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

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

CERTIFICATE

This is to certify that **Mohammed Ramshad K T** has participated in Interventional cases and Imaging Cases during the period January 2014 to October 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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Trivandrum, Kerala INDIA.

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.

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 fore most, 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 extent my heartful 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, junior DAMITS and my colleagues for their co-operation at work place and in studies.

COURSE CURRICULUM

POSTING	NUMBER OF MONTHS
DSA	7
MRI	8
CT	8
CARDIOLOGY AND BME	15 DAYS

Every Thursday 8:00 AM to 9:00 AM – Seminar

SEMINARS PRESENTED

1. Interventional radiology procedures
2. Contrast media ,CT,MRI,US
3. CT image Reconstruction technique
4. MRI image Reconstruction technique
5. CT Angiographic Techniques.
6. Routine pulse sequence in MRI
7. MR Spetroscopy
8. Cardiac MRI
9. Fow and haemodynamic in MRI
10. Materials used in Interventional Radiology.

PRACTICAL DATA SHEET

A) Cases done in OPD X-Ray.

Equipment : SIEMENS Heliophos 4M 500mA.
No of Cases : More than 1800 (Chest, Spines, Pelvis, and Extremities)

B) Portable X-Ray.

Equipment : SIEMENS Simox D 40mA. GE genius 60mA
No of cases : About 2600 including chest, abdomen, skull and CV Jn.

C) CT Scan.

Equipment : Brilliace iCT 256 slice/ GE light speed dual

No of Cases : Head	-	3040
Chest	-	600
Abdomen	-	350
CT Angiogram	-	1200
Cardiac CT	-	59

D) CT Interventional Procedures.

CT Guided Biopsies	:	15
Bone Biopsies	:	7
Stereotactic Studies	:	26
Laser Ablations	:	3

F) Magnetic Resonance Imaging.

Equipments:

1. **SIEMENS Magnetom Avanto Tim 76 x 18 - 1.5 TESLA**
2. **GE Discovery MR 750w - 3 TESLA**

No of Cases Done :

Brain	-	1980
Cervical Thoracic & Lumbar Spines	-	1400
Stereotactic MRI (Pallidotomy & Biopsies)	-	28
Musculo Skeletal System (Pelvis, Hip joint, Knee, Shoulder joint etc.)	-	65

Cardiac imaging	-	120
Abdomen and Chest	-	35
MR Angiograms	-	270

H) <u>D S A Lab.</u>

Equipment : **GE innova 3131**.

No of Cases Assisted:

4Vessel Angios	**:**	460
Aortograms	:	55
IVDSA	:	4
Peripheral Angios	:	42
Spinal Angios	:	64
Coronary angio	:	4
Bronchograms	:	4
PTBD	:	44
WADA Test	:	23
Ba Studies	:	25

Interventional Procedures:

Angioplasty	:	154
PTCA	:	6
PDA Coiling	:	8
Embolization (Fill, Sqid ,Onyx ,Glue & Particle)	:	98
Coil Embolization	:	63
Chemo. Embolization	:	25
Thrombolysis	:	12
Stenting	:	60
Tracheal Stenting	:	1
PLDD	:	6
Vertibroplasty	:	2
TGN laser ablation	:	9
Flow diverter	:	7
EVAR	:	3
TEVAR	:	7

SEMINARS PRESENTED

10. MULTIDETECTOR AND DUAL SOURCE CT; TECHNICAL ASPECTS AND APPLICATIONS
11. MRI SAFTEY
12. IMAGING PARAMETERS IN MRI
13. MR INSTRUMENTATION, COILS & GRADIENT SYSTEM
14. RADIATION PROTECTION
15. MRI GRADIENT ECHO
16. CATH LAB MATERIELS
17. MRI 1.5T & 3T
18. K- SPACE & PARELLEL IMAGING

10.DIFFUSION AND DTI

11.FMRI & BOLD

12. BODY IMAGING IN MRI

INDEX

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 - 200μS
- 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

Gradient specifications

- Max Gradient amplitude - 44 mT/m
- Min rise time - 220μS
- 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 – ±250kHz

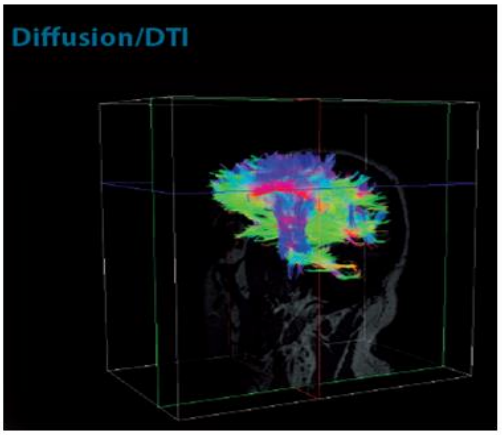
NEW POST PROCESSING SOFTWARE

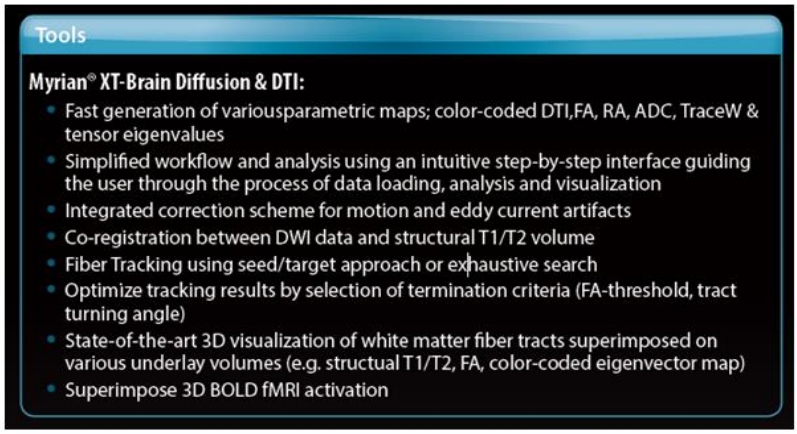
MYRIAN – INTRASENSE

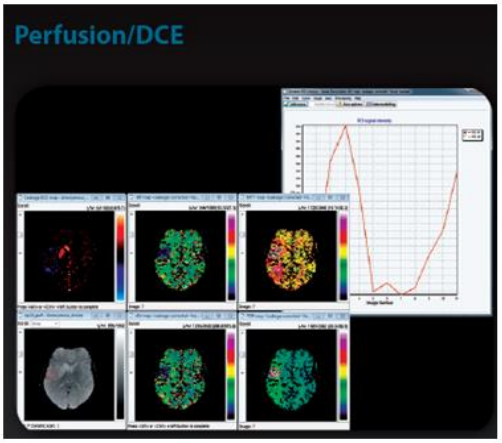
- Module based solution for Diffusion/DTI , Perfusion/DCE imaging
- Windows based software
- Vendor – neutral application , process image from any modality manufacture

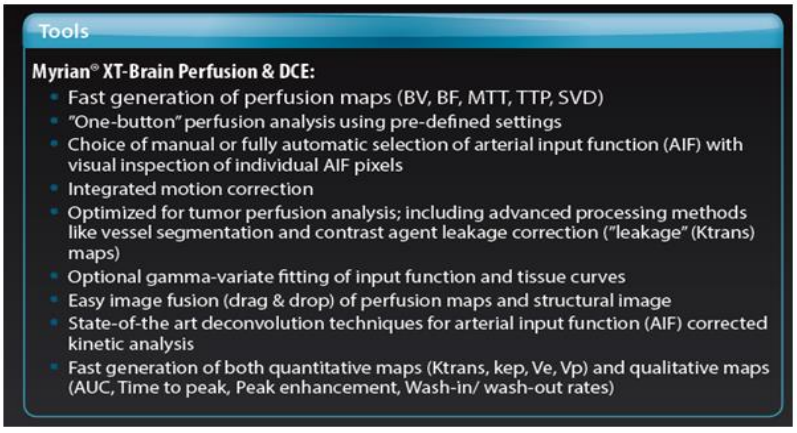
XT- BRAIN nordic ICE

Provide flexibility for research oriented work





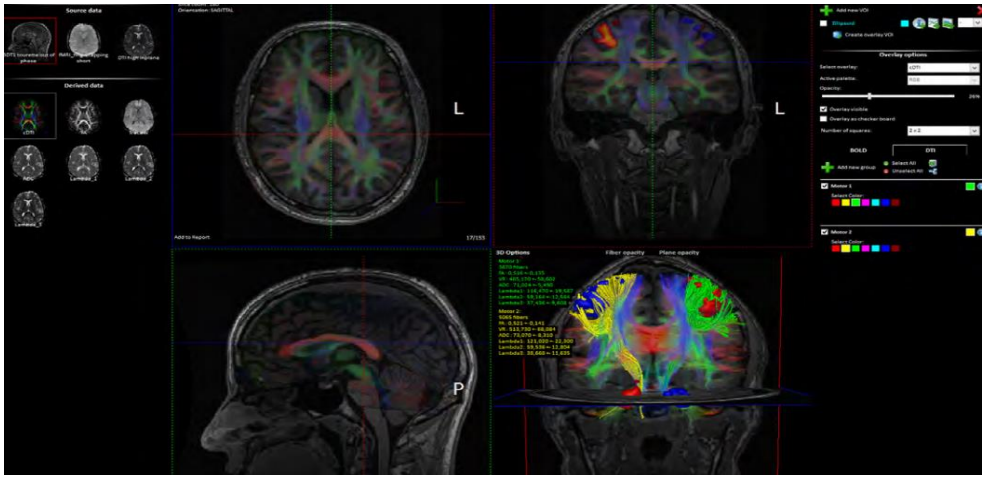




nordic Brain EX :

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

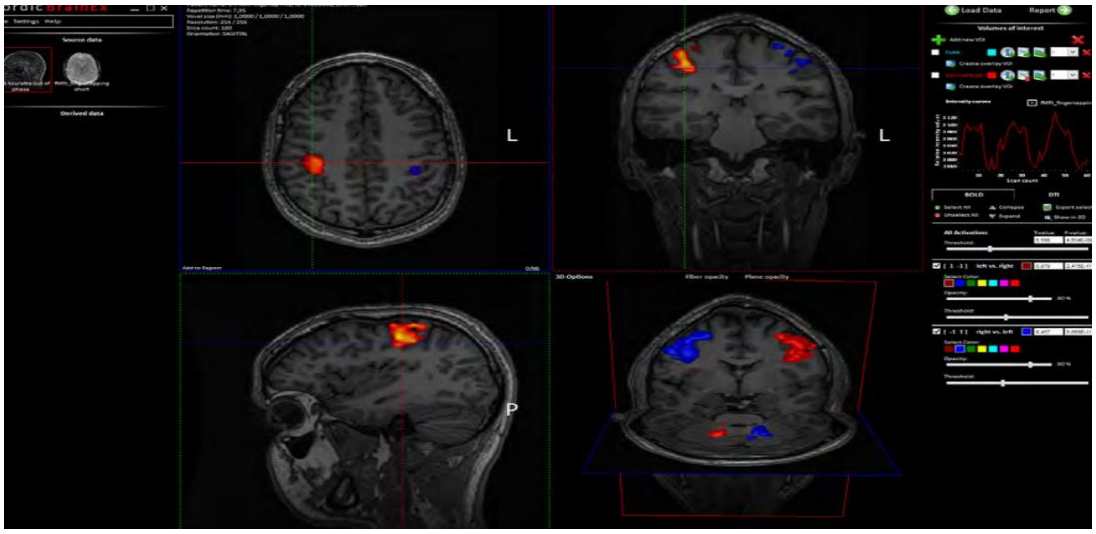
- DTI Fiber tracking Module



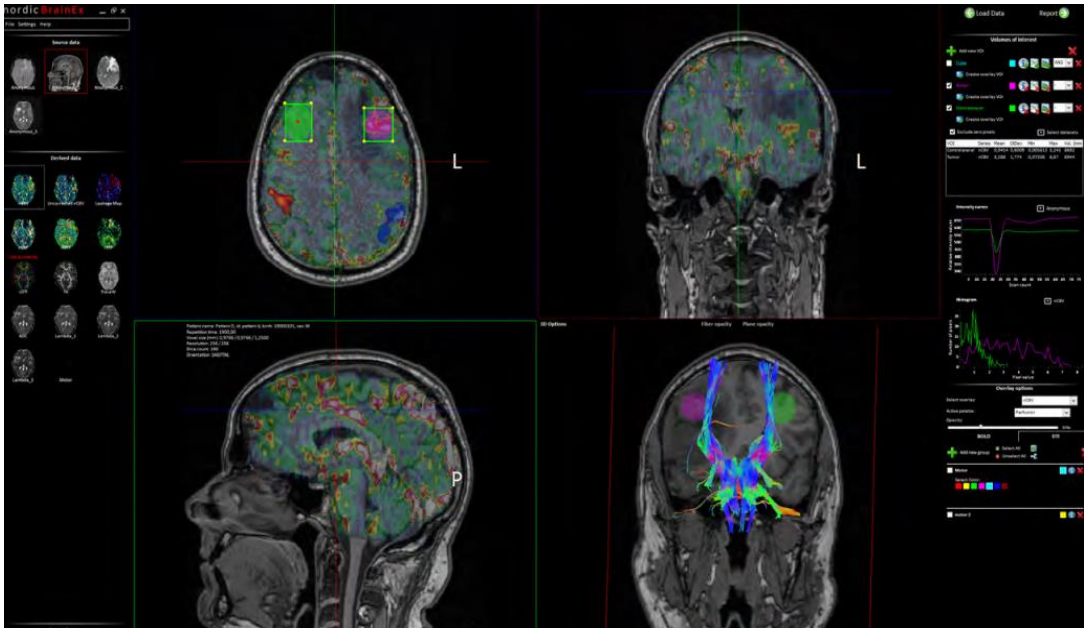
Preprocessing - Motion Correction, Eddy current correction , Smooth , Average ,Adjust noise level

Fibertracking – multiple VOI , AND OR & NOT option

- BOLD fMRI module



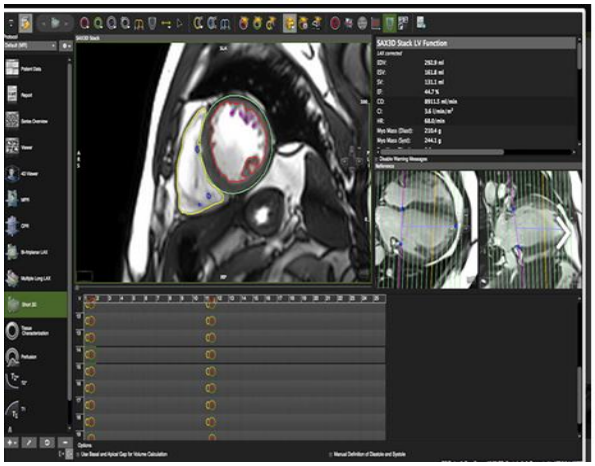
- Perfusion/DSC module

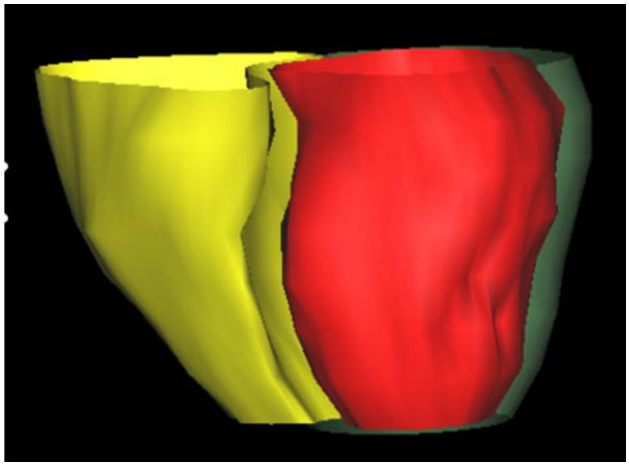


- Possible to combine the results from BOLD , DSC PERFUSION and DTI

CIRCLE CARDIO VASCULAR IMAGING

LV/RV FUNCTION

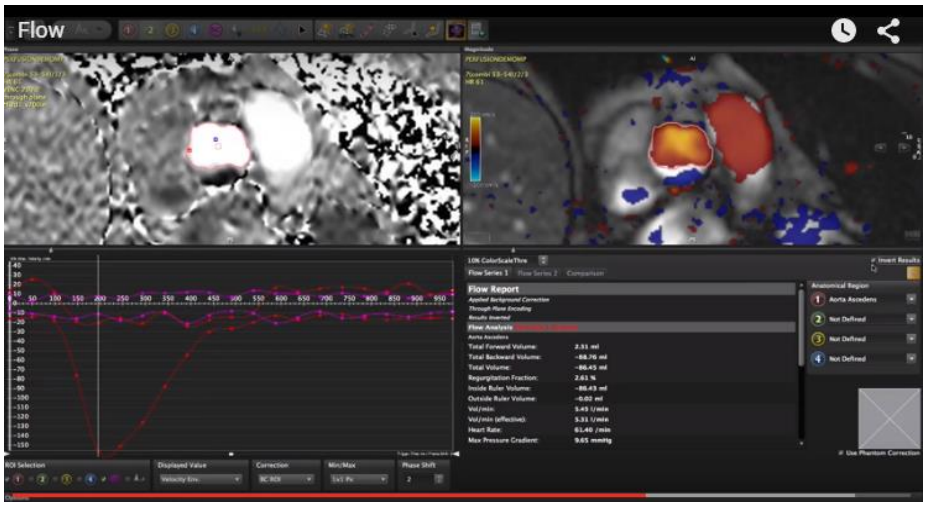




- Left and right atrial volumetry [disk area summation & area length method]
- Polar maps offering customizable segmentation including AHA segmentation model

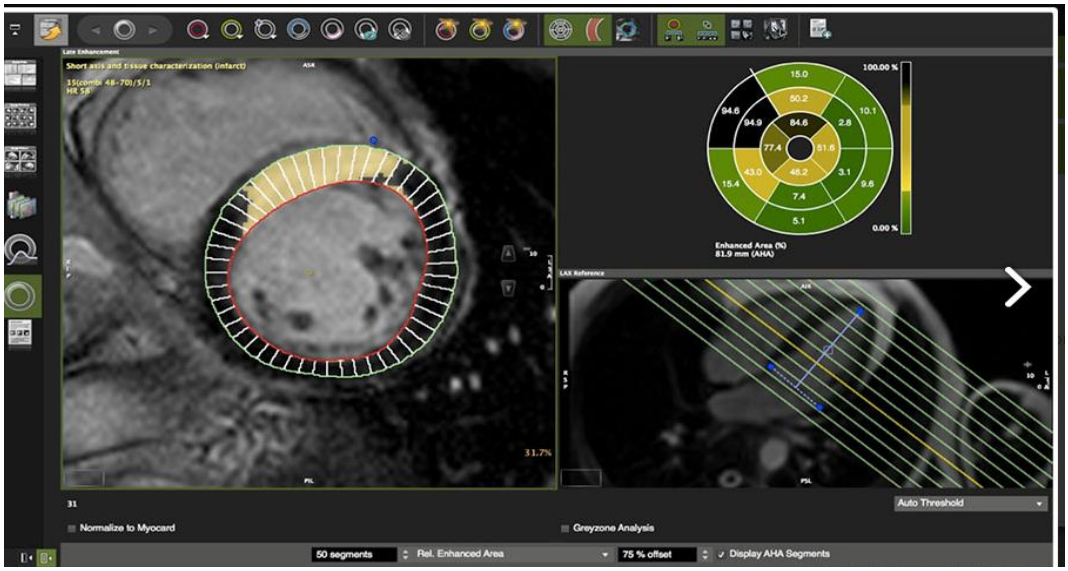
- Semi-automatic mitral & tricuspid valve correction
- Optional in- or exclusion of trabeculae and papillary muscles in/from myocardial mass
- Unique threshold based edge detection allows for quick and precise delineation of trabecular structures and/or papillary muscles
- 4D model of left and right 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 transmurality
- Color–coded 4D mesh model display of tissue characteristics

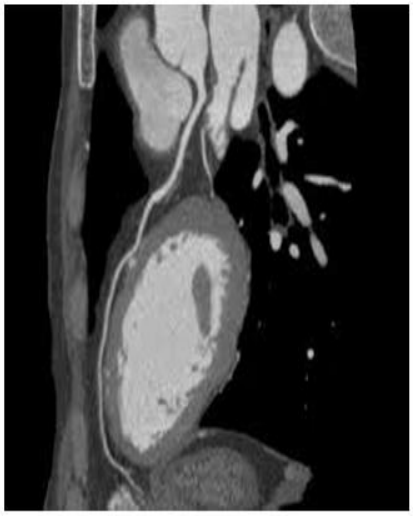
Early Gadolinium Enhancement

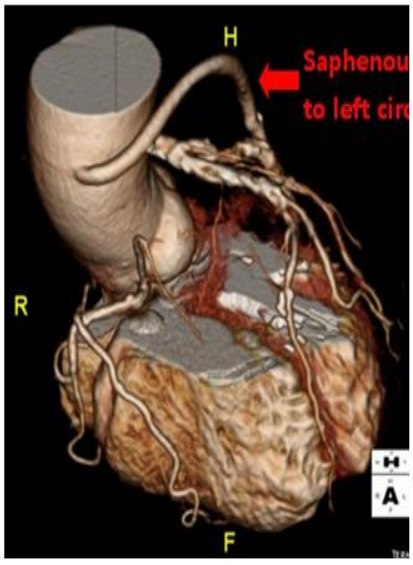
- Assessment of inflammation properties and/or MVO
- Contours are automatically forwarded to the corresponding baseline/post–contrast image
- Calculation and auto–display of myocardial early enhancement and T2 signal intensity ratio (quantitative Lake Louise Criteria for myocarditis)
- Color map of T2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

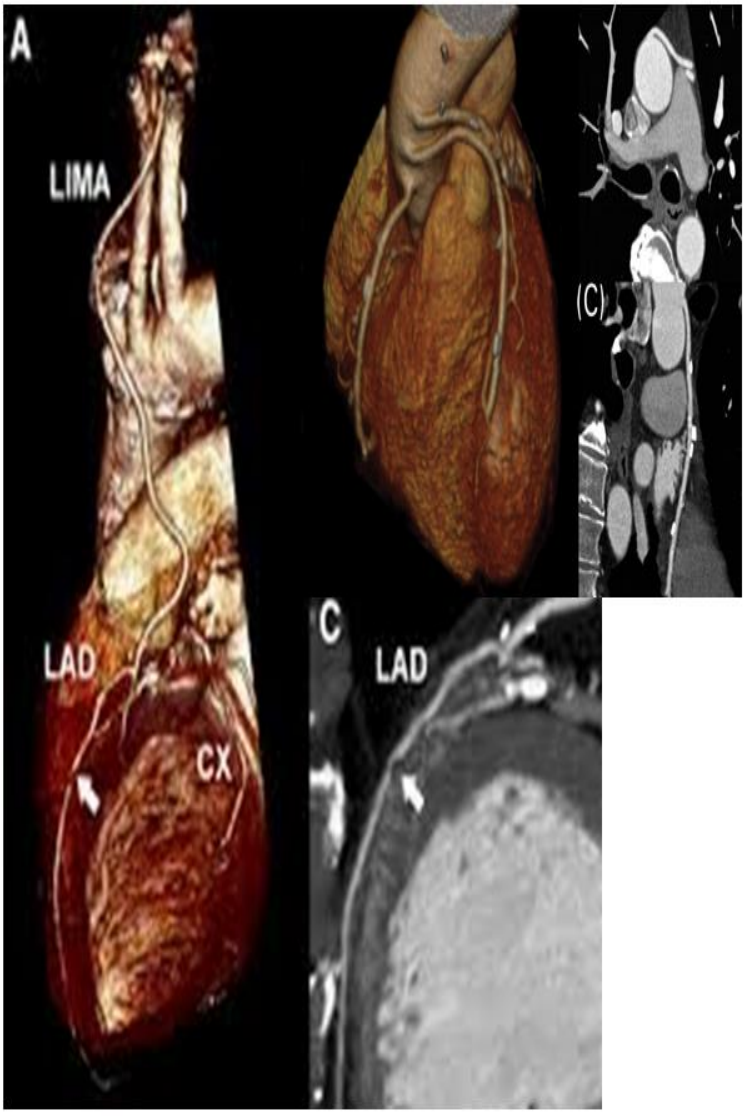
- **PERFUSION, T_1 MAPPING . T_2/ T_2^* MAPPING , 4D VIEWER**

TERARECON – iNtution

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







Advances in MRI

Advanced sequences for MRA

Recent Application :

- MR ECHO
- IDEAL IQ
- T_2 MAP [CARTIGRAM]
- GEN IQ
- READY VIEW
- CARDIAC VX
- BRAIN WAVE

Perfusion weighted imaging

Diffusion Tensor imaging

Susceptibility weighted imaging

Functional MRI

ADVANCES IN MRA

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

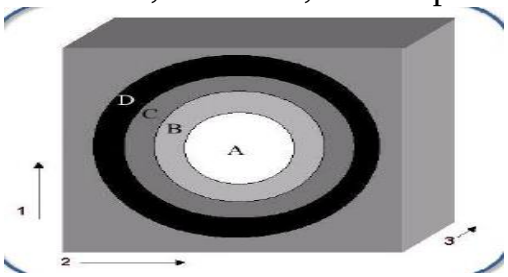
TRICKS / TWIST

. 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.

