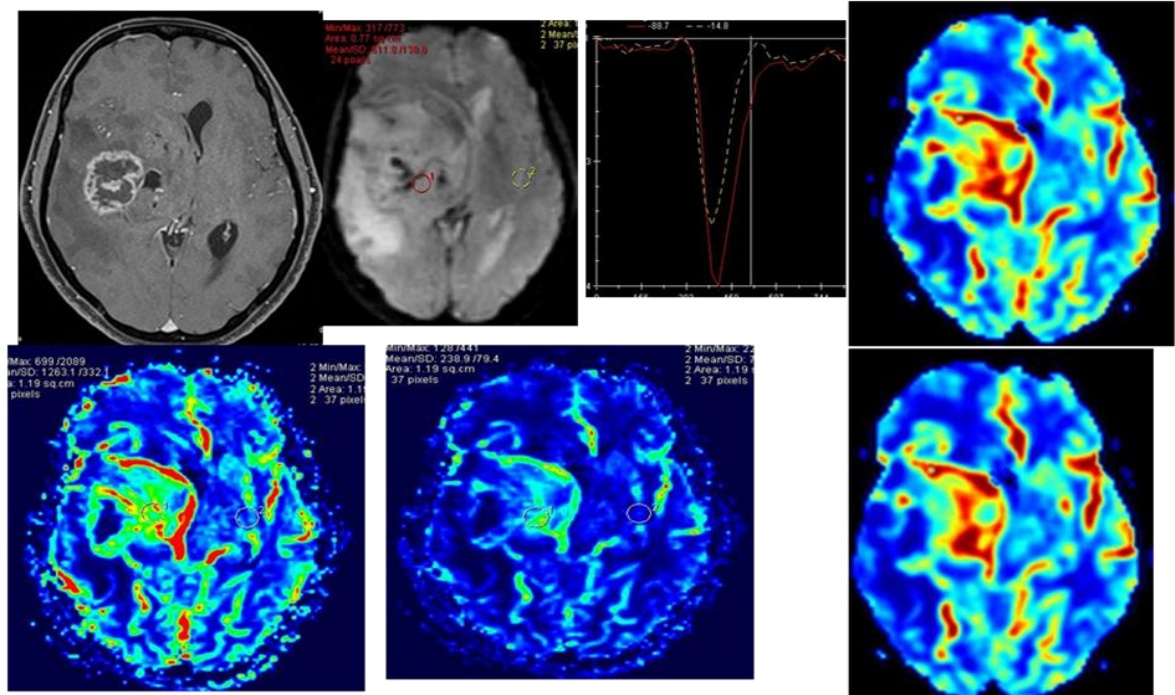
Case 1



cbv&cbf(Leo)

cbv&cbf(myrian)