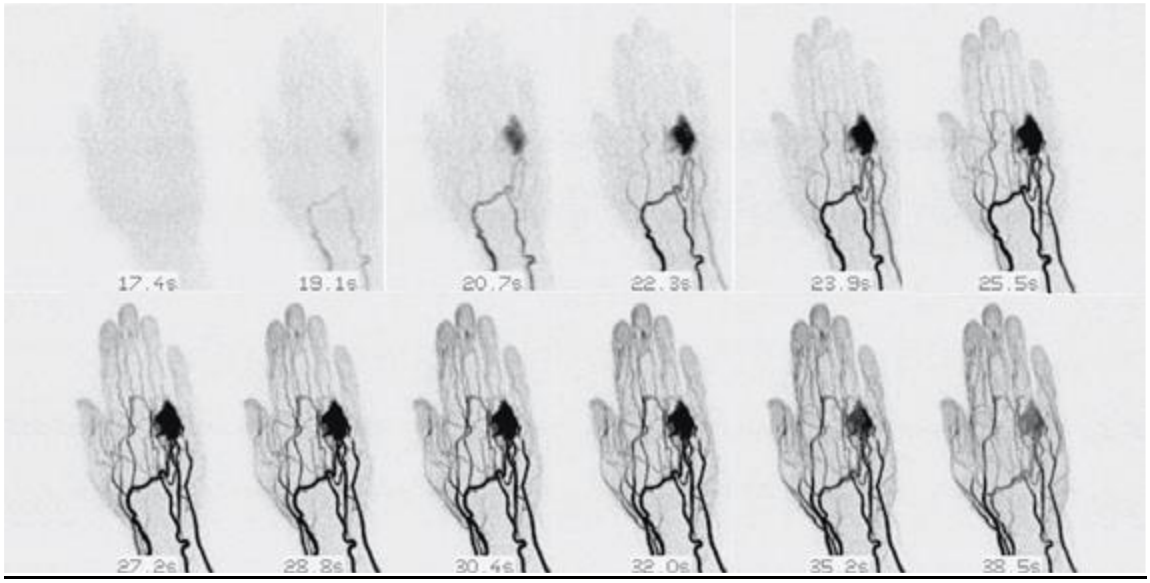
Background:

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.



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

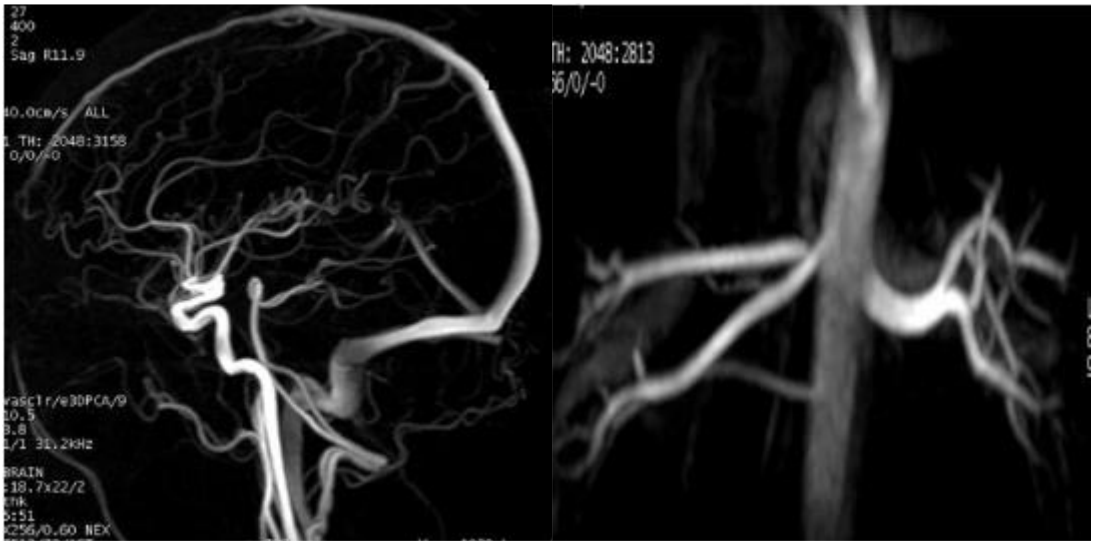
Advances in MRI is help full to provide non contrast MRA in abdominal and peripheral application. The early techniques of NON CONTRAST MRA include 2D &3D TOF IMAGING , GATED 2D TOF , PHASE CONTRAST ANGIOGRAPY

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.

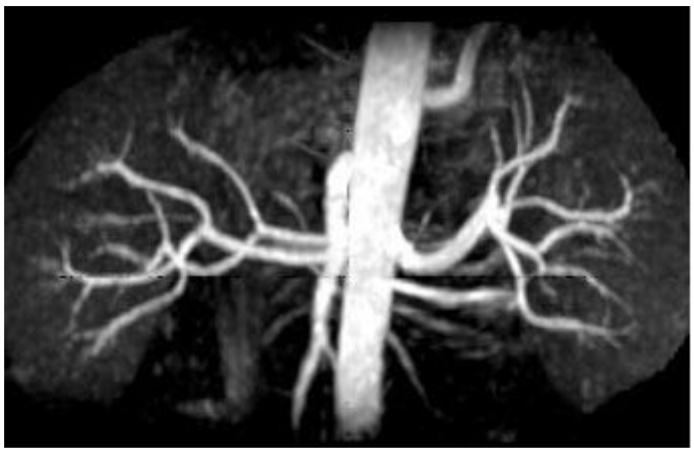
- Shortened scan times through the use of partial k-space filling technique, ASSET compatibility, and dB/dt optimization and RF pulse modifications for shorter TR and TE times.
- A spoiled gradient technique improves SNR and improves background suppression.
- T1-weighted magnitude images can be generated.
- 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]

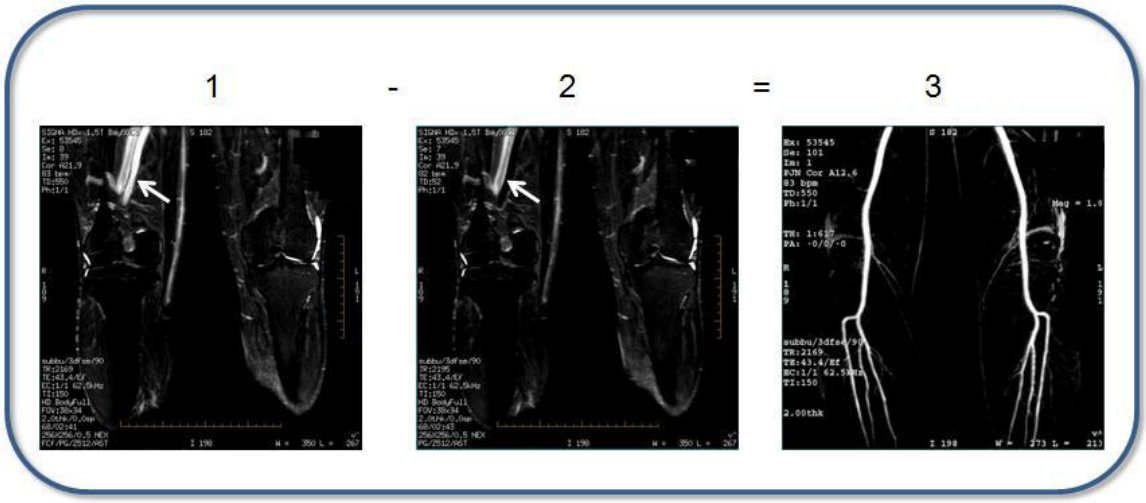
Inhance Deltaflow is a non-contrast agent MRA1 method that is typically used to image peripheral arteries in a run-off exam. Inhance Deltaflow acquires two 3D slabs: one during systolic phase and one during diastolic phase.
A multi-phase SSFSE scan is acquired to determine the diastolic trigger delay 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.

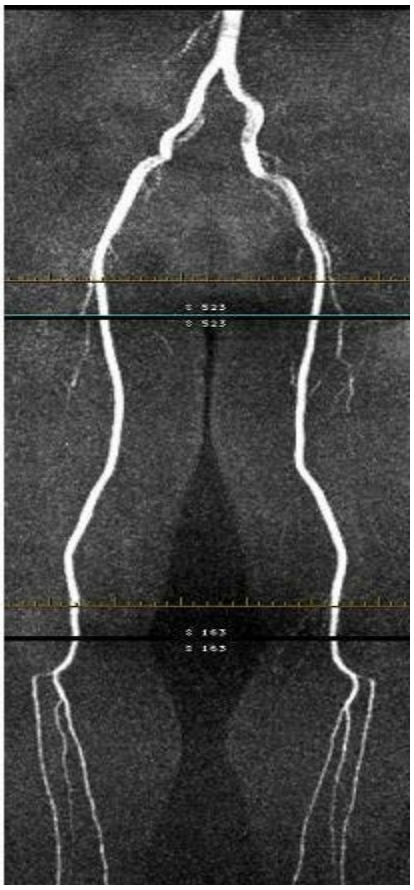
Subtraction of the systolic slab from the diastolic slab results in the visualization of the arteries with good background suppression. A STIR pulse can be applied to both the systolic and diastolic acquisition for additional fat suppression.

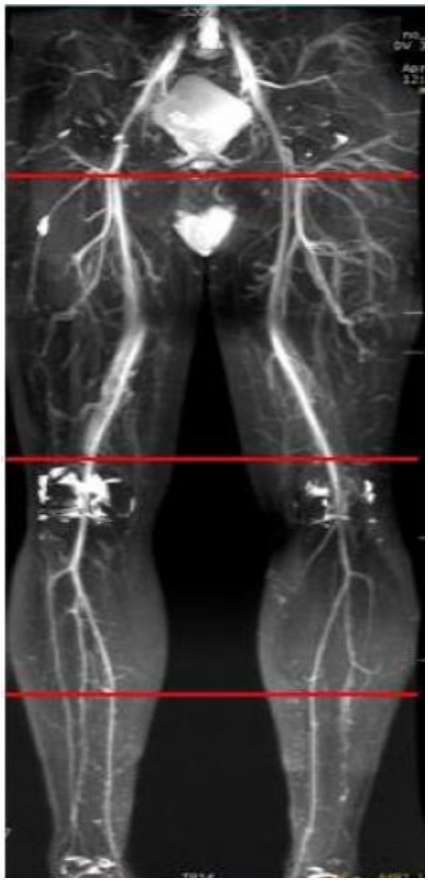
Inhance Deltaflow image results when the diastolic slab is subtracted from the systolic slab



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 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 efficientlyperformed using MR-Echo Scan and Save:

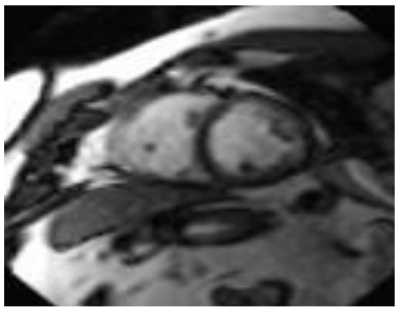
- Function scans, which are typically acquired for wall motion studies
- Time Course scans, which are typically used to evaluate the heart, using a single cardiac phase acquired at multiple locations that are continually repeated over a breath hold

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

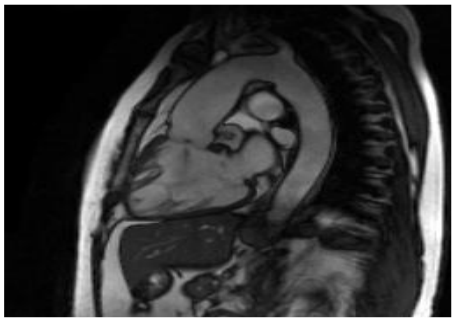
Background

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

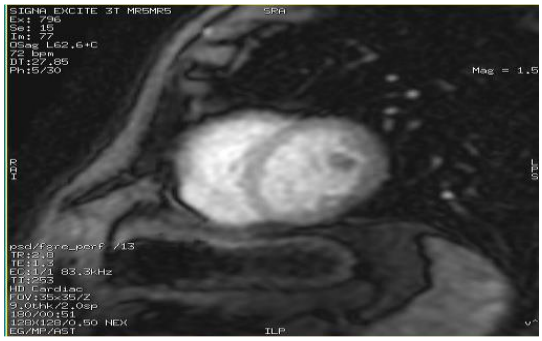
Realtime uses a non-gated 2DFIESTA PSD for acquiring real-time images of the heart using a FIESTA (bright blood) pulse sequence. The PSD acquires images at a high-frame rate for localization and qualitative ventricular function assessment.



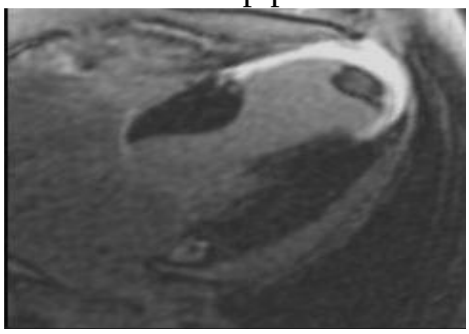
Function uses a gated 2D FIESTA PSD. It provides a multi-phase CINE high-frame rate acquisition mode for high-image quality breath-hold cardiac images that are added to the image database. This mode functions with both ECG2 or peripheral gating.



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.



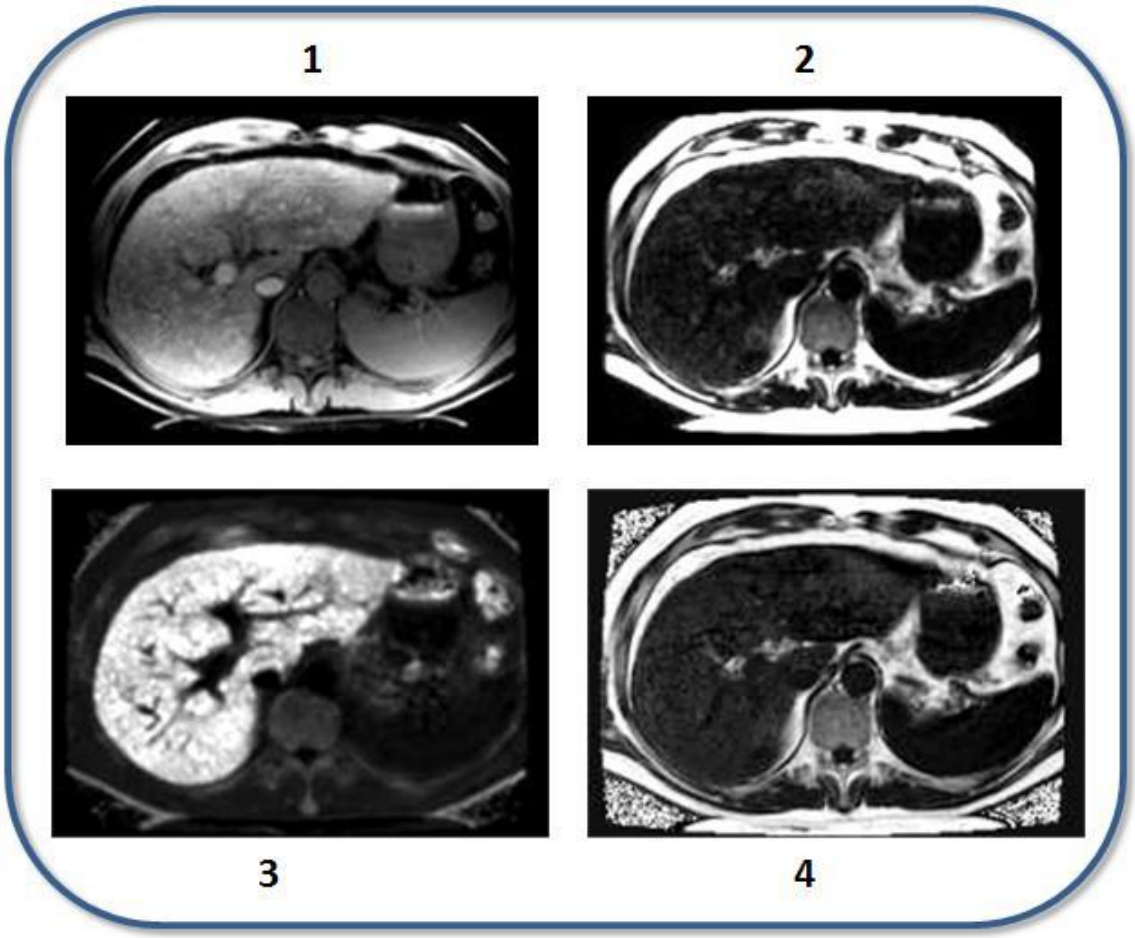
Myocardial Evaluation uses a single-phase, cardiac-triggered Fast GRE with an IR1-Prep pulse.



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 imagesof 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

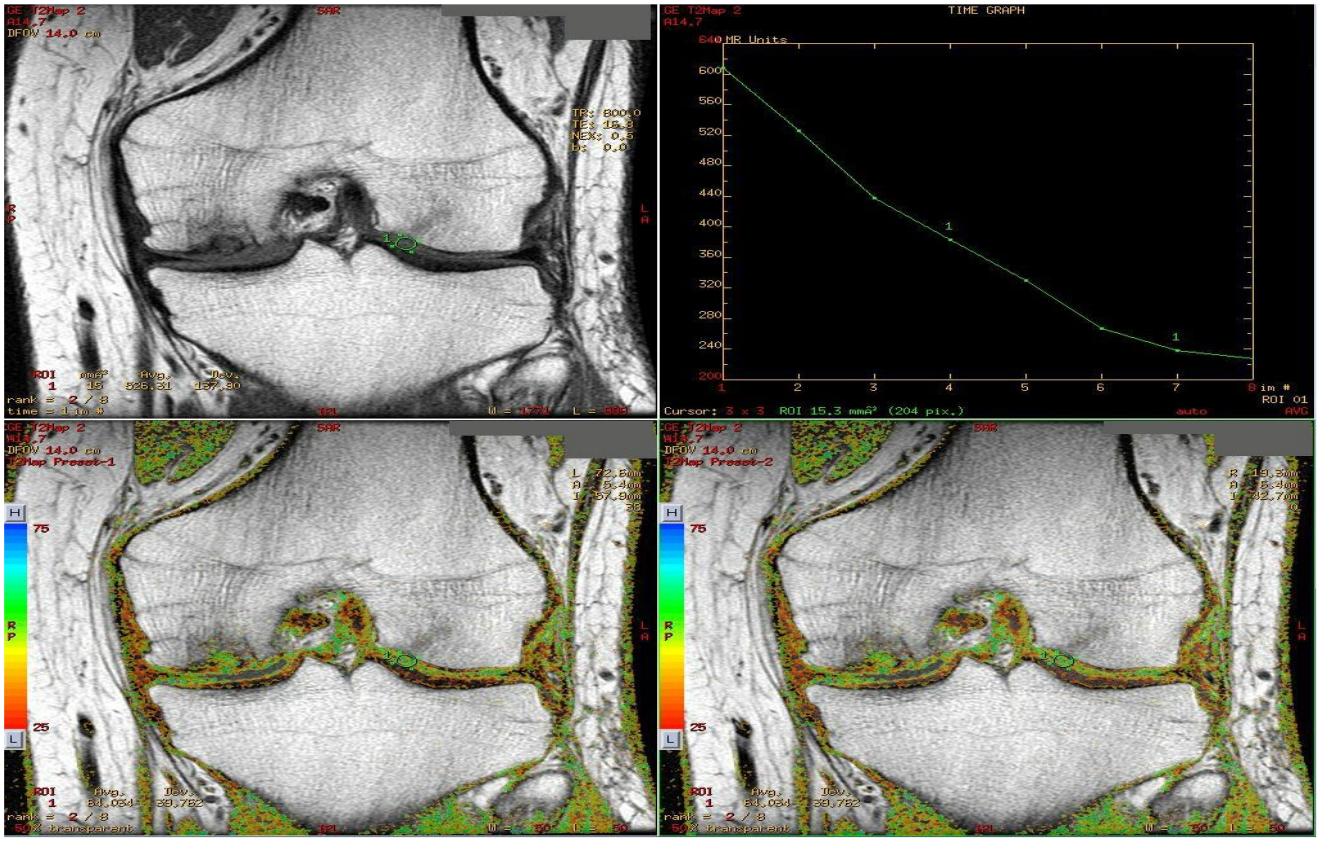


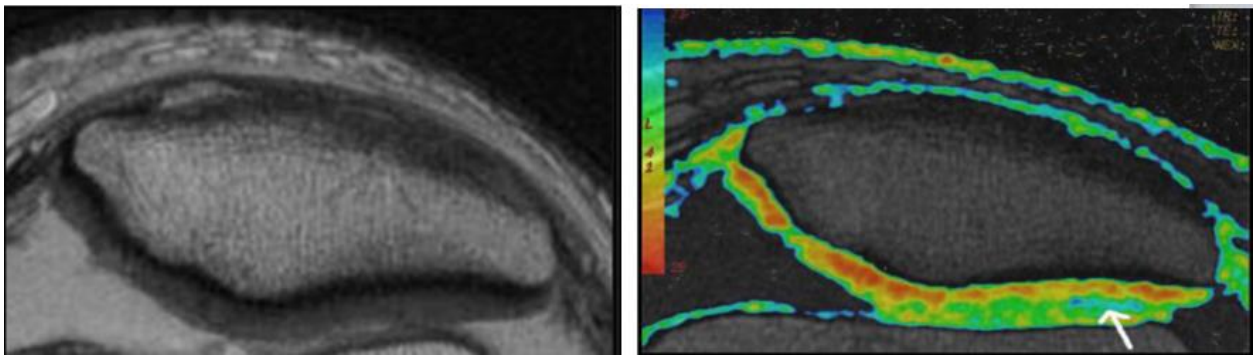
1= T2* corrected waterIDEAL IQ image ,2 T2* corrected triglyceride fat IDEAL IQ image ,3 R2* map IDEAL IQ image , 4 Triglyceride fat-fraction IDEAL IQ image

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.





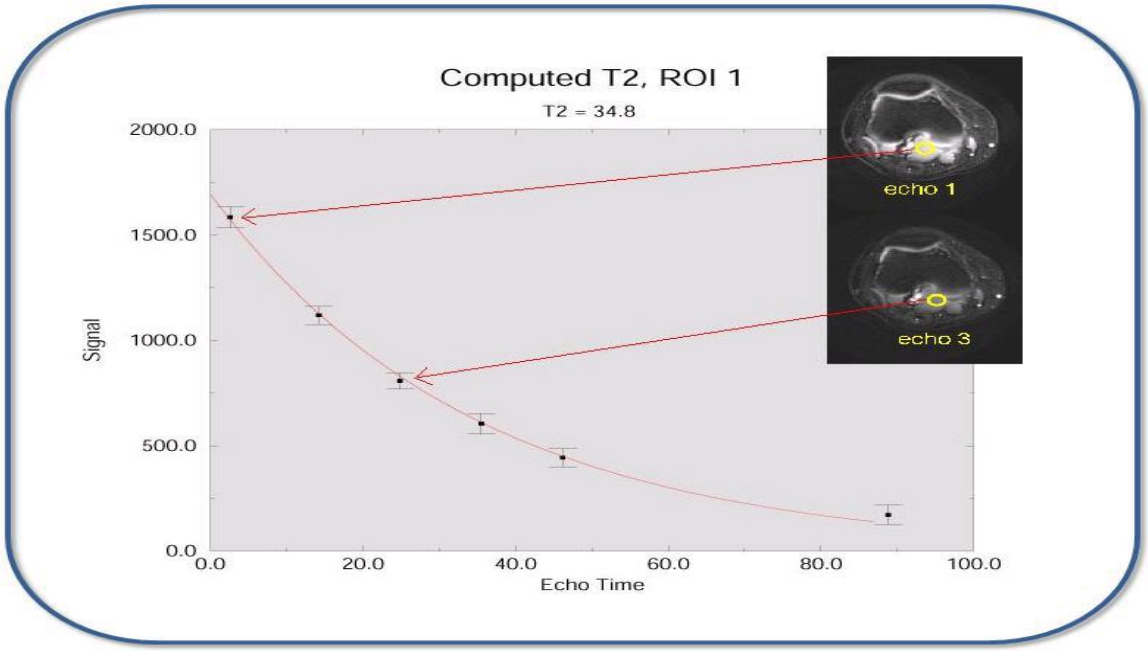
T2 Map knee and color map post-processed in FuncTool. Blue signal intensity indicates high T2 value

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.



GenIQ

Angiogenesis is the physiological process of new blood vessel growth from pre-existing blood vessels. This is normal process for growth and development ,wound healing etc.It also transition stage of tumors that move from a dormant to malignant state .GenIQ is an AW-software application used to asses DCE-mri images for tissue flow,permeability,and contrast leakage from vascular space in to extra vascular-extra cellular space and then slowly leak back in to vascular space.

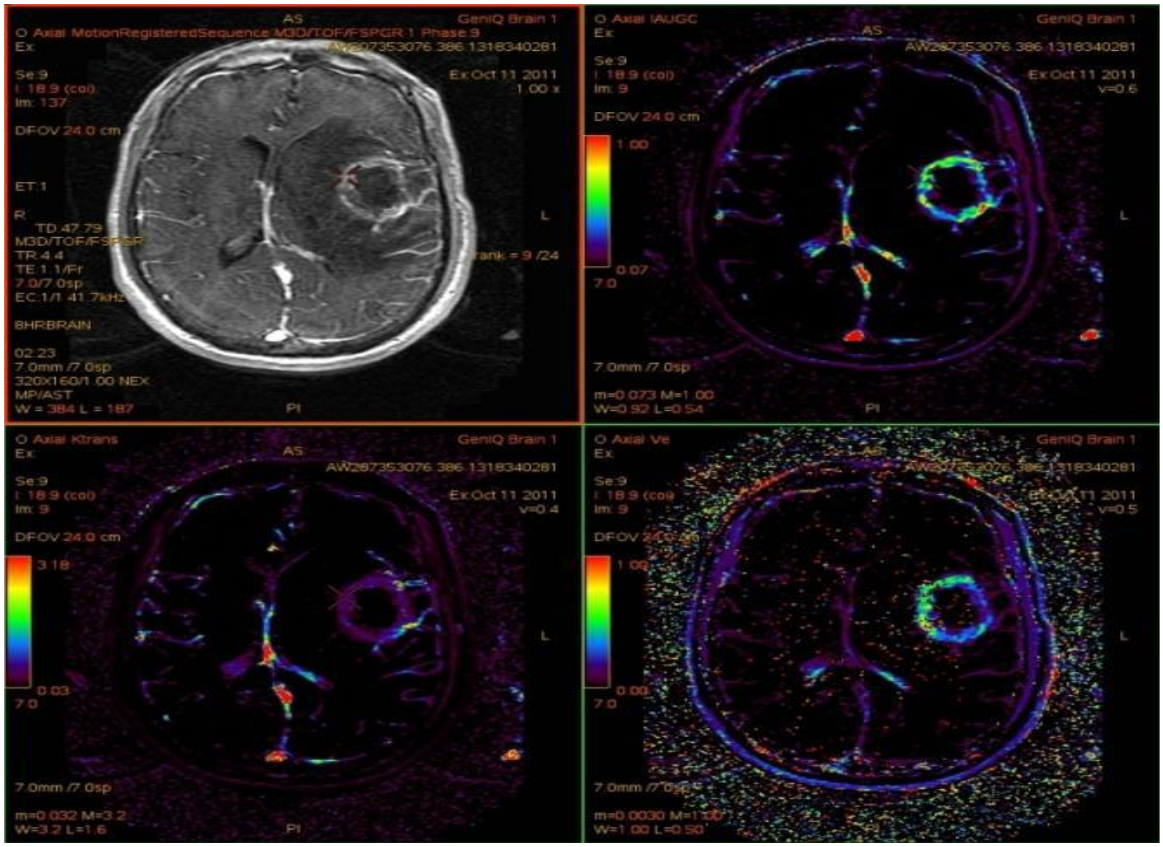
Permeability is a parameter that is related to rate of leakage of contrast agent from the blood plasma space to EES.tumour have a higher and faster uptake of MRI contrast agents.images acquired with T1 based scan parameters are sensitive to accumulation of contrast in EES

GenIQ application include

- Assist in monitoring lesion responses to the therapy

- Assist lesion detection and staging characterization
- Assist in directing lesion biopsy

1 2



3 4

1: Source image
2: K trans map
3: IAUGC map
4’.ve’ map

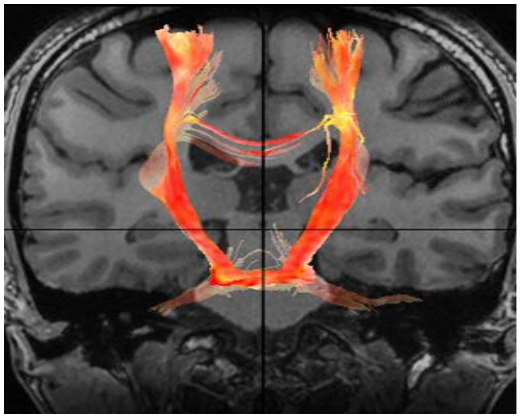
Initial area under the gadolinium contrast agent concentration time curve(IAUGC),bolus arrival time (second) (BAT),Kep-the transfer constant (often called wash-out rate) is a measure of movement constant agent from the extravascular extracellular to the intravascular space(min-1).K-trans-it is a transfer constant (frequently called wash in rate).which is a measure of movement of the contrast agent from intravascular to the extravascular extracellular space.it describes forward leakage rate of the contrast medium,min-1,Maximum slope increase (mMOL/sec) and volume of extravascular extracellular space(Ve),it is leakage space

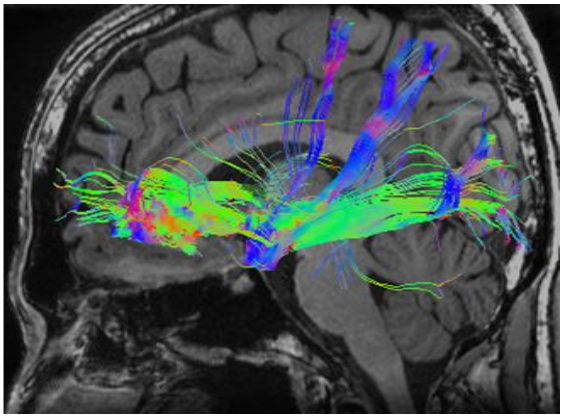
REDYVEIW

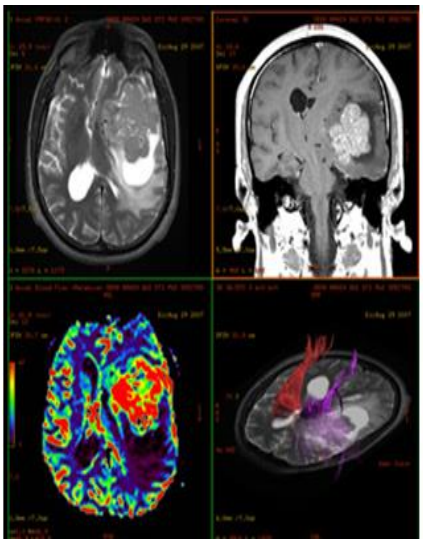
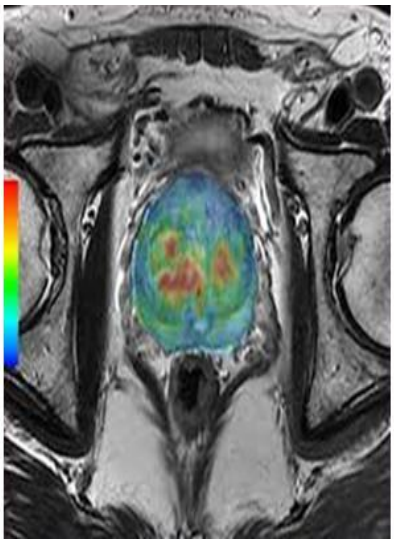
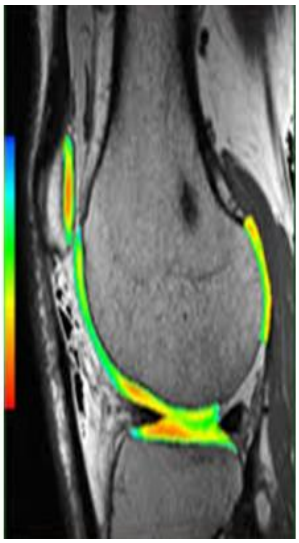
The Ready view software package is a general post-processing tool to create graph (time curve, spectrum) and color parametric images from specified algorithms that provide addition clinical information for diagnosis purpose.it permit overlay color images on anatomical reference using sipmle “drag and drop” functionality. Ready view offer default protocol and optional; protocol for processing MR functional data .

APLICATIONS :

- 3D ASL work flow
- DWI work flow
- Diffusion tensor work flow
- Fiber track work flow
- fMRI work flow
- R2star work flow
- T2(cartigram) map work flow
- MR slandered brain work flow
- Brain stat consideration
- Brain stat work flow
- MR Spectroscopy workflow
- Stroke Workflow





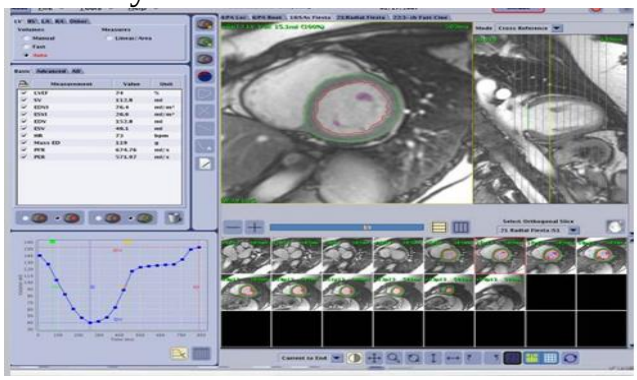
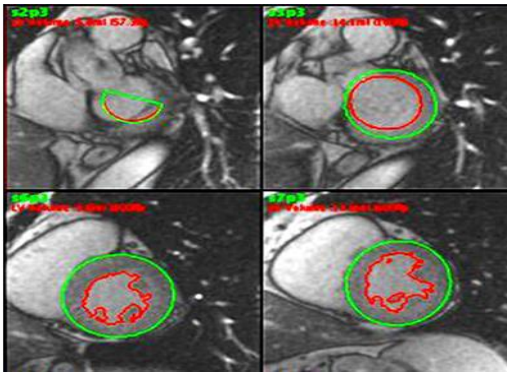




Cardiac VX

Cardiac VX is a application of viewing multiple studies and series of multi-slice,multi-phase images.multi-phase sequence of images can displayed in cine mode to facilitate visualization.

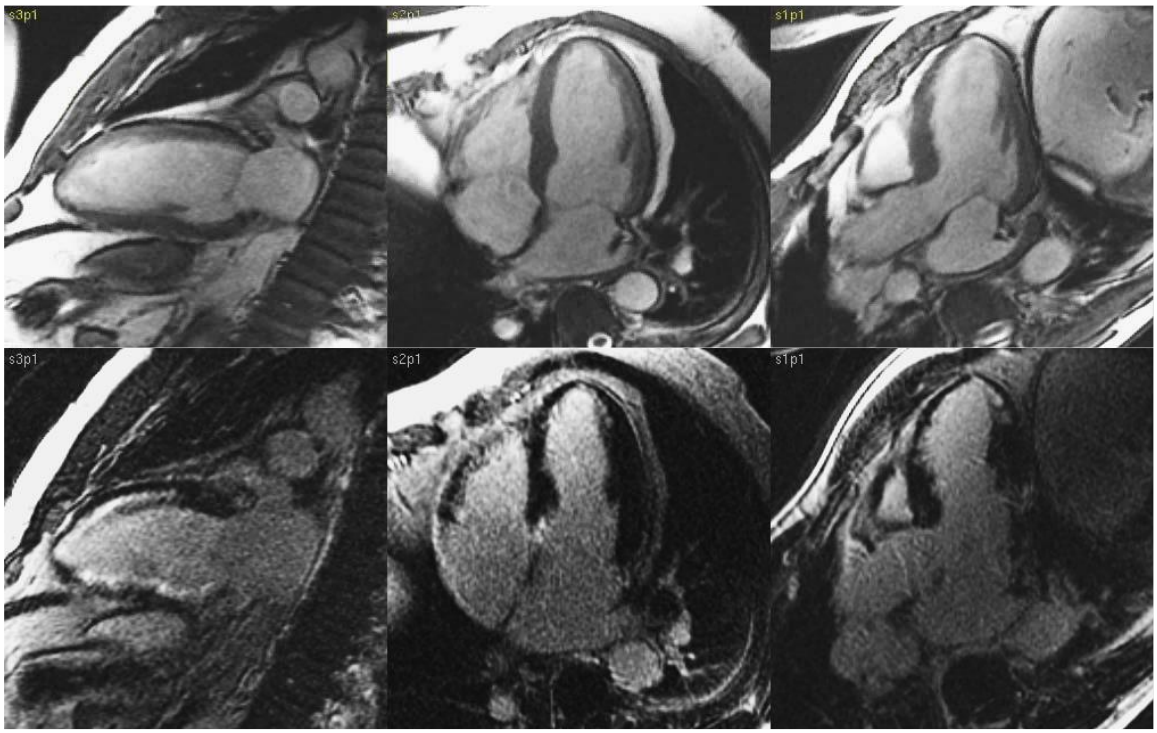
A report input interface is also available. measurement tool on the report interference make it possible to quickly and reliably fill out a complete clinical report of an imaging exam, available tools include point, distance, area and volume tools such as ejection fraction, cardiac output, end diastolic volume, end systolic volume and volume flow measurement.

semi-automatic tools are avialble for left ventricular counter detection,valve plane detection,vessel countou detection for flow analysis
,signal intensity analysis for myocardium and infarct size mesurment and t2 star analysis

CARDIAC IN 3T

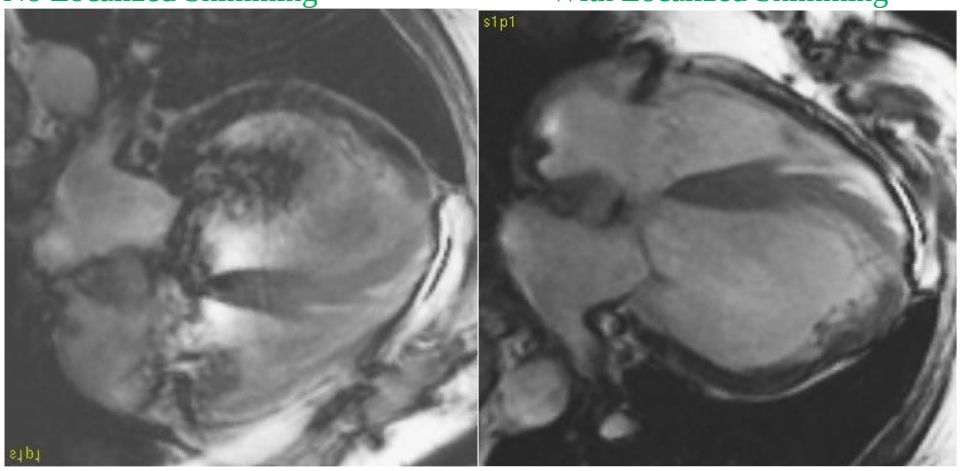
In order to keep the SAR within limits at 3T, the flip angle must be reduced for TrueFISPsequences . This causes a drop in blood pool signal and decreases the contrast between the blood pool and myocardium. Consequently, while blood-pool/myocardial contrast-to-noise (CNR) with gradient recalled echo Turbo FLASH sequences may be less than in 1.5 T Greater 3T. increased sensitivity to flow-induced noise, known as the magneto-hydrodynamic effect, can interfere with ECG-gating at 3T,Assessment of cardiac morphology with spin-echo images seems to be superior at 3 T than at 1.5 T



functional quality may be reduced at 3 T due to artefacts associated with SSFP imaging highly susceptible to field in homogeneities short TR in combination with high flip angles which leads to a high SAR deposition.Remody are second order shimming corrections turbo gradient echo (TGrE) techniques but lower contrast between blood and myocardium performing LV imaging after contrast administration.for perfusion 3T Is superior better diagnostic accuracy like TGrE techniques cause very few subendocardial susceptibility artefacts and late gadolinium enhancement(viability) also better reduce the dose of contrast agent higher

spatial and temporal resolution.in 3T Possible to do the quantification of t2* Relaxation time.it is an ECG-gated multiecho spoiled gradient echo sequence acquired at a single cardiac phase, most commonly at mid to late systole to ensure that the optimal

No Localized Shimming With Localized Shimming



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 & DCE 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 dropin the MR signal when a T2- or T2*-weighted sequence is used. Thissignal–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 Gd3+ 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.

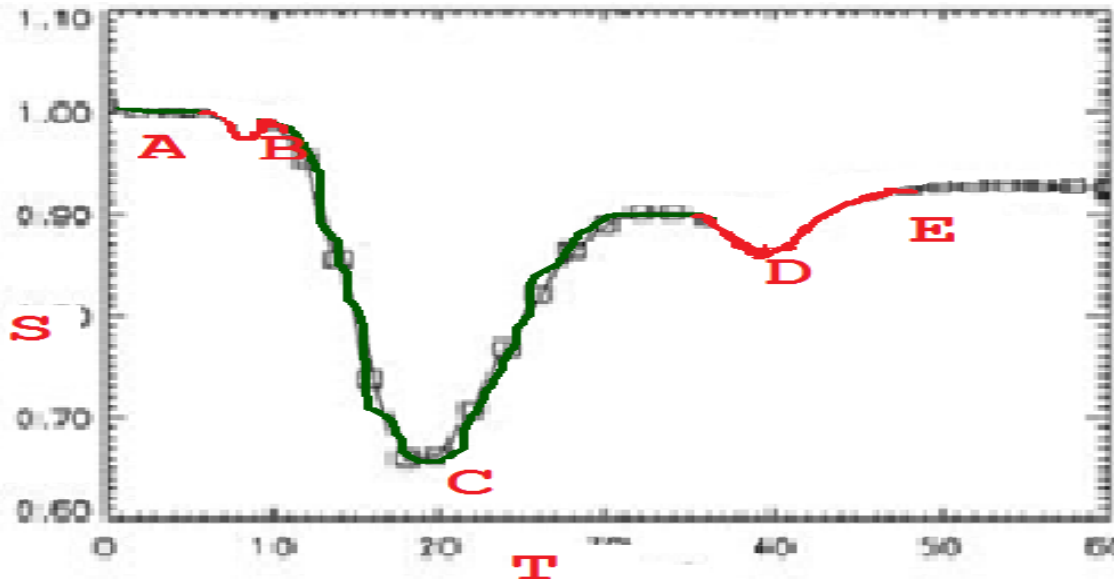
The susceptibility contrast generated by the passage of a paramagnetic contrast agent through the microvasculature is imaged using T2- or T2*-weighted sequences (see step 6). Fast acquisition imaging techniques, such as echo planar imaging (EPI), are required to characterize the transient MR signal drop (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 in homogeneities 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 60–90º at 1.5-T or 60º 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 X 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)

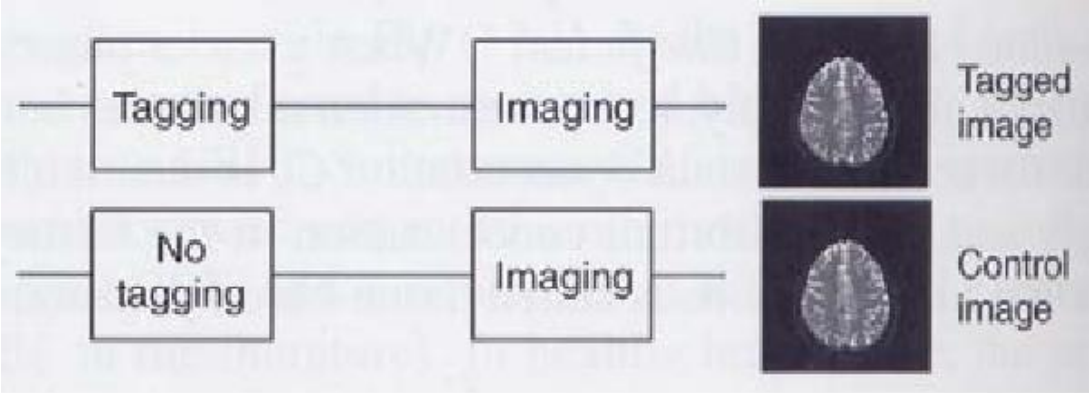
- Tmax is the arrival delay between AIF and the tissue
-

Clinical application

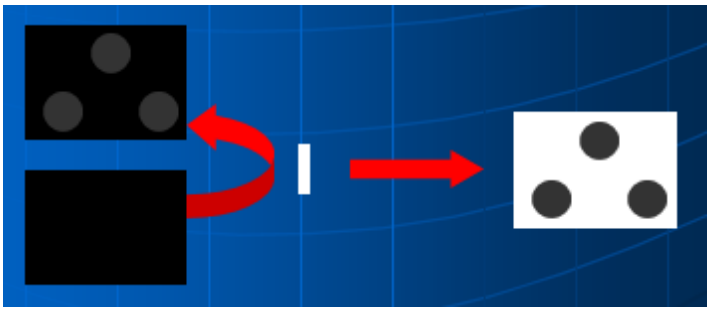
- Evaluation of ischemic penumbra in stroke.
- Classification of brain tumor.
- Grading of brain tumor.
- Cerebral infarction risk assessment
- Selection of patients for extracranial to intracranial bypass surgery
- Moyamoya evaluation
- Assessing risk of hyperperfusion syndrome
- Balloon test occlusion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

ASL

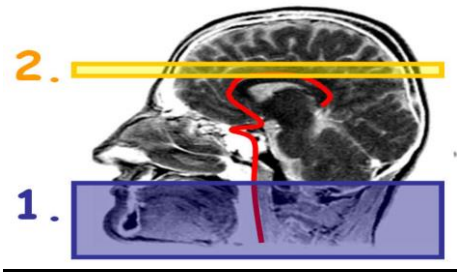
- ASL technique was conceived more than 15yrs ago.No exogenous contrast bolus required. ASL is based on labeling protons in the blood in supplying vessels outside the imaging plane and waiting for a period called post delay period for reaching the parenchyma.



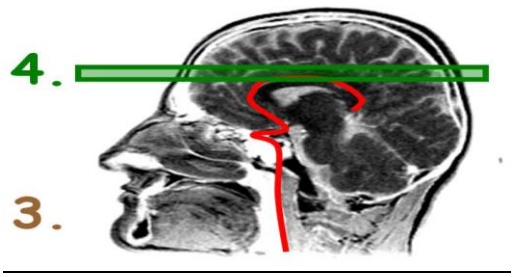
- Images are obtained from the parenchyma in labeled and controlled state.
- Subtracting these two type of images eliminates the static tissue signal will give CBF images.