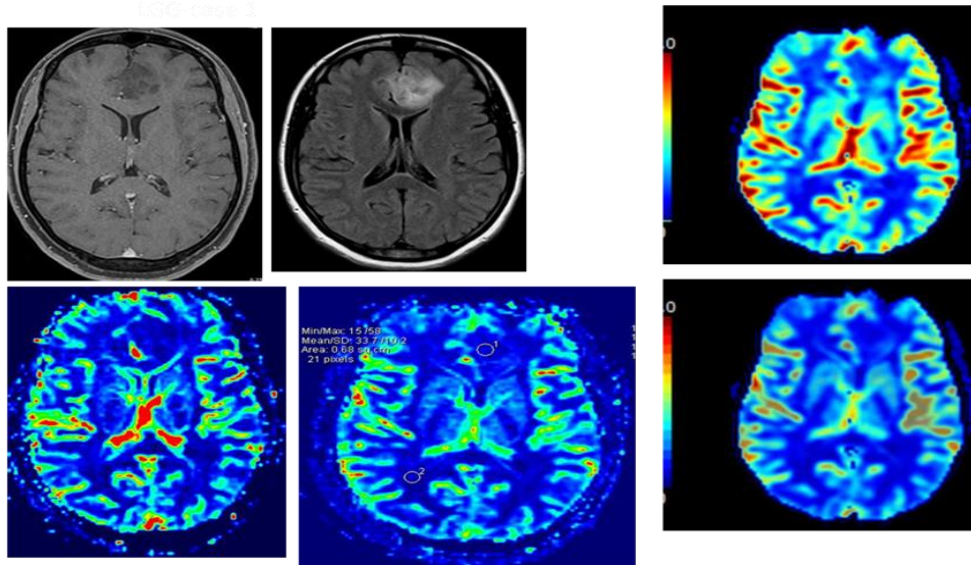
Case 2



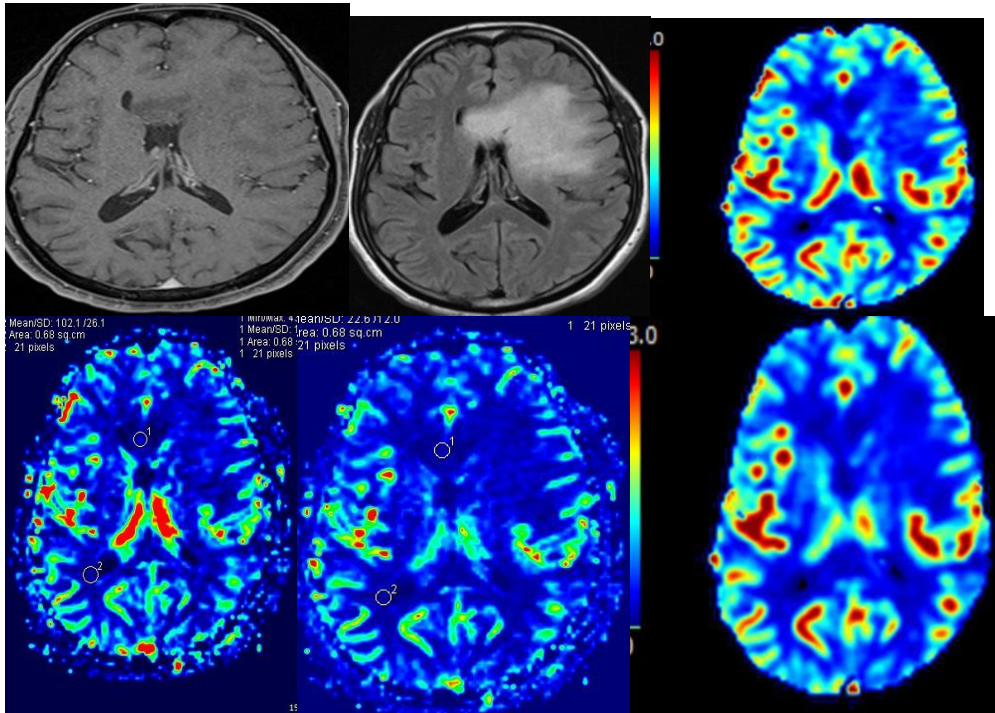
CBV&CBF(leo)

CBV&CBF(myrian)

# Case 1 LGG



# Case 2



CBV&CBF(Leo)

CBV&CBF (Myrian)

Sl No	Tumor type	rCBV (LEONARDO)	rCBV (MYRIAN)	rCBF (LEONARDO)	rCBF (MYRIAN)
1	LGG	1.28	1.2	1.1	1.1
2	LGG	1.1	1.6	1.2	1
3	LGG	1.15	1.8	1.5	1.7
4	LGG	2.	2.	2	0.88
5	LGG	0.97	0.33	0.79	0.39
6	LGG	1.5	1.8	1.2	1.8
7	LGG	0.92	0.98	0.82	1.0
8	LGG	0.88	0.63	0.83	0.72
9	LGG	0.34	0.61	0.44	0.48
10	LGG	1.1	1.1	1.3	1

<i>Sl No</i>	<i>Tumor type</i>	rCBV (LEONARDO)	rCBV (MYRIAN)	rCBF (LEONARDO)	rCBF (MYRIAN)
1	HGG	8.6	4.6	6.9	4.8
2	HGG	4.9	2.75	5	2.70
3	HGG	8	7	7.1	7
4	HGG	8.6	7.2	8.4	6.32
5	HGG	3.1	2.3	2.7	2.43
6	HGG	6.5	5.2	3.9	3.7
7	HGG	3.9	3.71	3.7	3
8	HGG	6.7	2.3	3.8	1.82
9	HGG	3.6	3.4	3.1	2.9
10	HGG	4.28	1.9	2.37	1.57
11	HGG	3.16	1.43	2.63	1.1