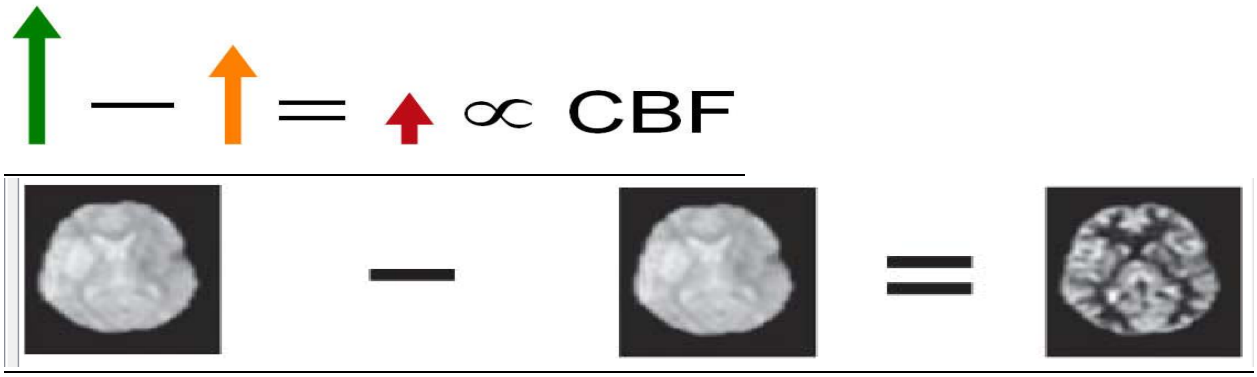
Principle of ASL



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



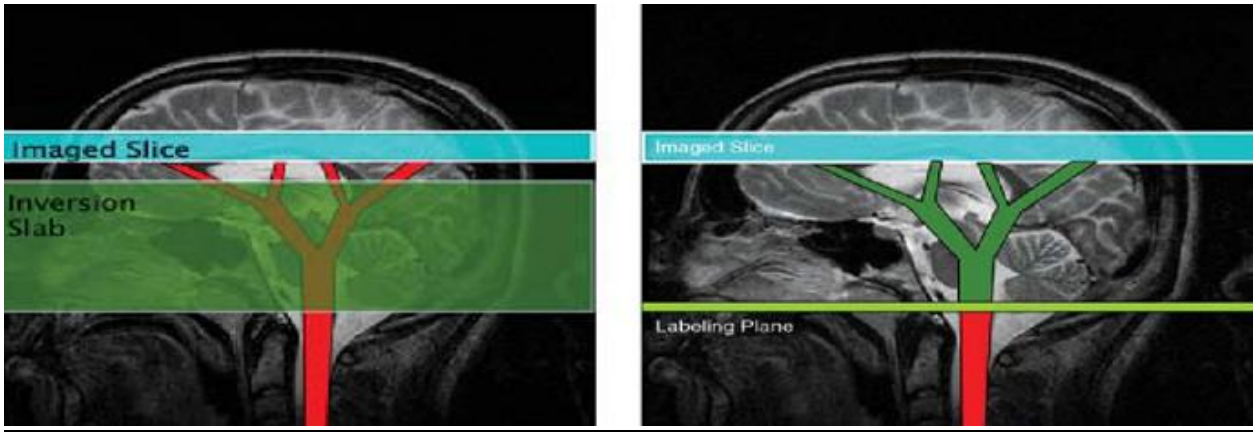
3. Repeat experiment without **tag**
4. Acquire the **control image**



TYPES OF ASL

i. Pulsed ASL
ii. Continuous ASL
iii. Pseudo continuous AS
iv. L
v. Velocity selective ASL

PASL **CASL**

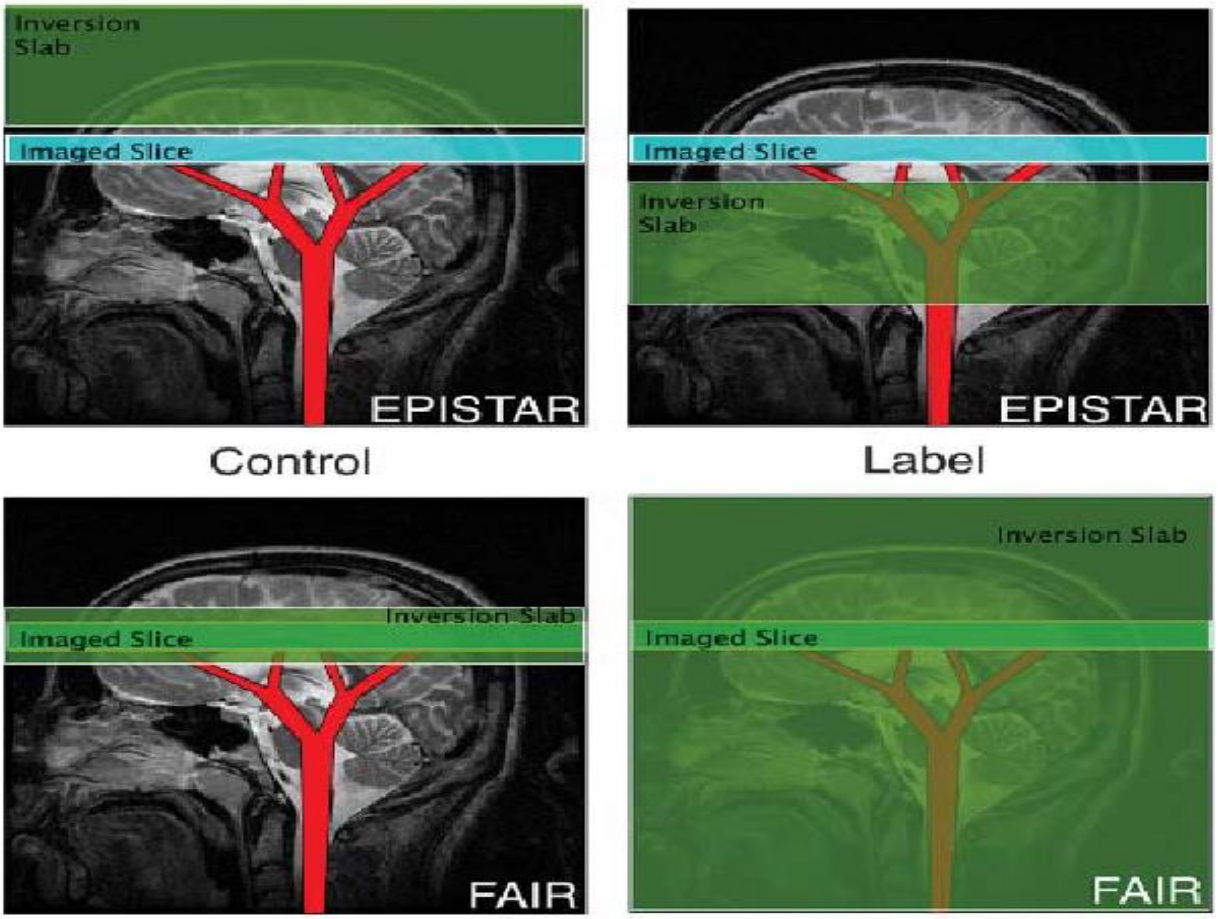


ASL Types	Advantages	Disadvantages
PASL	Higher tagging efficiency Lower SAR	Lower SNR
CASL	Higher SNR than PASL	Lower tagging efficiency Continuous RF transmit hardware required Higher SAR Magnetization Transfer effects
pCASL	Higher SNR than PASL Higher tagging efficiency than CASL	Higher SAR Limited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

Sequence for ASL

- EPISTAR-Echo planar imaging and signal targeting with all radiofrequency.
- PICORE-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 m2/s.

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

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 signalfrom pial veins located within the cerebral spinal fluid (CSF) The acquisition time was 2.58 min with the use of iPAT factor-2.

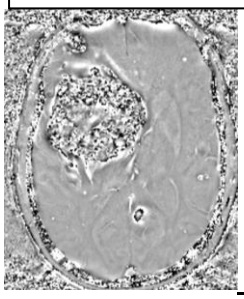
Usefulness of SWI/SWAN phase imaging

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.

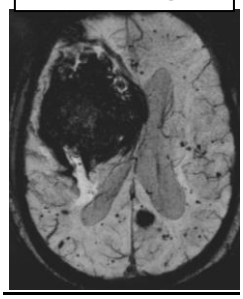
Blood oxygen level-dependent MR Venography / small vessel imaging

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.

Phase image



mIP image



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 de oxy 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 CMRO2.

- 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.

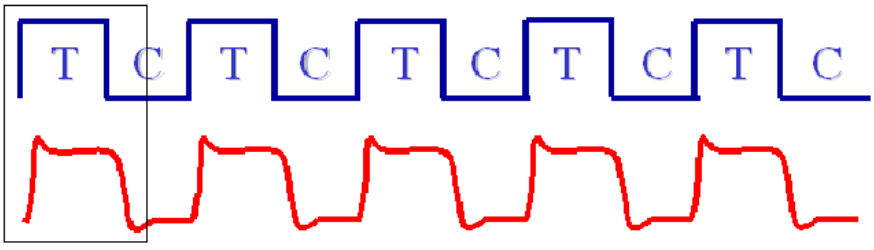
Hence there has been a push for larger field scanners to both improve localization and increase the signal

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

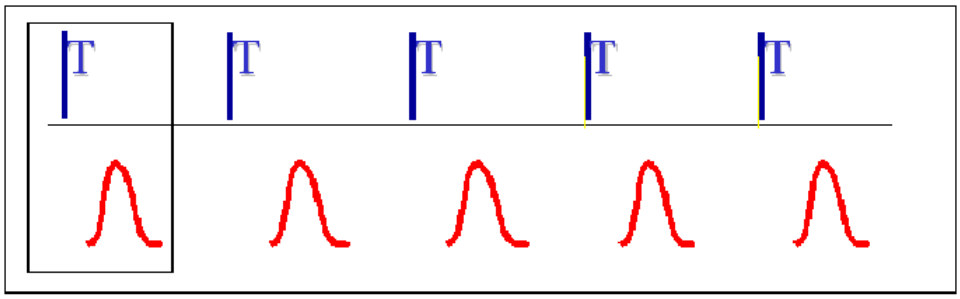
- First used in f MRI and still and the most useful in prevalent neurosurgery.
- It involves subject performs a task, alternated for a similar time with one or multiple control tasks.



Event related f MRI

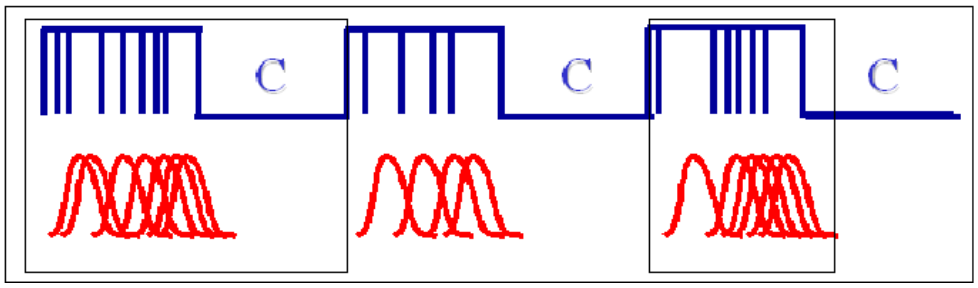
- The individual trials are randomized.

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

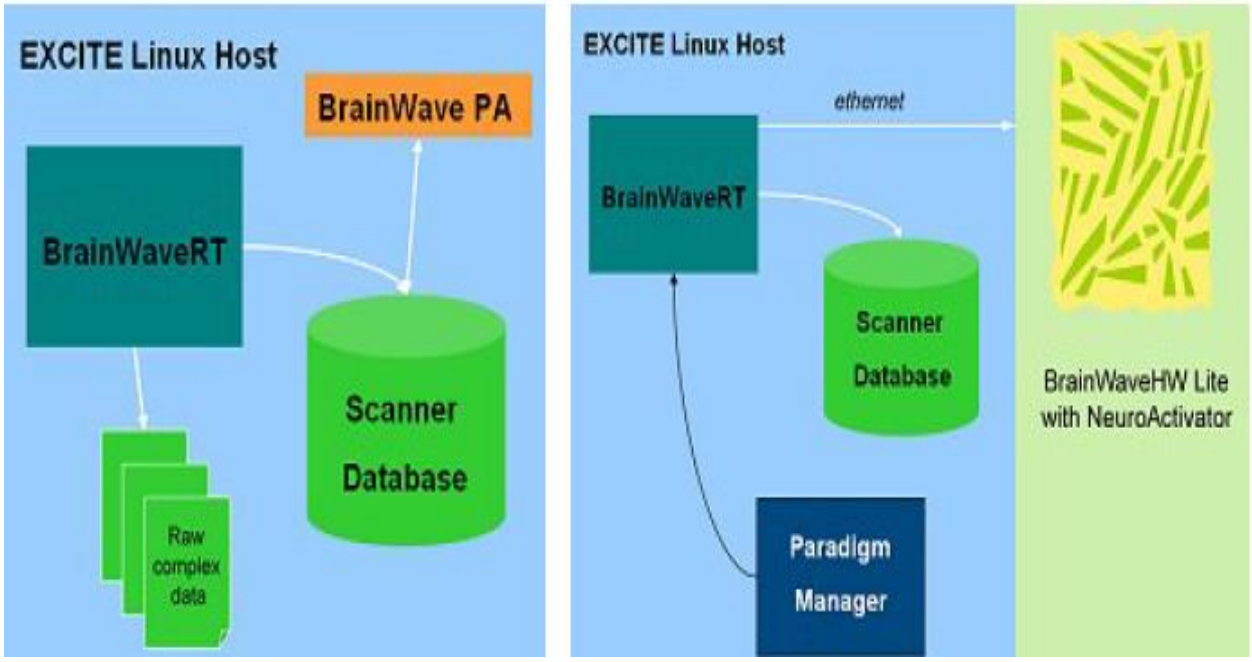
1. Motor paradigms
2. Bilateral finger tapping Vs Rest
3. Lip Pouting vs rest
4. Bilateral leg motor vs Rest
5. Language paradigms
6. Verb generation
7. Word pair
8. Syntax
9. Sematics

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 irtually 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.

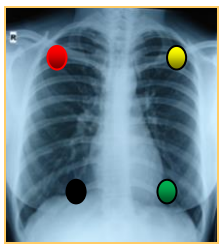
To acquire data over several heart cycles, scanning has to be done in relation to the heart beat. Retrospective ECG gating is therefore useful.

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.



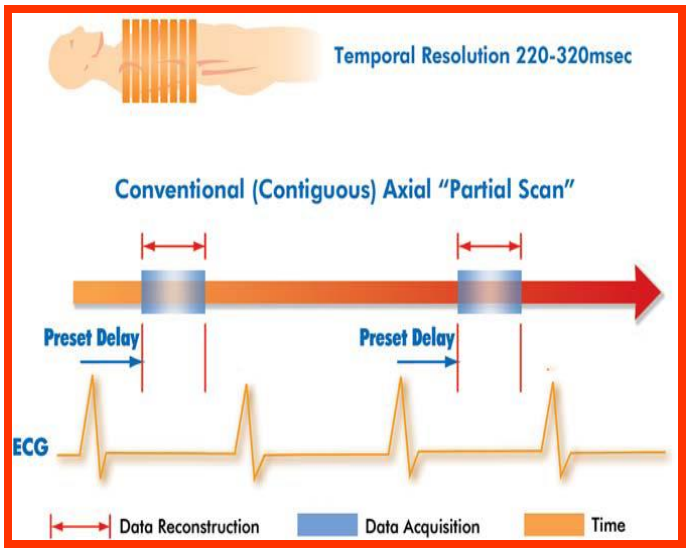
- Red electrode: on the right mid-clavicular line, directly below the clavicle
- Yellow electrode: on the left mid-clavicular line, directly below the clavicle
- Black electrode: right mid-clavicular line, 6 or 7 intercostal space
- Green electrode : on the left mid-clavicular line, 6 or 7 intercostal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

TWO MODES OF ACQUISITION

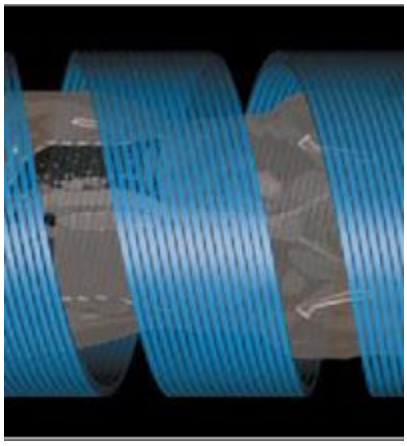
i. PROSPECTIVE
ii. RETROSPECTIVE

PROSPECTIVE SCANNING (AXIAL)

This mode is also called step and shoot method.in this method system detects the ECG from the patient body and calculates the diastolic phase where 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:

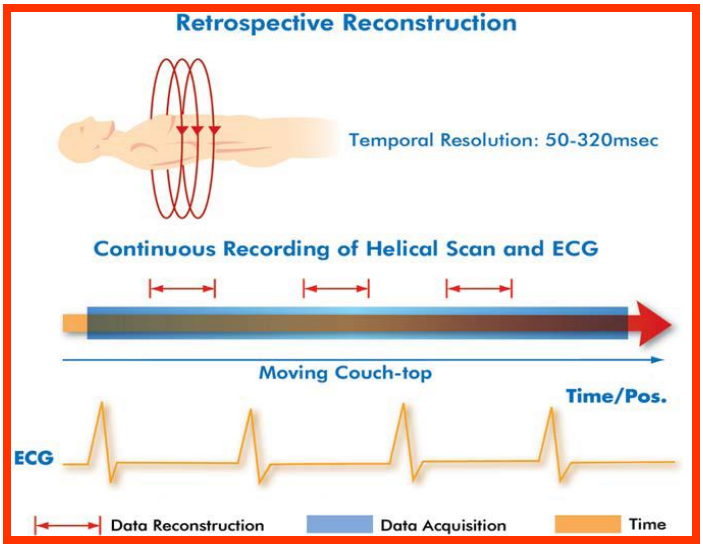


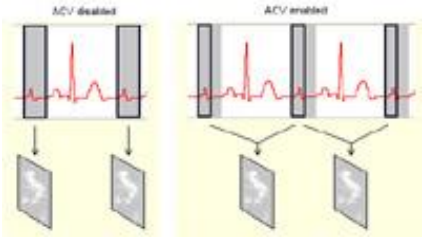
IMAGE RECONSTRUCTION

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 extrasystolse, 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.

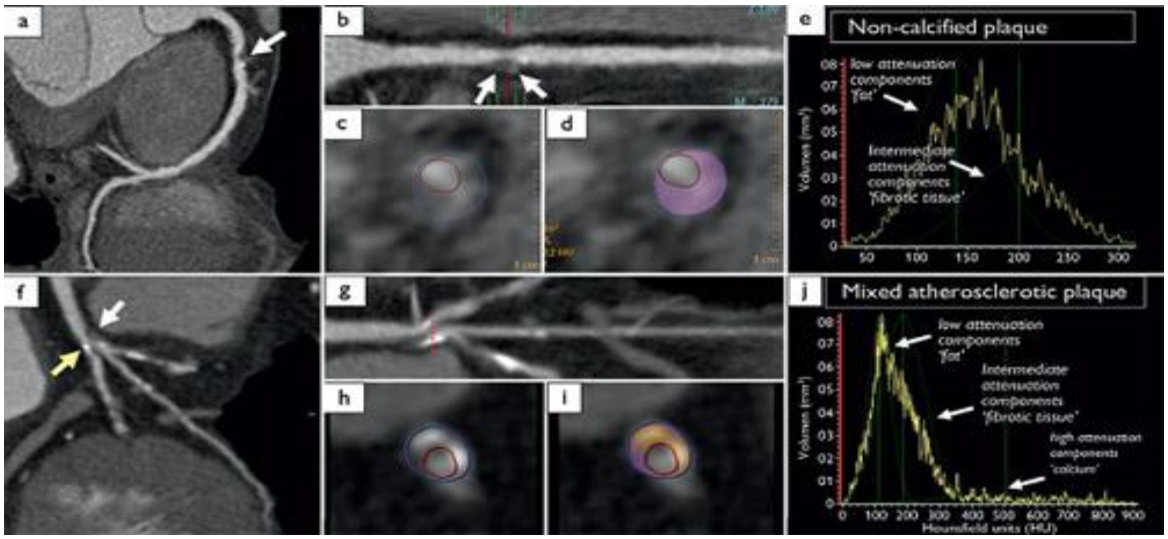


With the collimated slice width used (0.625 mm), images of nominal slice width of 0.625, 1, 2 and 3 mm can be reconstructed. We recommend to use slice widths of 1 mm to increase image quality by reducing artifacts.

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

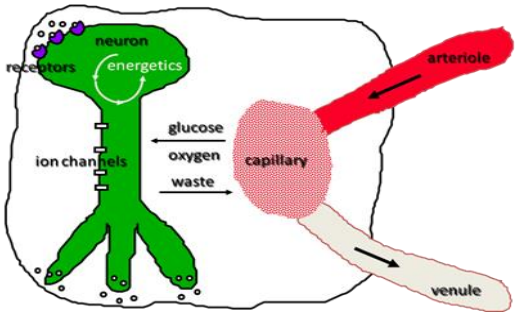
CALCIUM SCORE:

A cardiac CT scan for coronary calcium is a non-invasive way of obtaining information about the presence, location and extent of calcified plaque in the coronary arteries—the vessels that supply oxygen-containing blood to the heart muscle. Calcified plaque results when there is a build-up of fat and other substances under the inner layer of the artery. Because calcium is a marker of CAD, the amount of calcium detected on a cardiac CT scan is a helpful prognostic tool. The findings on cardiac CT are expressed as a calcium score.



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

Applications of CTP

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

II. Tumours

Protocol of CTP

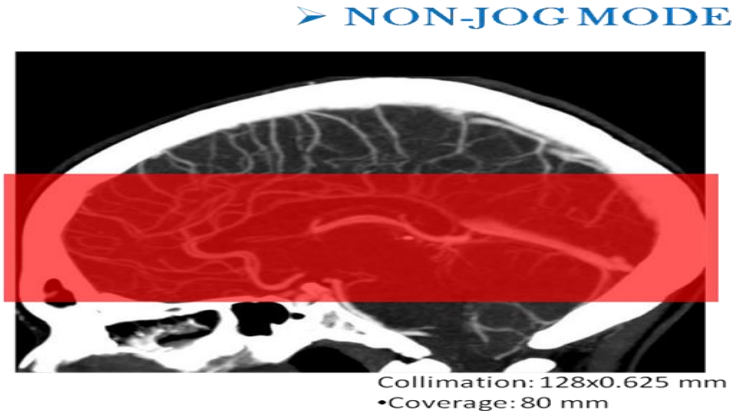
I. NCCT-Non contrast CT
II. CTP-CT perfusion
III. CTA-CT angiogram

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.

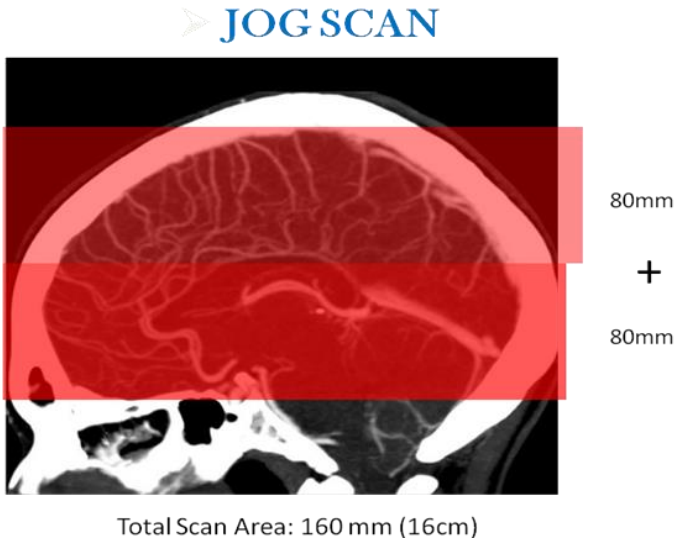
1. Jog mode
2. Non-jog mode



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



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

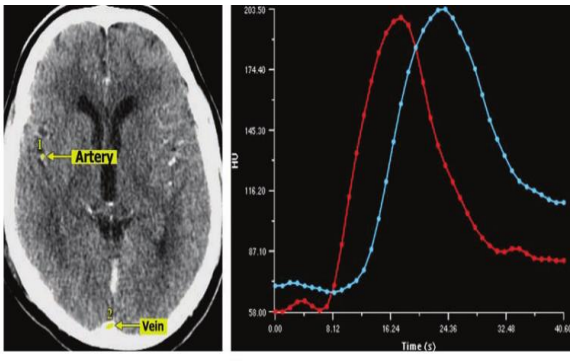
III. Scanner obtains Images from a single 360 degree rotation at location B
IV. Table travels 4 cm in opposite direction to return to position A
V. "Jogging sequence" continues for a total of 40-60 seconds.

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

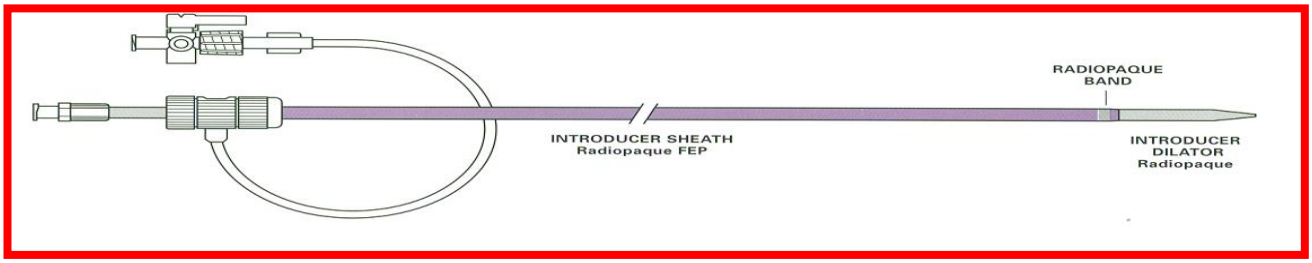
Innova 3131

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

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 safety features such as 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

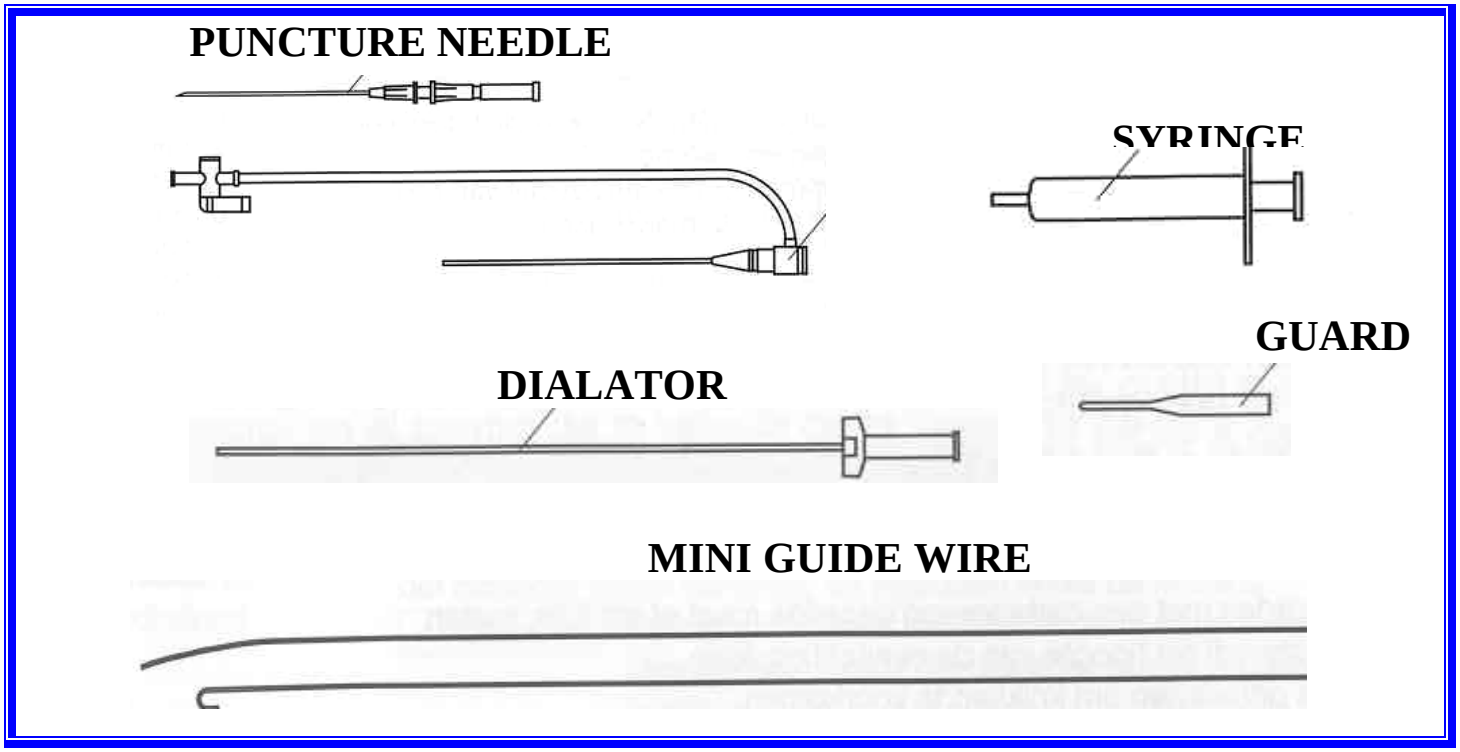
For most interventional procedure, after arterial access has been obtained, the placement of sheaths offers significant advantages.

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 miniguide wire**



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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. In the case of dilation of a graft, the interventionalist will find it necessary to overdilate , by going up one French size

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"

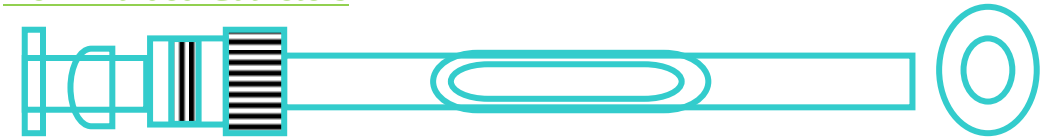
1F = 0.013"

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

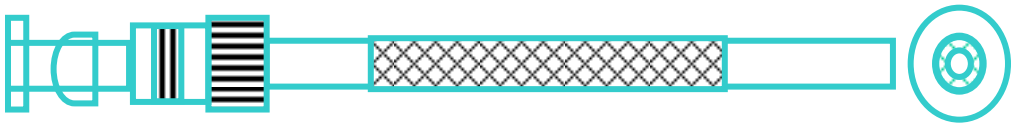
Types:

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

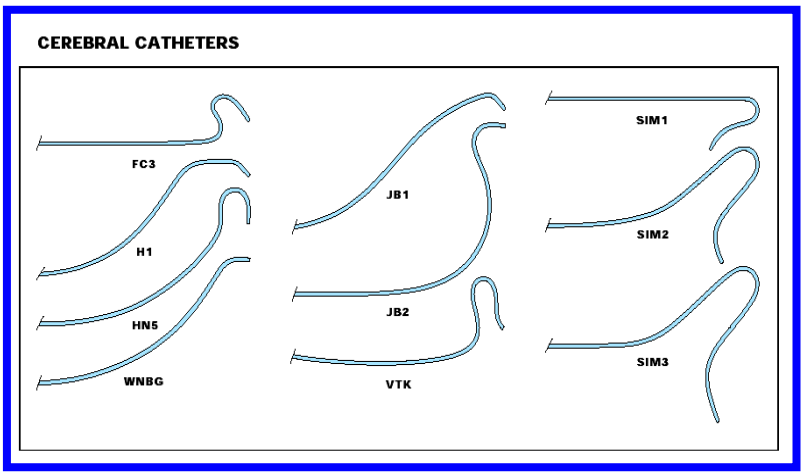


Catheter construction Cross section

Types:

Thin wall radio opaque polyethylene with torque control – has stainless s teel 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.

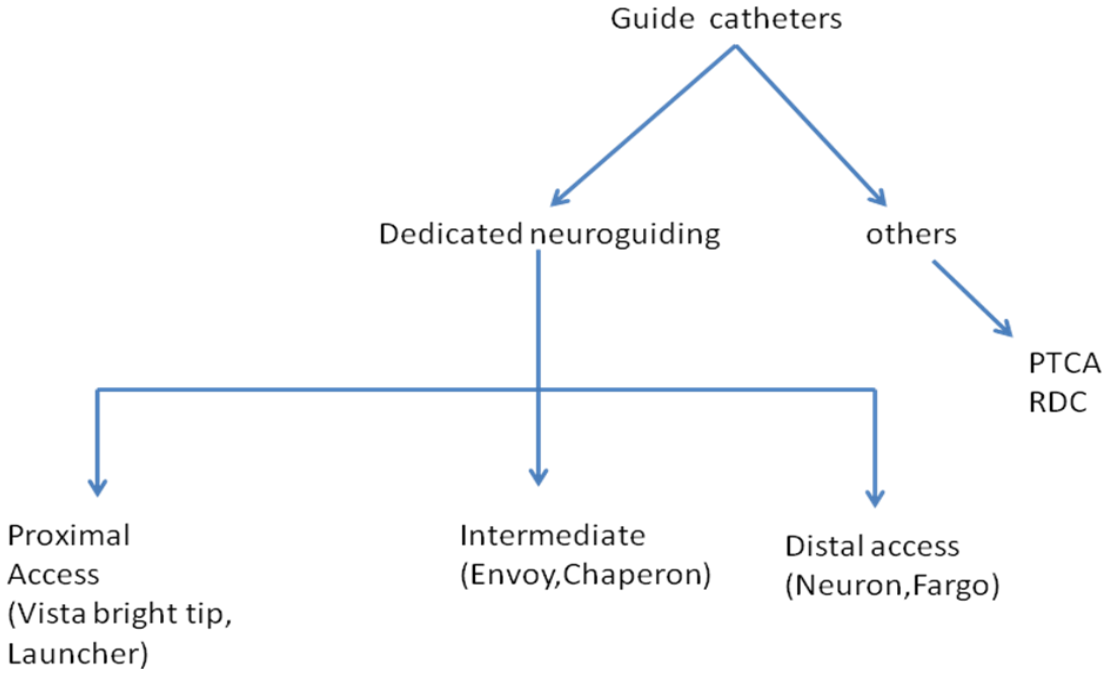
Thin wall Radio opaque Nylon with Torque control – has low coefficient of friction surface characteristics; incorporates stain steel braided construction with catheter shaft which imparts torque control to catheter tip for a 0ne to 0ne response. Bismuth salts are used for radio opacity. Suitable for 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 .In selecting the guiding catheter, the stiffness and shape of the tip are important. The guidecatheter frequently will move with respiration and with placement of the microcatheter. This can cause the tip of the guide catheter to dig in to the intima, which seems to be occur more frequently with the pre shaped models. The stiffness of the guide catheter shaft also is important, because the microcatheters can exerts force against the guide catheter and push it from the desired vessel. However, too stiff a catheter may make initial placement difficult and may also lead to undesired straightening of vessels and sometimes-intimal damage. 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.

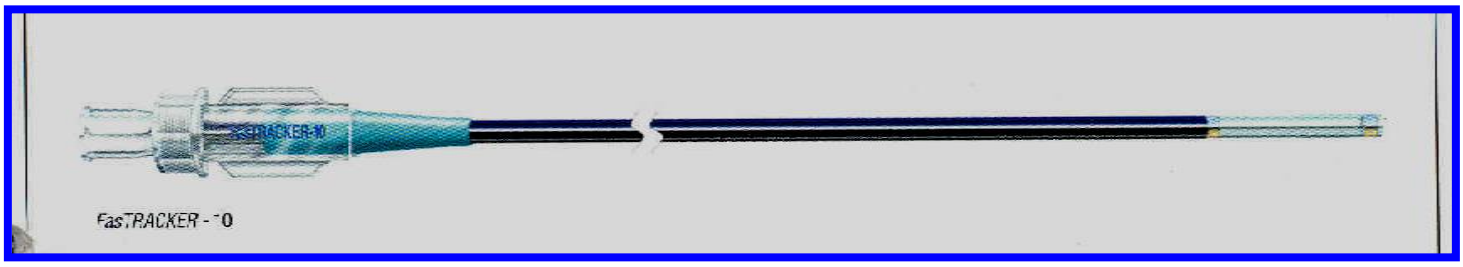


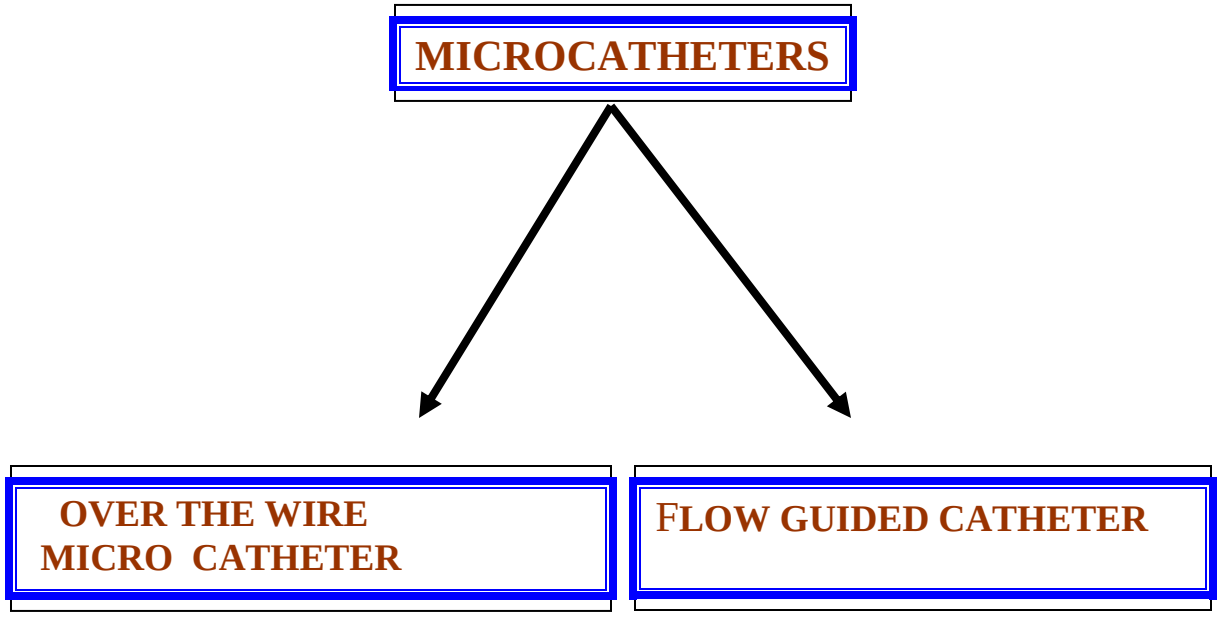
Fargo

MICRO CATHETER

MICROCATHETERS: - All of the commercially available micro catheters are constructed of polyethylene and are hydrophilically coated. Many micro catheters wall contain braided materials, which improves flexibility, pushability, and trarckability 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.

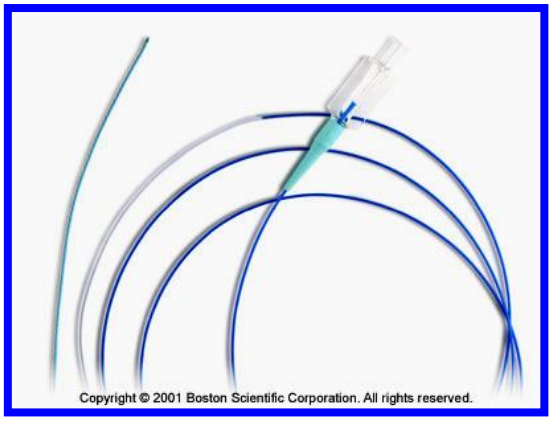
Prowler microcatheter(braided)

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 MICROCATHETERS

These are very flexible hydrophilic-coated catheters that are primarly designed to deliver liquid embolics such as glue, onyx, and dehydrated alcohol, PVA (less than 500μm) 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

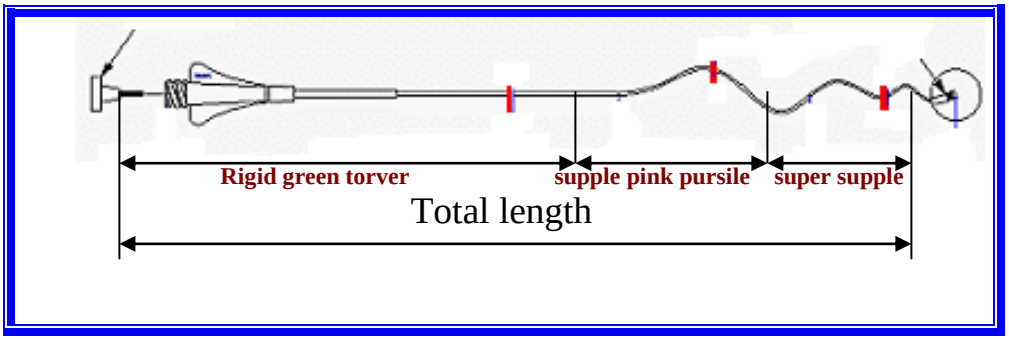
Distal tip of 1.3F, marker band profile of 1.4F and robust reinforcement

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 in to 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

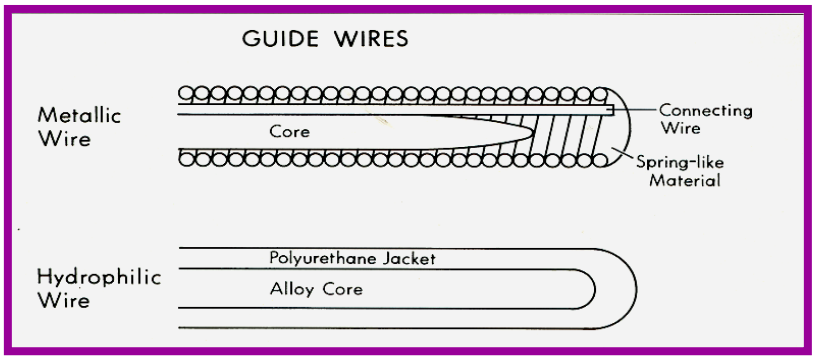
Working length	153	153	153
Distal flexible segment	170	170	170
Proximal O.D French	2.3	2.4	2.8
Proximal ID(INCH)	0.015	0.017	0.021
Braid material	Stainless steel	Stainless steel	Stainless steel
Distal OD French	1.7	1.9	2.3
Distal ID(INCH)	0.015	0.017	0.021
Tip marker OD French	1.7	1.9	2.3
Markers	2	2	2
Minimal guide(inch)	0.035	0.035	0.035

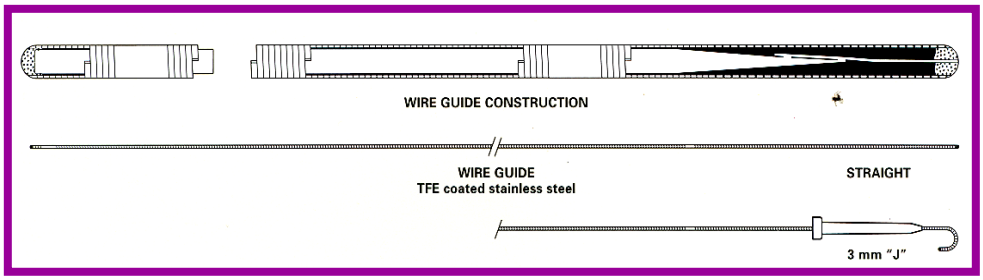
Maximum wire OD(in..)	0.012	0.014	0.018
Inner lumen construction	PTFE	PTFE	PTFE
Dead space	?	0.27	0.27

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.

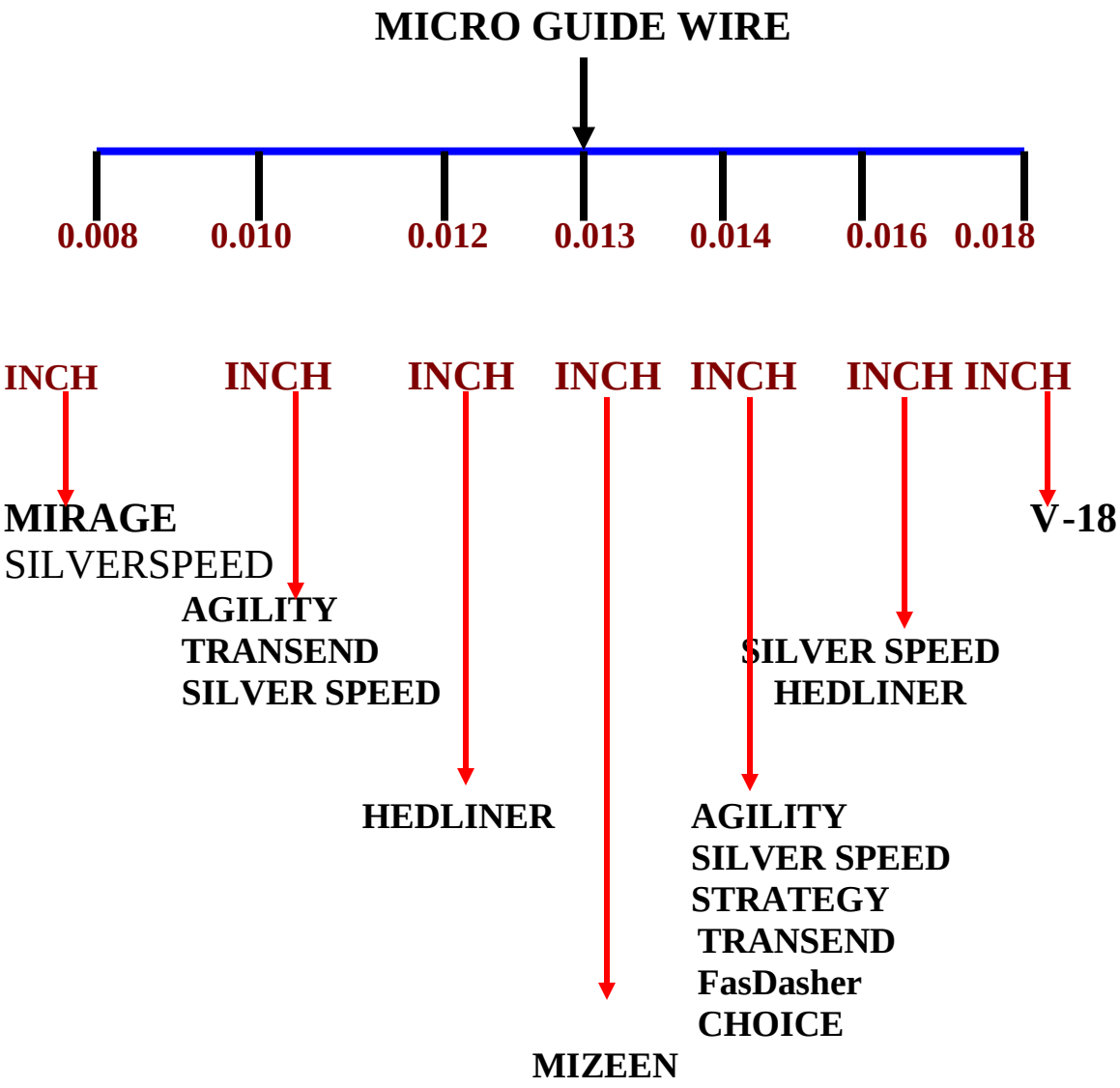
Guide wires are all constructed of fine stainless steel. Some guide wires are coated with Teflon (PTFE-Poly Tetra Flouro Ethylene) to reduce the friction coefficient of the guide wire within the catheter. Care must taken when a Teflon coated guide wire is passed through a metal needle or catheter hub,as the Teflon coating can become abraded and flake off.