HGG&LGG myrian & Leonardo

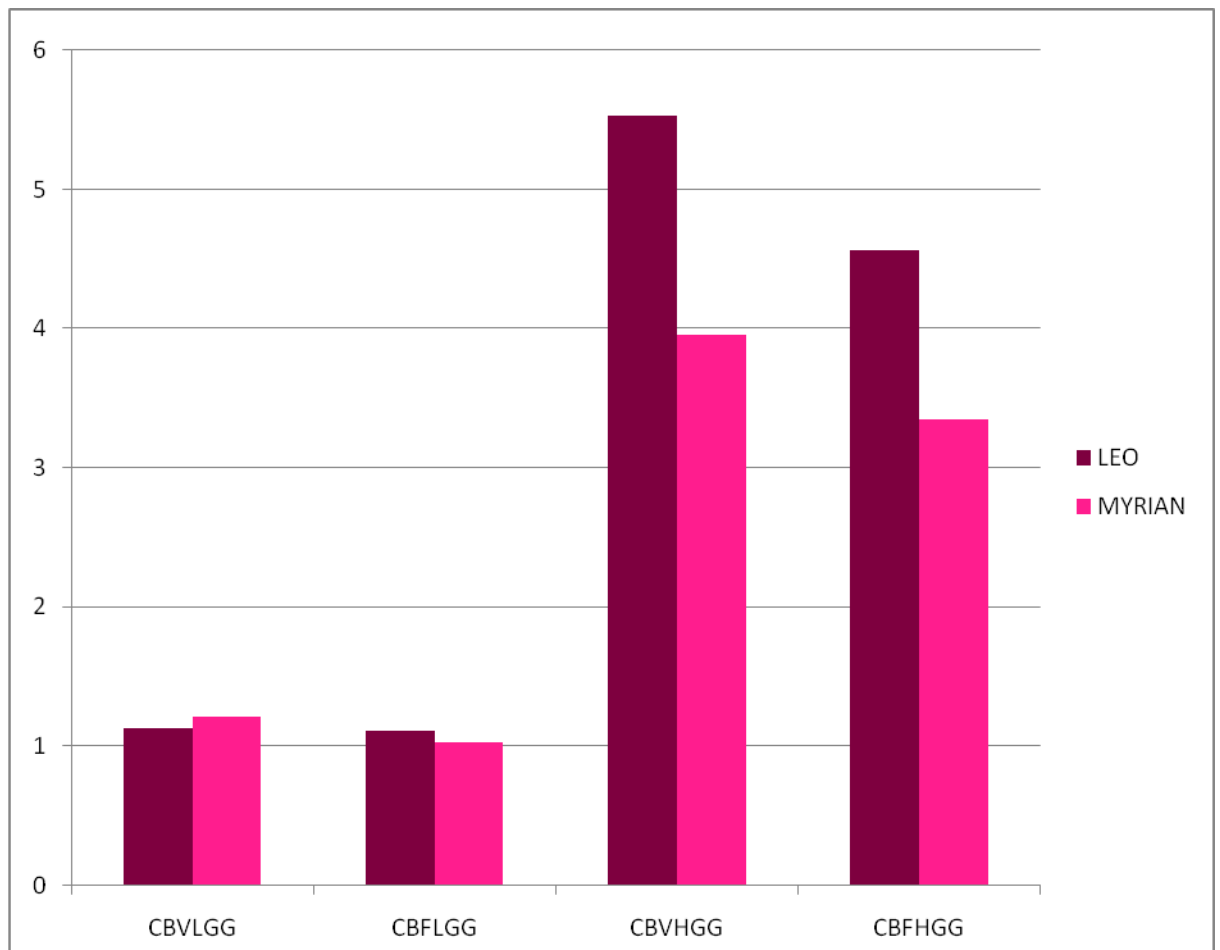
		Sum of Squares	df	Mean Square	F	Sig.
cbvmyrian	Between Groups	39.626	1	39.626	18.852	.000
	Within Groups	39.938	19	2.102		
	Total	79.564	20			
cbv leo	Between Groups	101.560	1	101.560	37.708	.000
	Within Groups	51.174	19	2.693		
	Total	152.734	20			
cbf myrian	Between Groups	28.395	1	28.395	13.403	.002
	Within Groups	40.253	19	2.119		
	Total	68.648	20			
cbf leo	Between Groups	62.425	1	62.425	24.547	.000
	Within s	48.318	19	2.543		

LGG in leonardo and myrian

		Sum of Squares	df	Mean Square	F	Sig.
CBVLGG	Between Groups	.033	1	.033	.126	.727
	Within Groups	4.682	18	.260		
	Total	4.715	19			
CBFLGG	Between Groups	.038	1	.038	.186	.671
	Within Groups	3.662	18	.203		
	Total	3.700	19			

HGG in leonardo and myrian

		Sum of Squares	df	Mean Square	F	Sig.
CBVHGG	Between Groups	13.588	1	13.588	3.144	.091
	Within Groups	86.429	20	4.321		
	Total	100.018	21			
CBFHGG	Between Groups	8.065	1	8.065	1.900	.183
	Within Groups	84.909	20	4.245		
	Total	92.974	21			



Diffrenciating LGG&HGG by analysing rCBV&rCBF both LEONARDO and nordicICE are good In LGG the rCBV and rCBF values obtained in both LEONARDO and nordicICE are almost same and it is stastitically corelated by using ANNOVA In HGG the rCBV and rCBF values in LEONARDO and nordicICE shows variations but it is statistically not significant

## DISCUSSION

The study is performed to analyze rCBV and rCBF maps in high grade and low grade glioma patients. The data sets are processed with the help of two different softwares, Siemens Syngo Multimodality Workstation and nordiceICE by Myrian. Both Leonardo and Myrian gives almost similar CBV, CBF, MTT and TTP results. In addition to this Myrian is having an additional parametric map, K2 map (permeability map). Both softwares use same deconvolution technique. Myrian have some advanced options like vessel removal, contrast agent leakage correction and gamma varriate fitting.