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

The selection of a microguide wire can be difficult because there is the trade-off between increased flexibility and decreased ability of the microcatheter to pass over the microguidewire. Increased stiffness of the microguidewire may make traversing numerous curves very difficult. 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. The softness of the tip ,although important when the microguidewire has been deployed several centimeters, is moot when the microguide wire is first emerging from the microcatheter because the microcatheter buttresses even the floppies tip to make it almost needle like on its initial emergence from the catheter. Almost all microguidewires have a hydrophilic coating that improves perfomance. The smallest microguide wires for neuro interventional use are 0.08 inch in diameter; other ranges up to 0.018 inch in diameter.

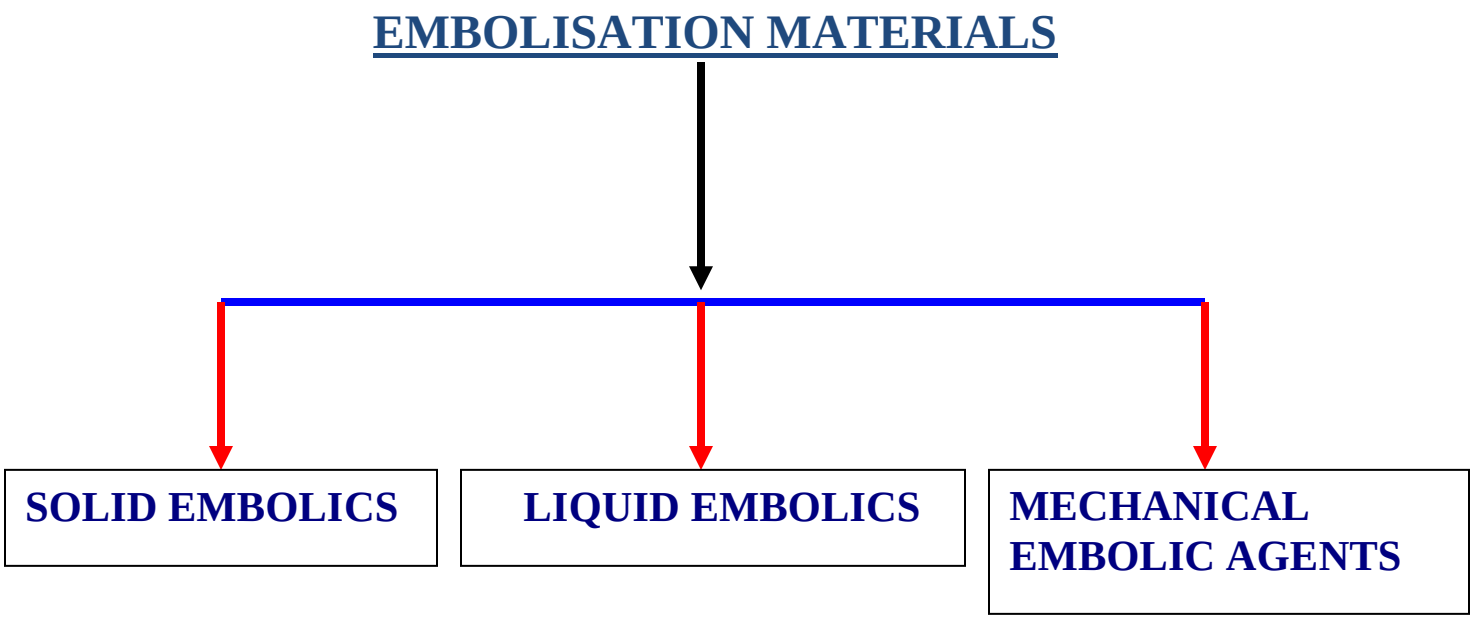


EMBOLISATION MATERIALS

The ideal embolic agent procedures should have several characteristics

1. readily available
2. easily prepared and injected

3. the agent should have little or no toxicity and cause minimal or no inflammation.
4. embolic should produce reliable occlusion that will persist for the desired duration at times,permenantly.
5. the agent should be radiopaque to illustrate delivery and should not hinder surgical removal of the embolised lesion.



Solid embolic agents

Solids thst have been used as a 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 with in the embolised vessel.

Polyvinyl alcohol

These are artifical embolisation devices .These devices are intended to provide vascular occlusion up on selective placement via an angiographic catheter.It is 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 determines 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
PVA	COOK
CONTOUR	BOSTON

COOK

SIZE RANGE
50-100µ
100-200µ
200-300µ
300-500µ
500-700µ
700-1000µ
1000-1500µ
1500-2000µ
2000-2800µ

BOSTON

SIZERANGE
45-150µ
150-250µ
250-355µ
355-500µ
500-710µ
710-1000µ
1000-1180µ

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 200µm-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 procine 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.It is available in a sponge form that can be cut into the desired pledget size, suspended in contrast, and injected though the microcatheter for non permanent occlusion of larger arteries supplying the lesion. Gelfoam is not radiopaque, and the contrast in which it is suspended serves as an indirect indication of its course and destinatio.Although compressible, the gelfoam pledgets can lodge in the catheter, causing it to become obstructed.The delivery catheter must not be over pressurized or the catheter will rupture and result in a proximal embolisation.

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.

Complications

1. stroke due to occlusion of undesired branches.
2. obstruction of venous out flow.
3. obstruction of catheter.
4. polymerization leads to a degree of angionecrosis.

HISTOACRYL CONCENTRATION CHART

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

DEHYDRATED ALCOHOL

It is a liquid agent used in the sameway 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 usally 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.

Besides brain AVM's and head,neck, and spine tumors,facial venous malformations can be treated with successfully with these agent Care must be taken to confine the alcohol to the venous mal formation, because tissue necrosis and superficial skin necrosis can be significant complications.

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 out side 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 withdrawl 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 confirm to the often-irregular shape of sacular 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.

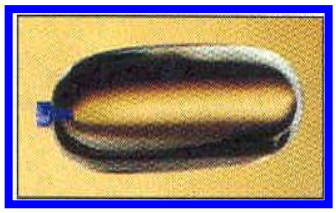
MATRIX COIL

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 patience 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 us cerebral angiography,pheripheral angiography,bronchography etc.

Therapeutic procedures again divided into restoration and obliteration procedure

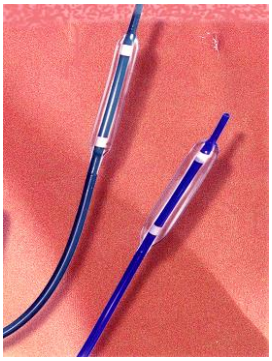
RESTORATION PROCEDURE

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

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.

BALLOON CONSTRUCTION

Balloons are constructed with specially treated polymers and processes, which provide maximum strength.

Each balloon inflates to its stated diameter and length over a range of 8ATM/BAR to its rated burst pressure.

The minimal dilating force required to dilate should be applied, minimizing the risk of balloon over inflation or rupture.

CATHETER CONSTRUCTION

The lumen marked distal is the central lumen of the catheter, which terminates at the distal tip. This lumen is used to pass the catheter over a guide wire. The lumen can also be used for infusion of contrast medium.
The catheter shaft tapers beneath the balloon segment to achieve the lowest possible deflated profile.

Radiopaque markers are placed under the balloon segment of the catheter to provide visual reference points for balloon positioning with in the vessel.

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. Biocompatiblity.
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 puzzle 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 flexiblity.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 excellerent 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.

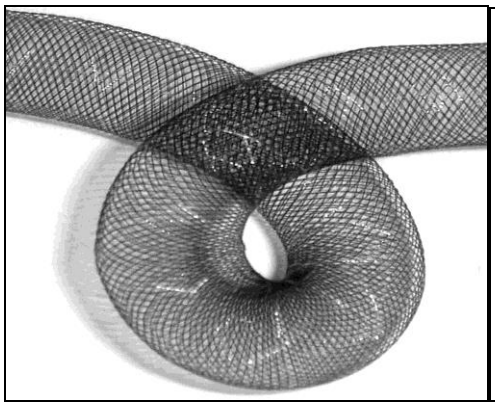
OBLITERATION PROCEDURE

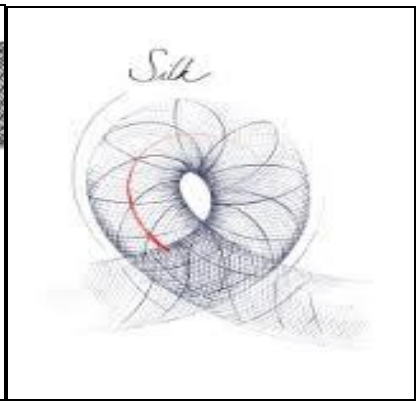
Otherwise referred to as 'Therapeutic Embolisation', using particulate materials delivered through micro catheters can be used in settings of acute bleeding from tumor vessels, vascular malformations, Aneurysms, Vascular tumors. Embolic materials in use include alcohol, metallic coils, gel foam,vascular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

Flow Diverter:

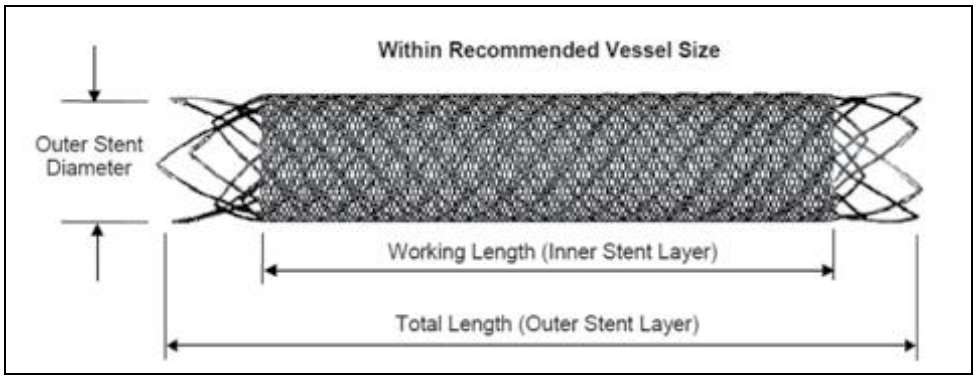
New Endovascular treatment option for complex inracranial aneurysms. The endo-vascular management of intracranial aneurysms include coil embolization techniques, such as balloon assisted and stent assisted coiling, are targeted towards the aneurysm sac, but flow diverters are endovascular devices placed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

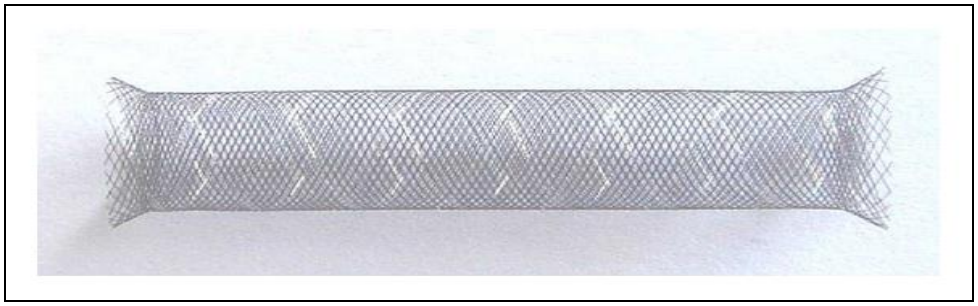




Pipeline flow diverter Silk flow diverter



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,

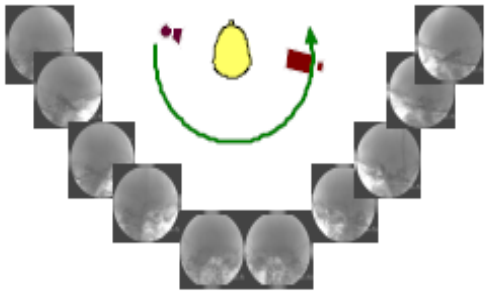
It can acquire and display three-dimensional volumes of the cerebral vessels during interventional procedures.An improved understanding of the three-dimensional vascular morphology positioning of catheters, coils, balloons, stents and glue.

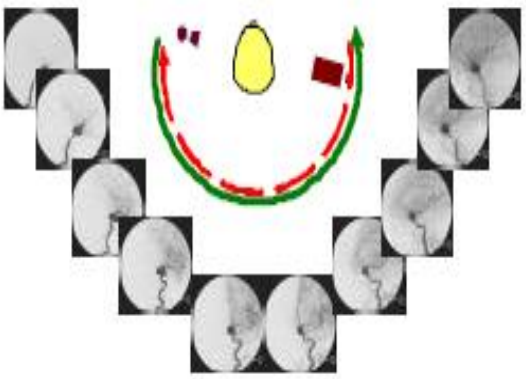
A series of images is acquired while the C-arm performs a continuous rotation around the region of interest.In this way, a complete series of images is obtained in a range of projections.The projections may be obtained in the axial plane, or with cranial or caudal angulation.

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





Patient Instruction and preparation:

The patient should be positioned on the table comfortably, with the head comfortably secured in the special head rest.

The patient must be fully warned of the possible sensation of the contrast including metallic taste in the mouth, warm sensation on the side of the head and face where the vessels will be injected and light flashes in front of eyes. The patient should be asked to close his or her eyes as there is a tendency for the patient to turn his orher head to follow the rotation of the gantry

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

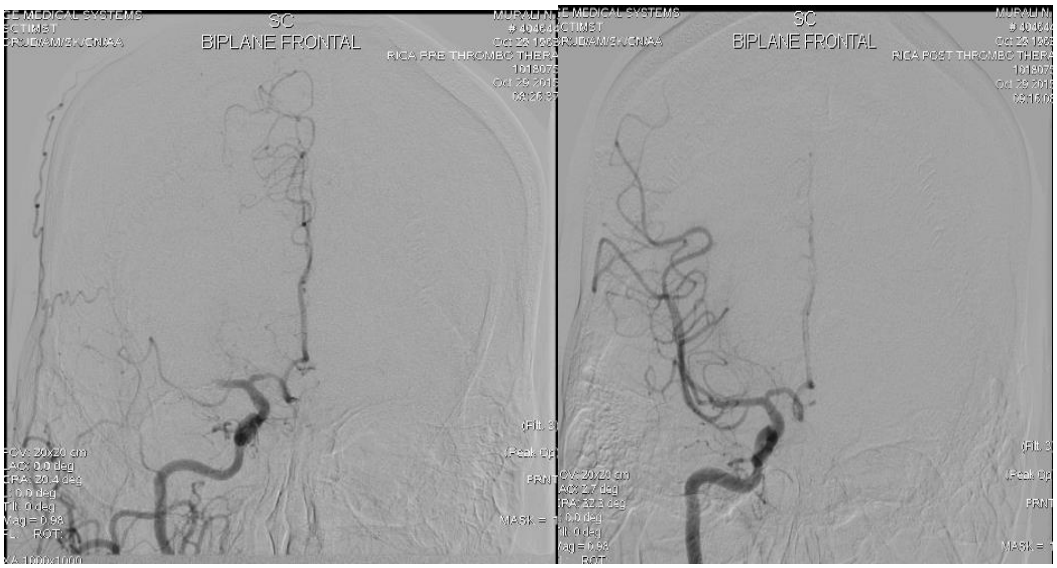
Acquisition

Images are acquired in the rotational angiography mode over an angle of 180°. The run may be performed in one of three different angulations of the C-arm: –30° cranial, 0° axial, or +30° 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° 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.

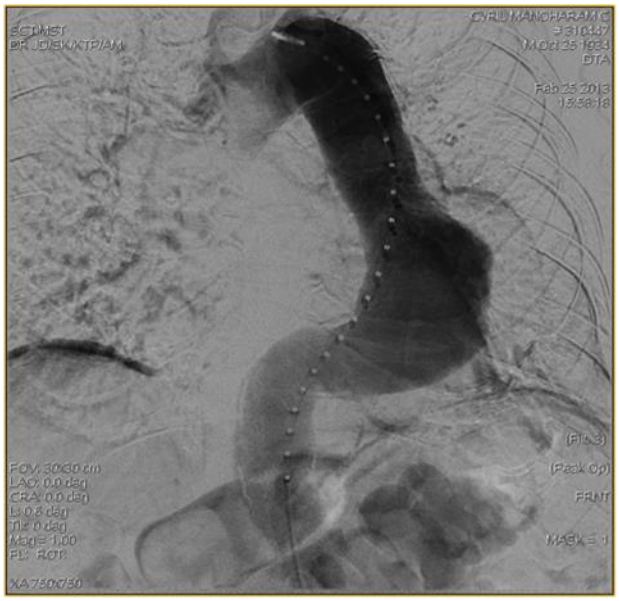
FEW EXAMBLES OF INTERVENTIONAL PROCEDURES ASSISTED

Mechanical thromboctomy

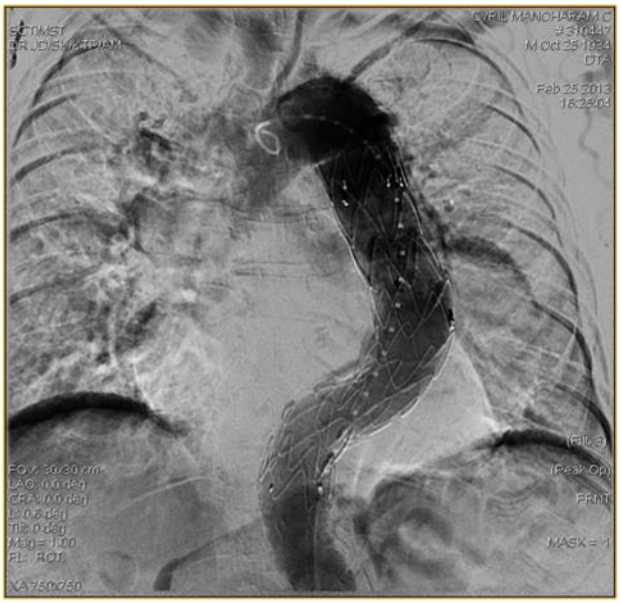


Pre procedure post procedure

TEVAR



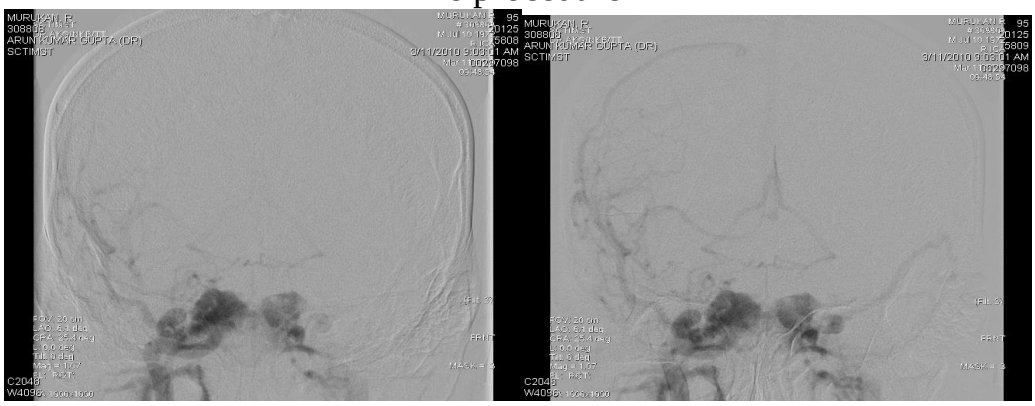
Before



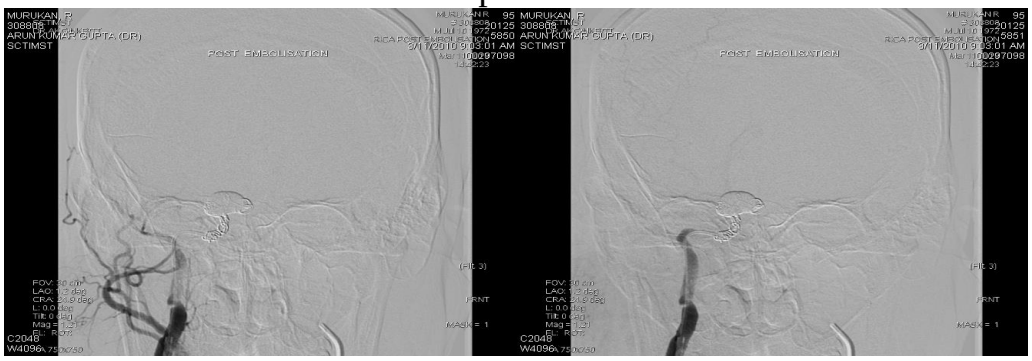
After

CCF embolization

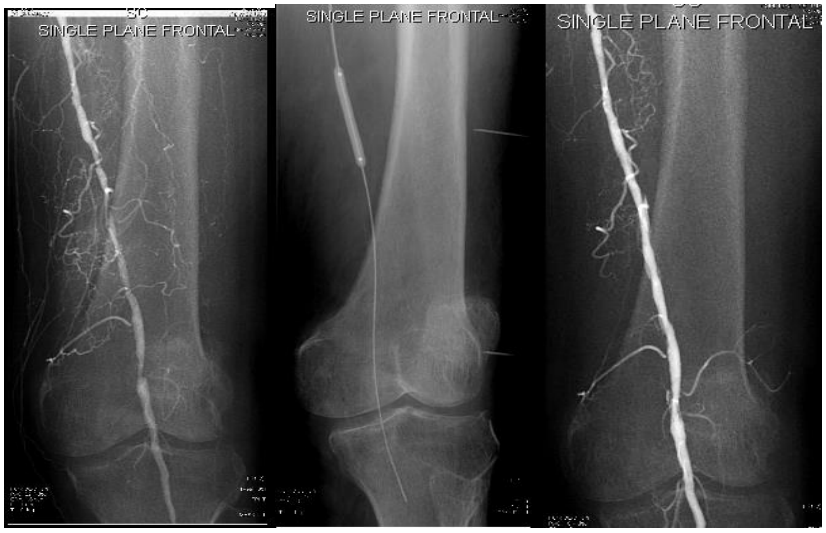
Pre procedure



Post procedure

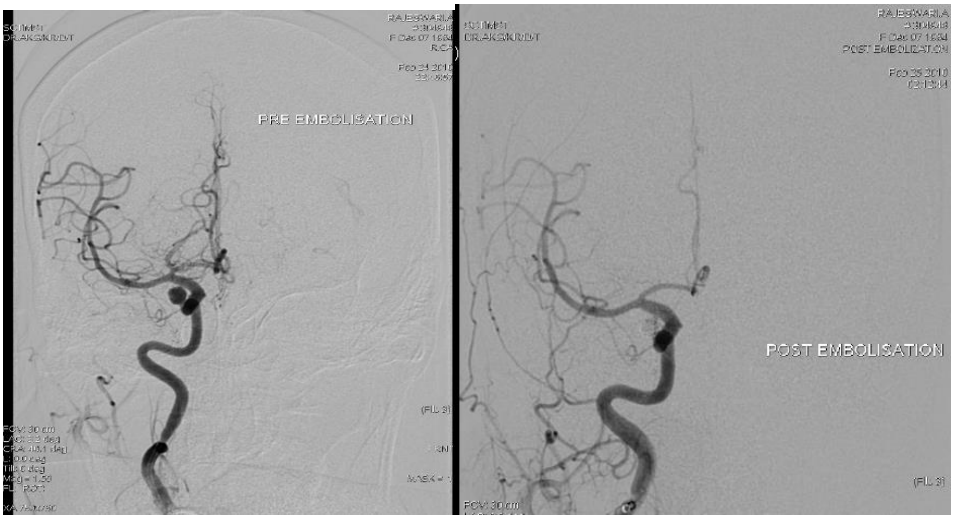


Angioplasty



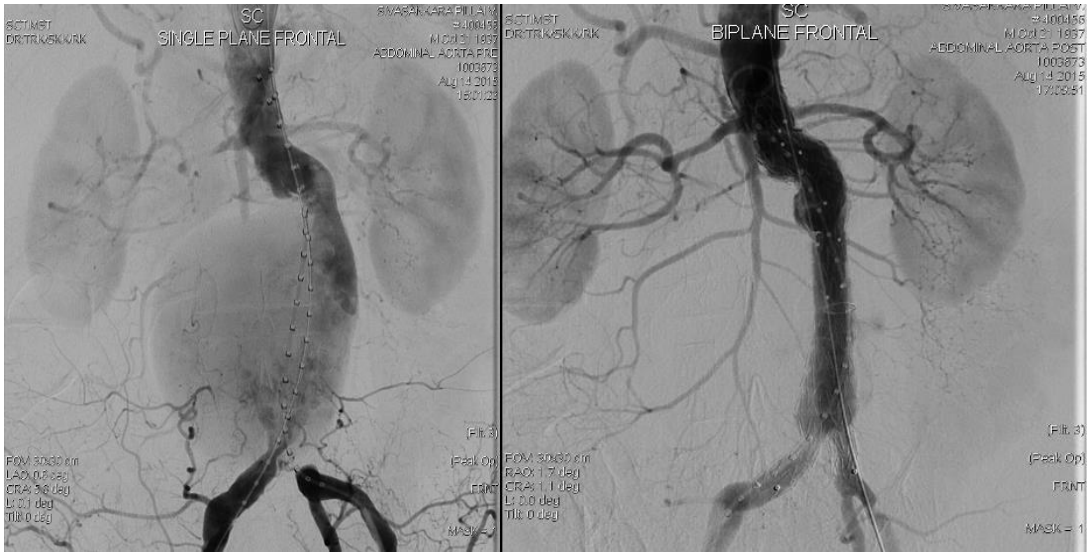
Pre procedure post procedure

ANEURYSM COILING



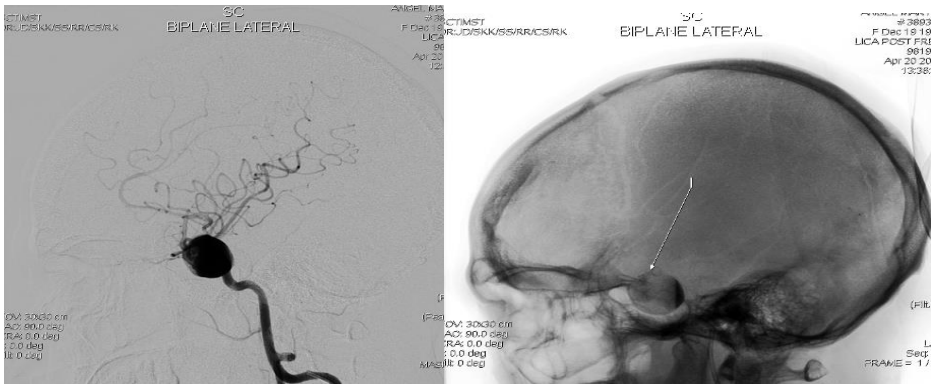
Preprocedure post pocedure

EVAR

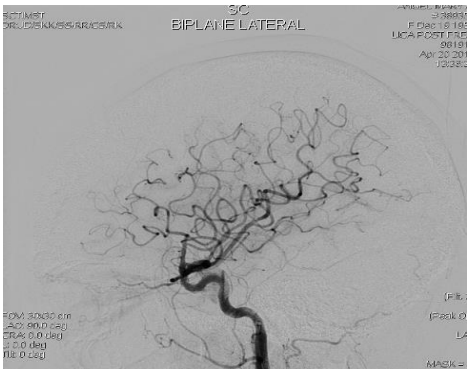


Pre procedure post procedure

FRED Flow diverter

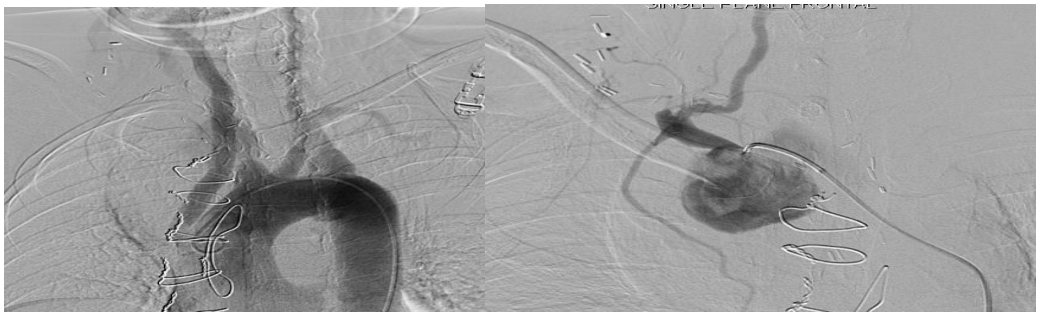


Pre procedure

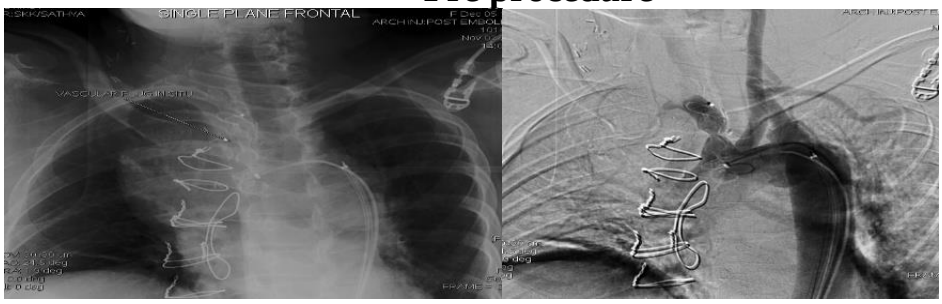


Post procedure

Vascular plug

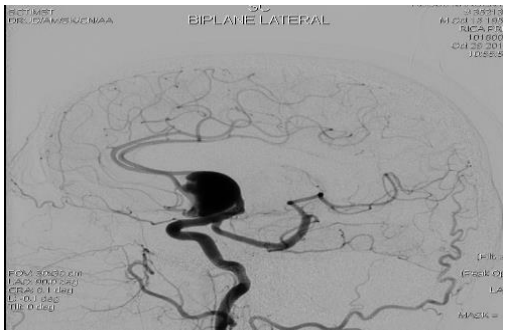


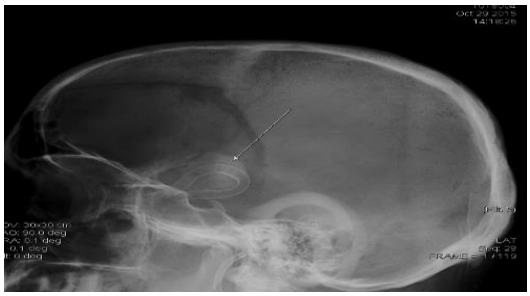
Pre procedure



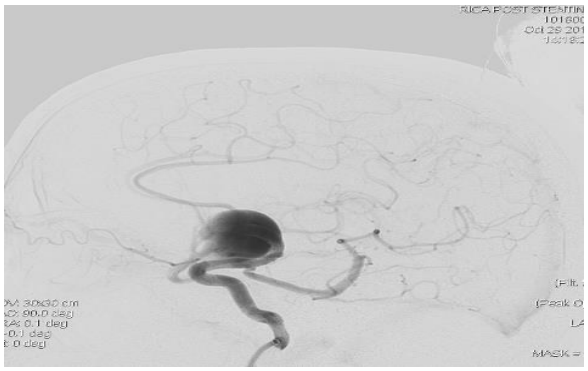
Post procedure

Pipeline flow diverter





Pre procedure



Post procedure

PROJECT

Effect of post labeling plane and post labeling delay in pseudocontinuous arterial spin labeling MR Perfusion

Effect of post labeling plane and post labeling delay in pseudocontinuous arterial spin labeling MR Perfusion

Introduction

Arterial spin labeling(ASL) perfusion method in MRI has reached in to higher level which allows its application in multiple clinical and research areas, for the visualization and quantification of cerebral blood flow (CBF).ASL labeling approaches mainly in two types: pulsed labeling and continuous labeling. The main difference between two methods are, implementation of RF labeling and its spatial extent. PASL uses a single short pulse or a limited number of pulses to invert a thick slab of arterial blood; on the other hand, labeling occurs over a long period in CASL, while blood flows through a single labeling plane. Pseudocontinuous ASL (PCASL) is a distinct form of PASL and CASL. pseudocontinuous arterial spin labeling is not strictly an adiabatic inversion and the efficiency of labeling may be subject specific. Here, first experiments were performed to study the better labeling plane in pseudocontinuous arterial spin labeling method to achieve the highest sensitivity

Second experiment were performed to study Post Label Delay (PLD),it is an important parameter associated with CBF,.The uses of multiple PLD methods were recommended recently In the clinical field

The purpose of this study was to compare quantitative CBF values in healthy control subjects using a whole-brain three-dimensional (3D) pulse sequence with pseudocontinuous technique in 3.0 T. Both short and long PLD were used in order to analyze the impact of delay time on CBF.

Review of literature

Arterial spin labeling (ASL) (Detre et al., 1992) is emerging as a powerful magnetic resonance imaging (MRI) technique for non-invasive assessment of cerebral blood flow (CBF). In contrast to commonly used but invasive perfusion imaging modalities, such as positron emission tomography (PET), dynamic susceptibility contrast (DSC)-MRI and CT perfusion, ASL uses magnetically labeled arterial water protons as an endogenous tracer. Perfusion is then calculated from the difference of labeled (tag) and non-labeled (control) images. Despite early concerns due to ASL's intrinsic low sensitivity, recent developments of labeling strategies (Wu et al., 2007; Dai et al., 2008) and acquisition methods (Fernández-Seara et al., 2005; Garcia et al., 2005) have considerably

improved its reliability, with a high degree of agreement to PET (Xuet al., 2010; Donahue et al., 2006b) and DSC-MRI (Weber et al., 2003).In addition, ASL can be used to assess functional activity and functional connectivity, with a number of important advantages compared with the commonly used blood oxygen level-dependent (BOLD) approach(Boscolo Galazzo et al., 2014; Federspiel et al., 2006; Liang et al., 2012,2014a). All these advances have led to ASL being increasingly used in clinical studies, and a consensus recommendation has recently been published for the ASL implementation for clinical application.

Estimation of Labeling Efficiency in Pseudocontinuous Arterial Spin Labeling by “Sina Aslan”,3 compared the labeling efficiency of pseudocontinuous arterial spin labeling MRI under normocapnic and hypercapnic (inhalation of 5% CO2) conditions and showed that a higher flow velocity in the feeding arteries resulted in a reduction in the labeling efficiency.he suggest that labeling efficiency is a critical parameter in pseudocontinuous arterial spin labeling.

MATERIALS AND METHODS

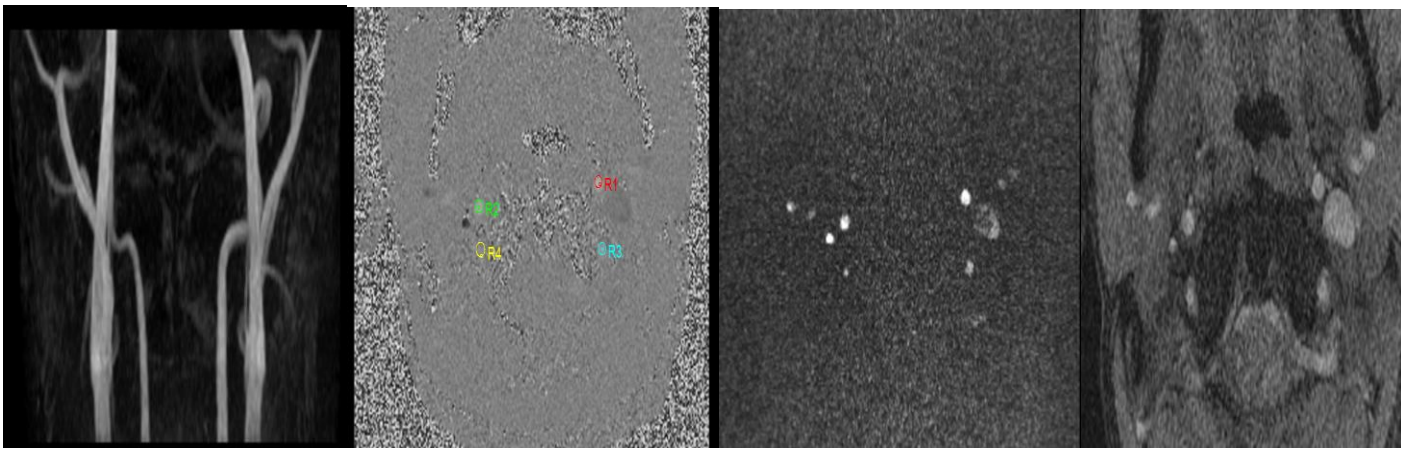
A total 5 subjects, were included in this prospective study. The subjects were defined as healthy they had no neurologic or cardiac disease, hypertension, peripheral vascular disease, or renal disease., age limit is taken between 25 to 30 years Each subject was scanned by using a 3T MR imaging unit (Discovery MR 750; GE Healthcare,) supplied with a 24 HNU channel coil

Three-dimensional time-of-flight angiography was performed to visualize the ICAs and the VAs ,all subject vessels are normal and normal vessel orientation no tortuosity is noted.PCMRI is performed to look for velocity of the intracranial vessels because higher flow velocity in the intracranial arteries resulted in a reduction in the labeling efficiency so The velocity of the bilateral ICAs and VAs were summed, and the derived blood velocity was averaged over the cardiac cycle ,all subjects velocity is in normal range. TOF angiography was used to position a perpendicular PCMRI plane at the cervical (C1–C2) level. The 2D PCMRI data were acquired with in the following protocol:

TR, 20ms; TE, 10ms; slice thickness, 5mm; flip angle, 15°; FOV, 220X220 mm2; views per segment, 6; velocity encoding, 70 cm/s; and NEX, 1. Twenty

six velocity-coded and magnitude images throughout the entire cardiac cycle were collected. A peripheral pulse signal was used for retrospective cardiac gating. The acquisition time of the PCMRI was approximately 3 minutes, depending on the subject's heart rate.

FIG-1

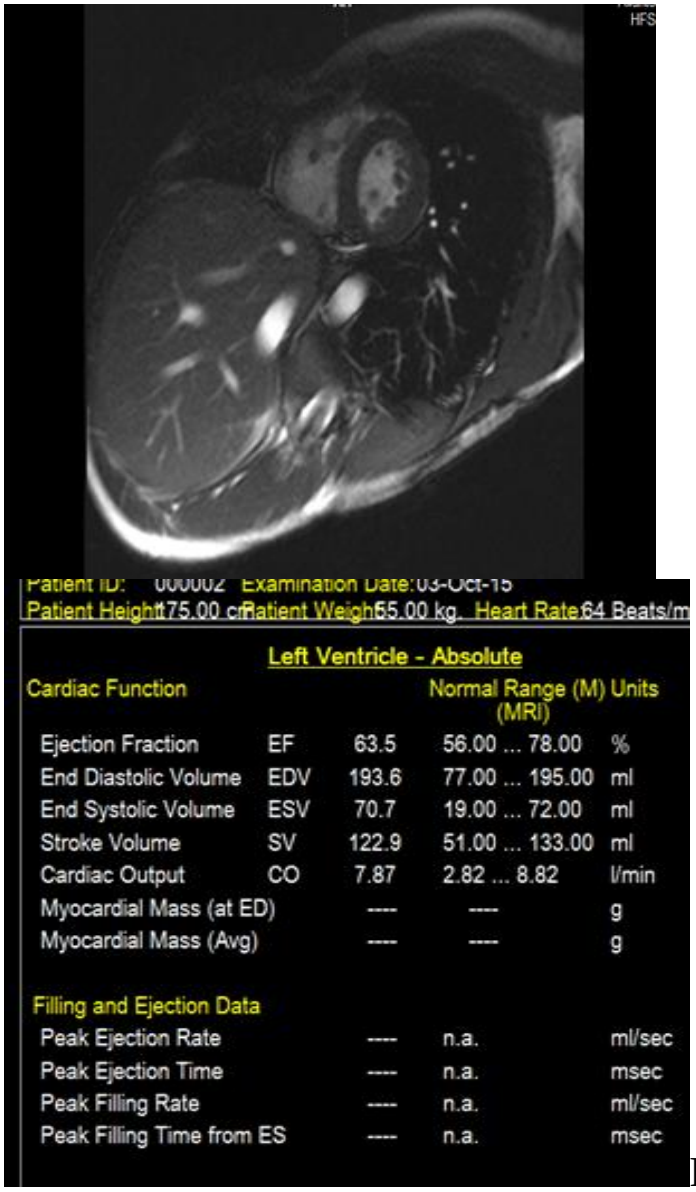


A B C D

Fig-1TOF AND PC velocity MRI of ICAs and VAs. A)3D Reconstruction of TOF angiogram used for the planning. B)Velocity map from the PC velocity MRI. Positive value indicates inflow blood, often corresponding to arteries, whereas negative value indicates outflow blood, typically from veins.C) Magnitude image of PC velocity MRI. The insets show the left and right ICAs and VAs, as well as the manually drawn ROIs.D) Raw image of PC velocity MRI.

Cardiac output would affect in the cerebral blood flow so all subjects cardiac ejection fraction calculated using cardiac cine short axis, all subjects were scanned in 1.5T MRI system. They were scanned in supine position with ECG and breath hold Phased array cardiac coil was used for signal collection. We are used cardiac gated multi segmented cine steady state free precession sequence .multi segmented cine imaging parameter as follows TR/TE 3.1/1.56ms, flip angle 70, FOV 320-380 mm, matrix 192X 256 ,slice thickness 8mm, gap 2mm

FIG-2 A B



Fig(2) A),short axis cine image of cardiac obtained in 1.5T Siemens system B)Result chart from acquired data that are processed using Argus software provided by Siemens

Study-1

Purpose of the study is to look for the cerebral blood flow changes based on the variation in labeling plane of ASL .for this study 5 subjects examined with the labeling plane varies from, 60,70, 80, 90,

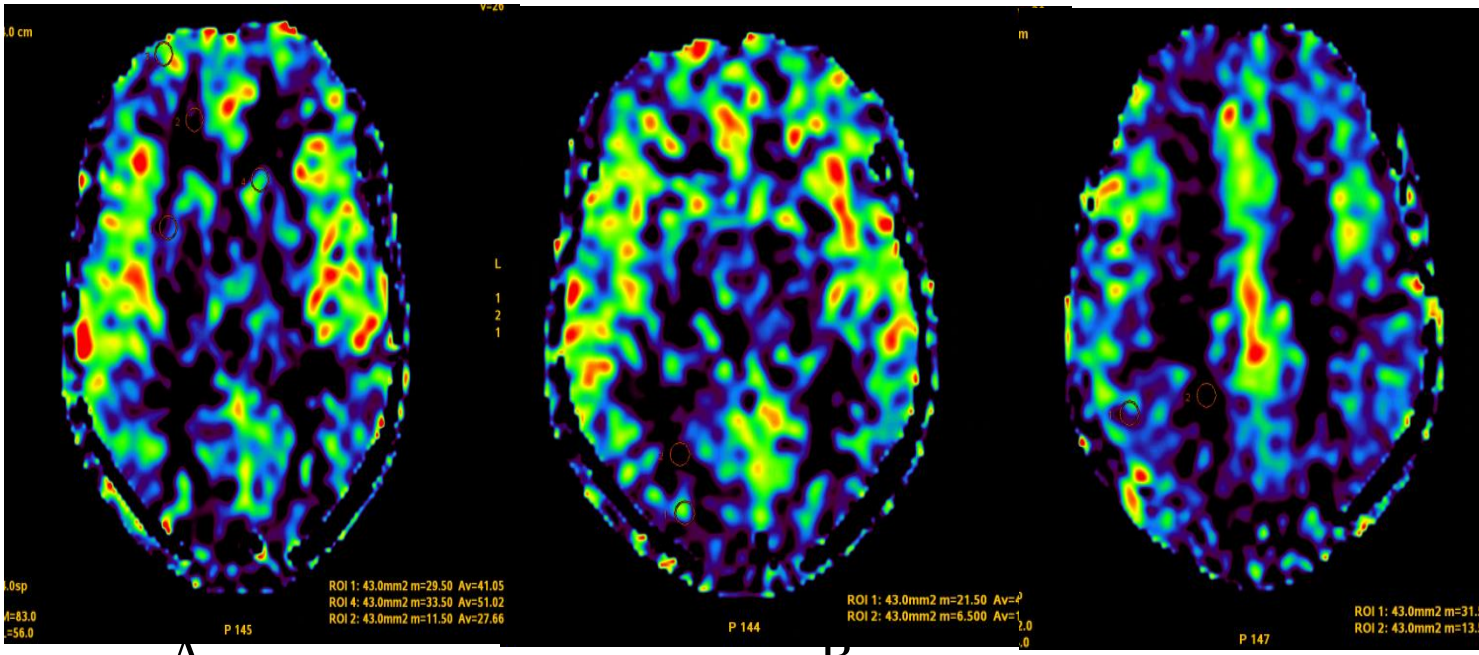
100, 110, and 120 mm distal to the anterior commissure –posterior commissure line

ASL perfusion data were obtained by using a 3D pseudo continuous ASL (pCASL). Followed by an interleaved 3D stack of spiral fast spin-echo readout with background suppression. The pCASL parameters were as follows: sampling points on 8 spirals, 512; FOV, 240X240mm2;reconstructed matrix,128 X 128; TR, 4674ms; TE, 10ms; NEX, 3; section thickness,4 mm; labeling plane position Varies from 60mm to 110mm;labeling duration-1500ms;Post labeled delay-2025ms,acquisition time was 4 minutes 31 seconds.

The pCASL CBF maps (in mL/min/100 g) were computed by the post processing REDY VIEW software (version 10.4.04; GE Healthcare) that was based on a general kinetic model for ASL. ASL Measurement of Cerebral Blood Flow in different brain region was taken placing the ROI In following regions Frontal gray matter, Parietal gray matter Occipital gray matter, Frontal white matter, Parietal white matter, Occipital white matter Caudate, Putamen. After that all the value in the different region are analyzed based on the labeling plane distance from the anterior commissure - posterior commissure line

Fig3-Asl images processed by using Ready view software that provide by GE Healthcare A).Showing ROI in Frontal gray matter, Frontal white matter, Caudate , and Putamen B). Occipital gray matter, Occipital white matter C) Parietal gray matter, Parietal white matter

FIG-3



A B

C

Study- 2

The goal of this study was effect of different post label delay on the resulting quantification and CBF Map and importance of proper post label delay time Settings based on the clinical application of brain perfusion

ASL was performed five times with different Post Label Delays (PLD)(1025,1050,2025,2550,and

3025).Comparisons of CBF map were made between five different Post Labeling Delays (PLD) in healthy control subjects .Bar diagram was generated from CBF measurements in the different regions of brain ASL. Measurement of Cerebral Blood Flow in different brain region was taken placing by ROI In following regions Frontal gray matter, Parietal gray matter Occipital gray matter, Frontal white matter, Parietal white matter, Occipital white matter Caudate and putamen

ASL perfusion data were obtained by using a 3D pseudo continuous ASL (pCASL). Followed by an interleaved 3D stack of spiral fast spin-echo readout. The pCASL parameters were as follows: sampling points on 8 spirals, 512; FOV-240x240mm2,reconstructed matrix-128 x128; TR-4674ms; TE,-10ms,NEX-3; slice thickness-4mm; labeling plane positioned at the base of the cerebellum; labeling duration-1500ms; post labeling delay-2025 ms20,PLD-1025,1055,2025,2525,and 3025.