I have observed post processing of datas Myrian is fast compared to Leonardo. apart from this Myrian can process multiple dataset at a time but in Leonardo only one dataset can be processed at a time. Automatic and manual arterial input function is possible in Myrian but in Leonardo only manual arterial input function selection is possible.

Measuring of rCBV and rCBF values from the archived data is possible in Leonardo but not from Myrian, For getting the same in Myrian we need to save the images as gray scale instead of colour map. I found tht saved colour map images from Myrian has giving different values when compared to normal gray scale images. nordicICE provides flexibility for the research-oriented user who wants to explore and take advantage, but in Leonardo modifications are not allowed. Myrian is a multi vendor supporting plat form, Leonardo is vendor based plat form. Differentiation of low grade and high grade glioma by analyzing rCBV and rCBF, both Leonardo and Myrian are

good .In low grad glioma tha values obtained from Leonardo and Myrian are almost same but in high grade glioma the values obtained from both softwares shows little variations but it is statistically not significant .

### SOFTWARE COMPARISON

Features	NordicICE	Siemens Syngo
Vendor	Nordic ICE	Siemens Syngo
Name	Nordic ICE	Perf MR
Source	paid Software	Vendor based(SIEMENS)
User Interface	User friendly	User Friendly
Graphic Display	good	Excellent
Processing Steps	Easy	Easy
Processing Time	fast	Time consuming
Input data type	Dicom(Dynamic perfusion data)	Dicom(Dynamic perfusion data)
AIF-option	Automatic &Manual	Only Manual
No of derived maps	5-6	4
Types of maps	CBV,CBF,MTT,TTP,K2 map	CBV,CBF,MTT,TTP
Mirror ROI	possible	Not possible
deconvolution	SVD	SVD
Supporting data	vendor neutral(all vendors)	Vendor specific
processing	Multiple data set at a	One data set at a

	time	time
Vessel removal	possible	Not possible
Contrast leakage correction	possible	Not possible
Gamma variate fitting	possible	Not possible
Drag&drop option	possible	Not possible
software	Windows based	Windows
Noise correction-threshold	Possible	Not possible
Imageoutputtype	Dicom ,JPEG	RGB ,DICOM
Out put image ROI evaluation (colour)	Not correct	possible
Secondary capture	Further evaluation not possible	possible
Data exporting	Easy steps	More steps

## CONCLUSION

- Differentiating LGG&HGG by analysing rCBV&rCBF both LEONARDO and nordicICE are good
- In LGG the rCBV and rCBF values obtained in both LEONARDO and nordicICE are almost same and it is statistically correlated by using ANNOVA
- In HGG the rCBV and rCBF values in LEONARDO and nordicICE shows variations but it is statistically not significant
- Both soft wares are userfriendly

## REFERENCE

- nordicICE Manual
- Siemens Syngo Manual
- Edelman. Magnetic Resonance Imaging.
- Catherine Westbrook. MRI at a glance
- J.R. Petrella, J.M. Provenzale  
MR perfusion imaging of the brain: techniques and applications
- E.A. Knopp, S. Cha, G. Johnson, A. Mazumdar, *et al.*  
Glial neoplasms: dynamic contrast-enhanced T2\*-weighted MR imaging
- B. Hakyemez C. Erdogan I. Ercan N. Ergin S. Uysal S. Atahan et al.  
High-grade and low-grade gliomas: differentiation by using MR perfusion imaging

## APPENDIX

<i>DSC</i>	: <i>Dynamic susceptibility contrast</i>
<i>CBV</i>	: <i>Cerebral blood volume</i>
<i>CBF</i>	: <i>Cerebral blood flow</i>
<i>MRI</i>	: <i>Magnetic Resonance Imaging</i>
<i>FOV</i>	: <i>Field Of View</i>
<i>ROI</i>	: <i>Region Of Interest</i>
<i>rCBV</i>	: <i>Relative blood volume</i>
<i>rCBF</i>	: <i>Relative blood flow</i>
<i>AIF</i>	: <i>Arterial input function</i>
<i>LGG</i>	: <i>Low grade glioma</i>
<i>HGG</i>	: <i>High grade glioma</i>