FIG-4

A B

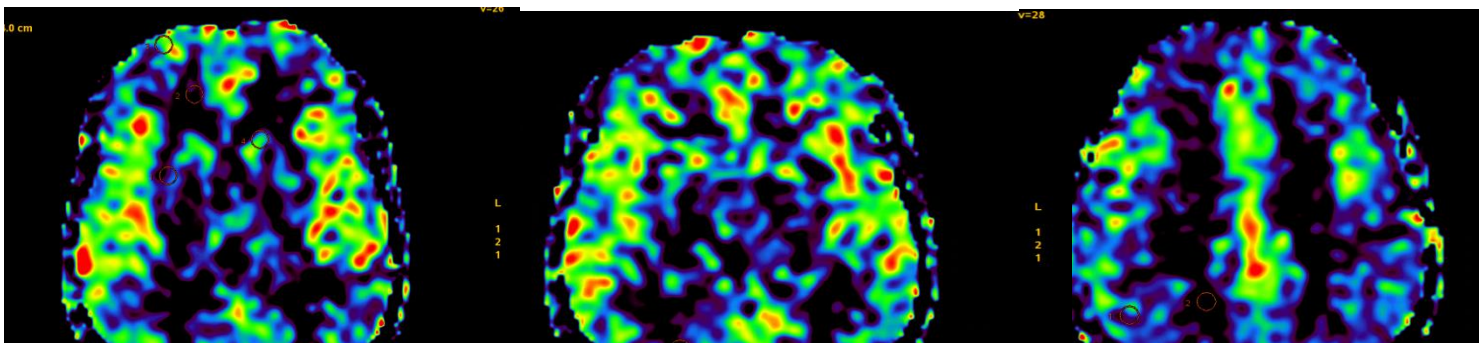


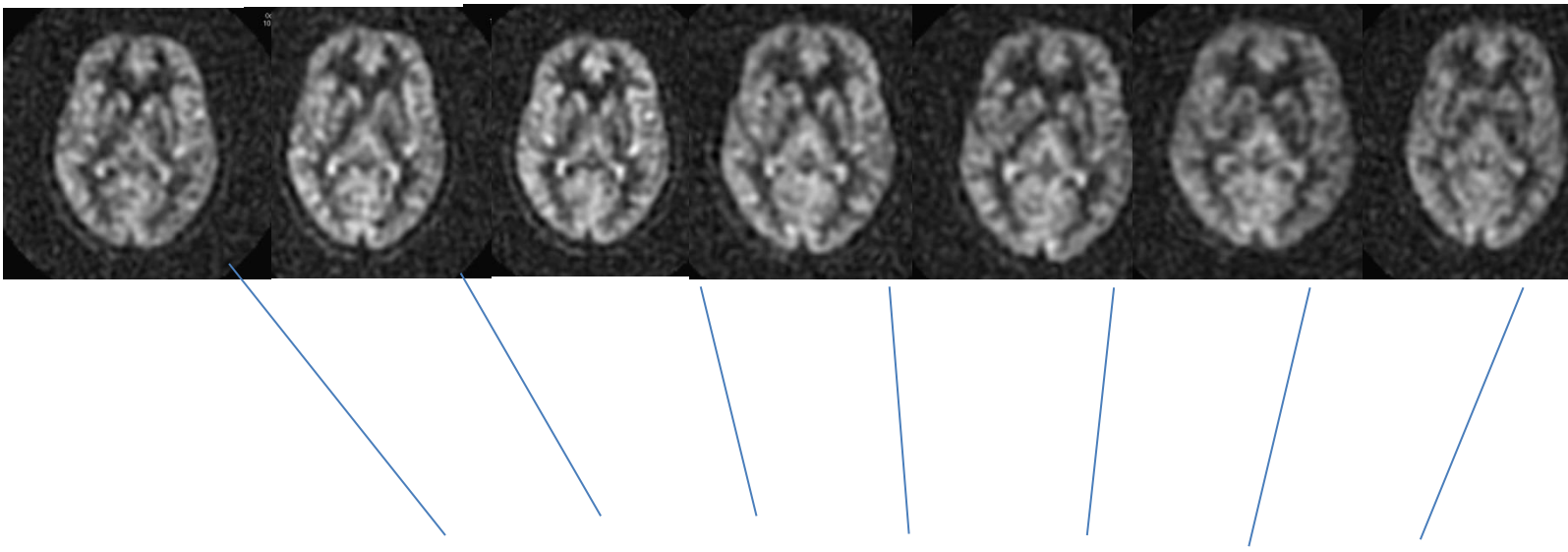
Fig4-Asl images processed by using Ready view software that provided by GE Healthcare A).Showing ROI in Frontal gray matter, Frontal white matter, Caudate, and Putamen B). Occipital gray matter, Occipital white matter C) Parietal gray matter, Parietal white matter

RESULTS

Study-1

Figure-5 shows the CBF-weighted signal intensity as a function of labeling position,The average CBF maps for each position -

FIG-5



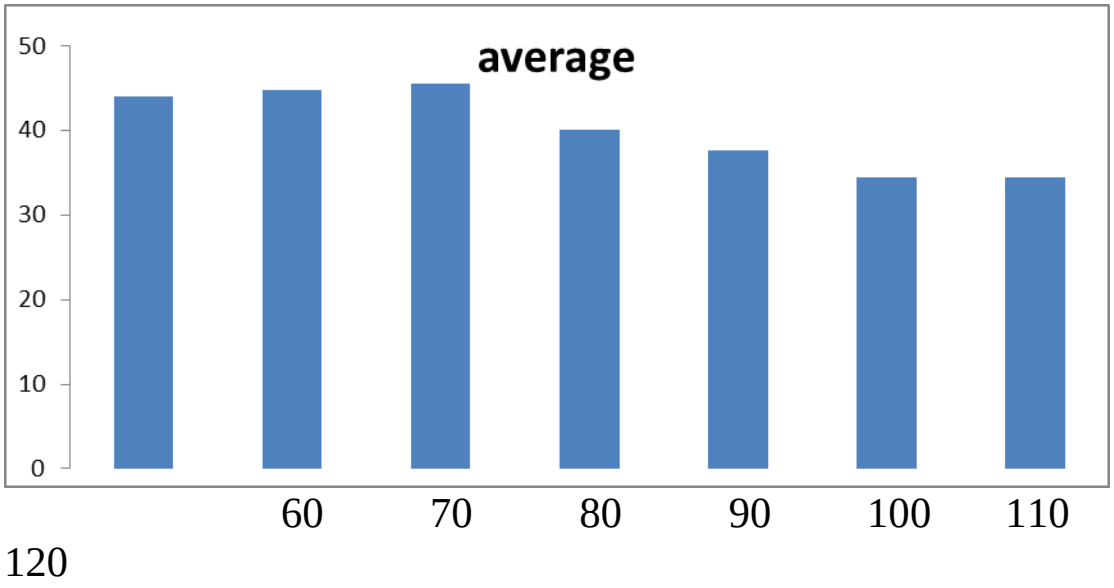


Fig-5 Here X- axis showing labeling plane distance from the anterior commissure-posterior commissure line that varies from 60-120mm.Y-Axis CBF Values (in mL/min/100 g) were computed by the post processing Ready view software, Measurement of CBF in different brain region was taken by placing ROI,and averaged value are taken.

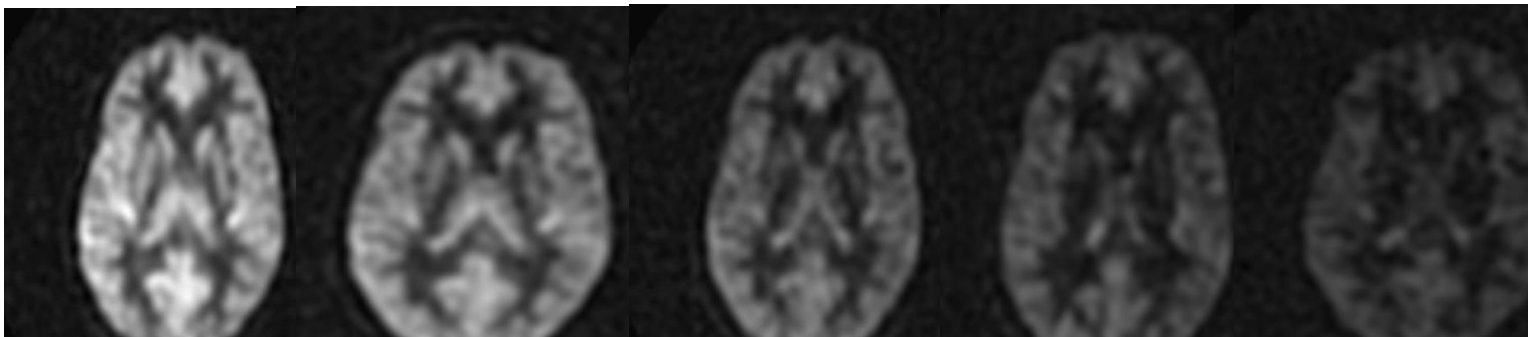
Are shown at the top of Fig. 5. Quantitative analysis revealed that the averaged signal intensity is highest when the label plane is positioned at 80 mm below the Anterior Commissure-Posterior Commissure line. For individual subjects, the peak location was 80 mm . CBF weighted signal at 120 and 110 mm was significantly lower than all other. It may be due to amplitude of RF field power decay of the

transmission coil at a distant location. When the labeling plane is very close to the brain that time also signal is decreasing may be due to vessels orientation .labeling plane 60,70, and 80 distance from AC,PC Line showing almost straight line signals.

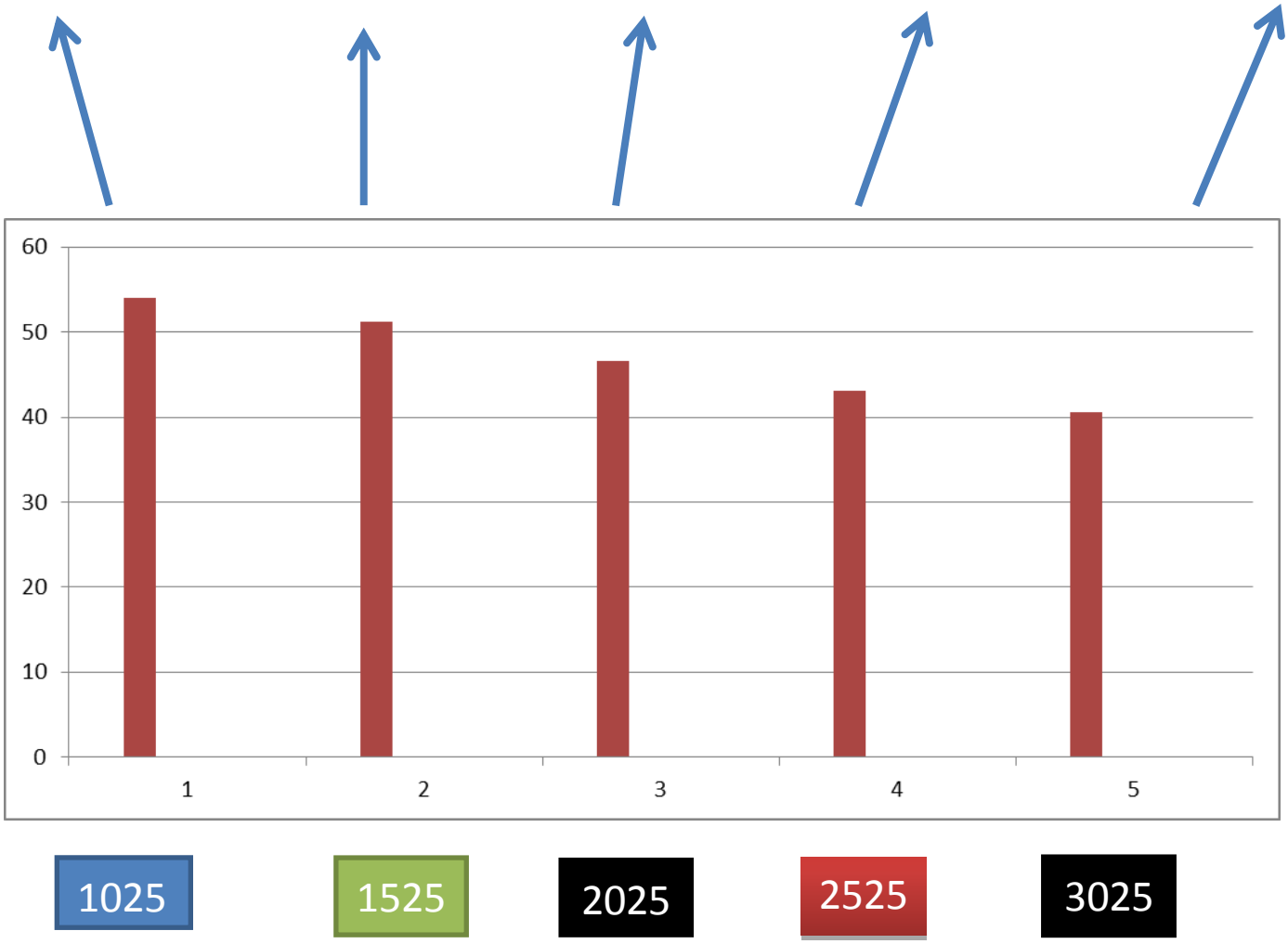
Study -2

FIG 6-shows the CBF-weighted signal intensity as a inversely proportional to the post labeled delay. The average CBF maps for each post labeling delay are shown at the top.Fig-7 calculation of averaged signal intensity using placing the ROI in the different brain regions .highest when the post labeled is at lowest 1025ms, that may be because of post labeling delay is significantly shorter than arterial transit time .without information about ATT, Keeping low PLD value CBF may be underestimated because a large portion of the tagged blood may not reach the capillary bed within this time frame. Hence there would be a significant large-vessel contribution to the CBF signal with a short PLD which means the labeled

FIG-6



FIG



X-axis-post label delay in ms
Y-axis –CBF Values (in mL/min/100 g)

Fig-6.Here X-axis showing different post labeling delay in ms including 1025ms,1525,2025,2525 and 3025. Axis CBF Values (in mL/min/100 g) were computed by the post processing Ready view software, Measurement of CBF in

different brain region was obtained by placing ROI,and averaged value are taken.

FIG-7

A B

C

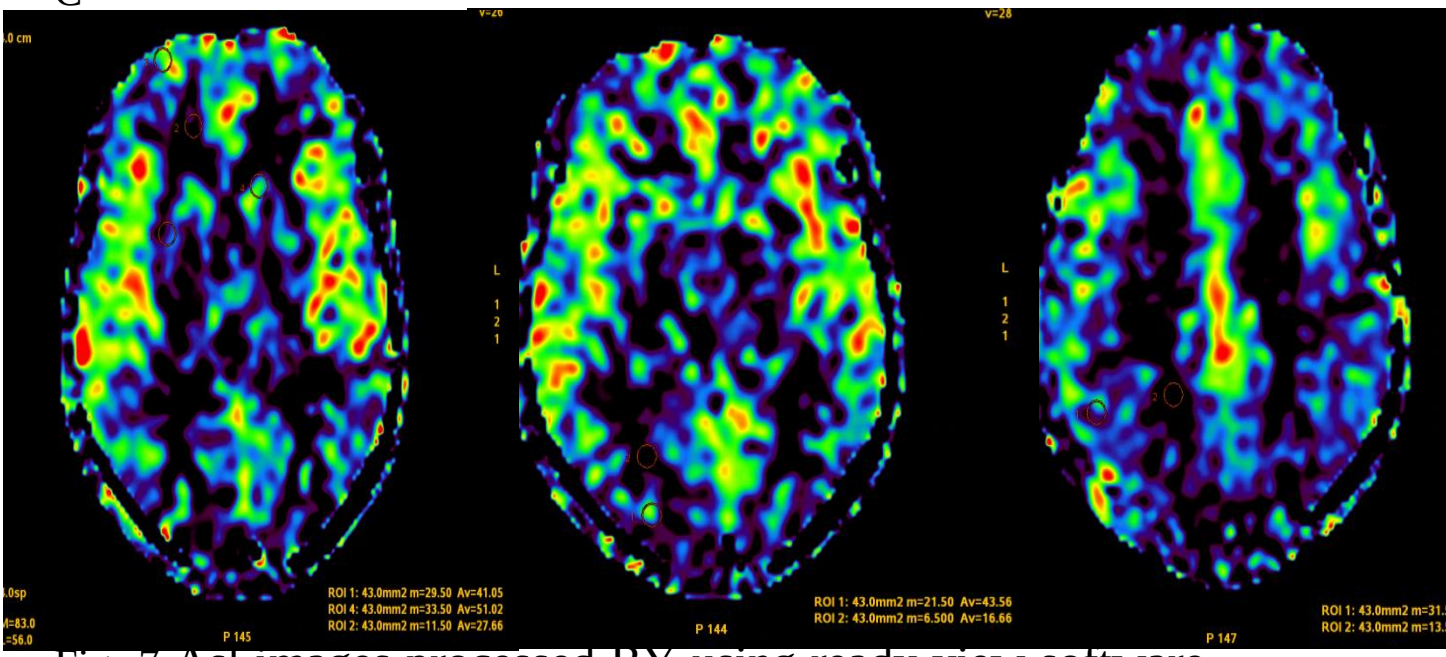


Fig -7-Asl images processed BY using ready view software that

provide by GE Healthcare A).Showing ROI in Frontal gray matter, Frontal white matter, Caudate , and Putamen B). Occipital gray matter, Occipital white matter C) Parietal gray matter, Parietal white matter

blood may be primarily within the vessels rather than the tissue.CBF weighted signal at 3025 ms was significantly lower due to When PLD is longer than ATT, the signals from the

extravascular compartment start to dominate, which means the PLD should be longer than ATT for the

intended tissues based on the ATT appropriate post labeling delay is important

DISCUSSION

In this study, We performed pCASL labeling at different anatomic locations and determined that labeling at 80 mm below the Anterior Commissure-Posterior Commissure line yielded the highest signal intensity, although the curve was relatively flat within the range of 60–80 mm. Several studies have pointed out the importance of labeling efficiency in pCASL. Wong conducted numerical simulations and showed that the labeling efficiency is lower when the resonance frequency is shifted from the center frequency due to amplitude of static field inhomogeneity

The ASL sequence used in this study had a short MR imaging acquisition time (5 minutes for whole-brain coverage), and we used a pseudocontinuous arterial-labeling scheme with 3D segmented readout, which is considered one of the best ASL approaches for assessing pCBF. It is important to emphasize that in this study, the ASL data were obtained with a commercially available ASL sequence, and the CBF estimates were quantified by using the

manufacturer's post processing software READYVIEW without any additional corrections.

The following description of the CBF quantification method was provided by the manufacturer of the MR imaging scanner

$$\mathrm{CBF}=6000\lambda\left(1-e^{-T_{\mathrm{sat}}/\mathrm{T1_{GM}}}\right)\frac{e^{\mathrm{PLD}/\mathrm{T1_b}}\,\Delta S}{2\alpha \mathrm{T1_b}\left(1-e^{-\tau/\mathrm{T1_b}}\right)S_0},$$

where PLD is the postlabeling delay time (ms); τ is the labeling durationin ms); α is a combination of inversion efficiency (0.8) and background suppression efficienct, λ is the tissue-to-blood partitioncoefficient (0.9 mL/g)35; T1b and T1GM are the longitudinal relaxation times of blood (1600 ms) and GM (1200 ms), respectively; *T*sat is the saturation time (2000 ms)18; *S*0 is the reference image signal (obtained voxelwise); and Δ *S* is the ASL difference image signal. The scaling factor 6000 was used to convert to CBF units (mL/min/100 g).

Important factor that depend on the ASL perfusion accuracy is the location of the labeling plane. Recommended the planning plane is at the base of the cerebellum and should be oriented perpendicularly to the cerebral feeding arteries. This placement was difficult to achieve; and also manually placing the labeling

plane for ASL was not possible, because the current commercial implementation of pCASL does not allow it. Furthermore, the tortuosity of cerebral arteries increases with age, were which may partly result the underestimation of pCBF , we observed a minor increase (from 46 to 48 mL/min/100 g) in the mean pCBF ASL in HE subjects with changing labeling plane. In future studies, it will beImportant to investigate in detail how the tortuosity of ICAs affecting the CBF

So In addition, with in patient, proper labeling plane is very important may have changes from one labeling plane to another labeling plane, for ensuring the proper labeling TOF angiogram can be helpful to understand about anatomy of the labeling plane. Proper labeling plane may important when looking drug treatment responses and other clinical situation .other factors such as amplitude of static field and

amplitude of RF field inhomogeneity may cause the labeling efficiency to be different across subjects…
The PLD used should be chosen properly. In order to explain choice of PLD, another parameter, arterial transit time (ATT) should be considered. ATT is duration required for the labeled blood to flow from the labeling region to the imaging region. ATT may vary in different species and physiologic states. The delay time can have a great effect on the resulting ASL signal. Measurement of ATT by ASL is technically challenging, with limited reported studies on its Clinical application.

The relationship between PLD and ATT is Complicated,When PLD is significantly shorter than ATT, CBF may be underestimated, because a large portion of the tagger blood may not reach the capillary bed within this time frame [7]. Hence there would be a significant large-vessel contribution to the CBF signal with a short PLD which means the labeled blood may be primarily with in the vessels rather than the tissue. As the labeled blood still locates in the arteries, the real perfusion in the brain cannot be obtained . When PLD is longer than ATT, the signals from the extravascular compartment start

to dominate, which means the PLD should be longer than ATT for the intended tissues. Thus, the choice of a proper PLD is critical.
One of the methods to suggest to estimate post labeling delay is based on normalization of pCASL signal with PC velocity MRI. Position the PC velocity MRI slice, at the level of same labeling plane that is used for the ASL,And acquired PC MRI data can process and calculate the velocity of blood based on the velocity choose post label delay, this method adding another 1.5 min to the session duration. Therefore, an additional 2–3 min of scan time is needed for our proposed technique. This may be particularly challenging for clinical scans. The processing of the PC velocity data involves manual drawing of four ROIs covering left/right ICAs and VAs, respectively

At present processing scripts are optimized and this typically takes less than 3 min. At present all vendors are providing only offline processing of PC MRI ,it is very easy in terms of the algorithm and procedure; they are quite straightforward and fast. Cerebral artery steno-occlusive lesions cause prolonged arterial transit time (ATT) that is required for delivery of the arterial water to the imaging plane . The choice of postlabeling delay (PLD) and pst labeling plane the range can affect accurate cerebral

blood flow (CBF) measurements that are taken using arterial spin labeling (ASL)

Comparing the above different post label delay and CBF differences, there is significance relation is there between post labeling delay and CBF, the differences of five subject PLD were compared. based on the clinical situation selection of proper post label delay is important not only the achieving the higher signal but also for the accurate quantification of the CBF, some of the clinical situation multiple PLDs may be helpful. It will be ideal to acquire serial ASL images at multiple PLD. Such a multi-delay ASL approach has several potential advantages over single delay ASL, including improved accuracy of CBF quantification, imaging of multiple hemodynamic parameters, and better visualization of collateral flow through dynamic image series [9]

Limitation of this study

When using a fixed labeling location the Anterior Commissure-Posterior Commissure line a range of labeling efficiencies was observed across subjects. But that may not be applicable to patient due to normal variance in vessel anatomy So In addition, with in patient wise there will be chance of variance

in the anatomy, So may have changes in the CBF Map from same labeling plane in different patients, for ensuring the proper labeling TOF angiogram can be helpful to understand about anatomy of the labeling plane

In this study The actual values in a voxel may be slight different from the assumed values. This will introduce error in the estimation. In particular, if there are regional differences in arterial transit time, tissue T1, or blood brain partition coefficient, CBF in some brain regions will be overestimated, while other regions will be underestimated. As a consequence, even though the whole brain averaged CBF is still correct; the regional values may contain errors. This issue is not specific to the efficiency estimation technique proposed in this study but is related to ASL CBF measurement in general. If an accurate relative CBF map can be obtained with ASL, our method of quantification will also be accurate. A well-known approach to reduce arterial transit time sensitivity is to use longer delay times. Motion artifacts during the ASL scan were not corrected, which might be a source of error in the pCBFASL estimates.

Second study, another factor that might influence the ASL perfusion accuracy is the location of the labeling plane. In the second study, the labeling plane was located at the base of the cerebellum and should

be oriented perpendicularly to the cerebral feeding arteries. This placement was difficult to achieve; manually placing the labeling plane for ASL was not possible, because the current commercial implementation of pCASL does not allow it and this study also quantified the CBF based on placement of ROI in different regions of the brain, so The actual values in a voxel may be slight different from the assumed values. This will introduce error in the estimation. This limitation also can overcome by calculating total brain parenchymal CBF.

CONCLUSION

- Labeling position is a critical parameter in pCASL MRI not only in terms of achieving highest sensitivity but also in quantification of absolute CBF in units of milliliters per minute per 100 g. For better CBF Map and quantification ASL appropriate post-labeling delay is very important,The post label delay time have a great effect on the resulting ASL signal

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