RESULTS

Table XXXI shows age distribution in 40 examined cases suffering from different vascular lesions studied in our series. Classifying them into three age groups, the first group till 20 years old, the second age group is between 20 and 50 years old and the third age group is more than 50 years old.

From this table we can see that the majority of intracranial lesions examined were in middle age group (22/40).

age	no.of case	%
<20 Y	6	15%
20-50Y	22	55%
>50 Y	12	30%

Table XXXII shows distribution of different lesions examined in our series. The number of aneurysms studied were 6, while the number of studied cases of arteriovenous malformations were 10 out of 40 thus representing the majority of studied cases.

Aneurysm	= 6
Artereovenous malformation	= 10
Arteriovenous fistula	= 4
Carotido-cavernous fistula	= 1
Dysplastic venous anomaly	= 2
Occult vascular malformation	= 1
Tumor vessel study	= 5
Vessel patency study	= 12

Vessel patency study is meant for analyzing the different possible vascular causes from vessel stenosis or occlusion that are responsible for the presenting radiological lesion. The collective number of different vessel patency study cases were 12/40.

The next three tables, XXXIII-XXXV, show comparative study between catheter angiography and MRA, whether native or after contrast injection, for the different cases studied in our series. MRA implies 2 characters, first its anatomical descriptive capability which is comparable to other radiological methods such as computer tomography or standard spin-echo. In addition to its vascular mapping nature, whether native or after contrast injection, which is comparable to catheter angiography.

Case	Lesion	CATHETER ANGIOGRAPHY	MRA/ + C.I.
2	Parenchymal high parieto-occipital AVMs.	Enlarged feeding artery. AV shunting/nidus. 3 early draining veins. No signs of thrombosis.	Enlarged feeding artery. Nidus detection. 3 draining veins after C.I. No signs of thrombosis.
3	left parieto-occipito-temporal AVM.	Multiple enlarged feeders with early multiple shunts. Better hemodynamic evaluation.	Enlarged feeding artery. Nidus detection. High flow pseudo stenosis segment. No signs of thrombosis.
6	2 Meningiomas right sphenoidal ridge + right high parasagittal.	Tumor blush. Prolonged vascular stain. Poor vascularity meningeal supply. Displaced right MCA.	Displaced right MCA. Absent neovascularity. Failed detection of vascular supply.
7	Left Right brain stem AVM with multiple vertebrobasilar system feeders.	Multiple enlarged feeders namely, right post. cerebral a, right SCA, right AICA and an ascending sharer from right vertebral artery. Nidus evaluation and venous drain was identical to MRA. Hemodynamic steel phenomenon from left posterior cerebral artery.	Indefinite proper evaluation of which artery from veterbrobasilar system is sharing in the AVM. Venous drainage detection after contrast injection was identical to catheter angiography. Definite exclusion of sharing of the carotid system in the angioma.
10	Brain tumor? Metastasis? 4x4 cm.	Highly vascular with multiple feeders & abnormal tumor vessels. Missed anomaly detection.	No signs of high vascularity. Central vascular signal void. Failed detection of vascular supply. Additional anatomical anomaly.
11	Carotido-cavernous fistula	Multiple dilated right CCF tributaries,sup.ophth., inf ophth.,sup.&inf.petrosal sinuses and ?other cavernous sinus.	Only the right superior ophthalmic v. was clear as the only arterialized tributary.Additional tributaries Additional tributaries required another excitation volume. Inferior ophthalmic vein was even not detectable by new study.

Case	Lesion	CATHETER ANGIOGRAPHY	MRA / + C.I.
14	Multiple bilateral cerebellar infarctions.	Multiple sites of embolic occlusions and slow flow areas along vertebro-basilar system on both sides with additional artery-to-artery collaterals.	Absent flow-related enhancement along major vertebro-basilar system vessels namely PCA, AICA, SCA, vertebrals on left more than on the right side.
16	Occult vascular malformation	negative external angiography study. No underlying cause could be detected for subacute hemorrhage. No trial for new catheter angiography study was planned.	No vascular lesion could be detected related to the hemorrhage area. The study was not conclusive. Contrast injection showed an ascending cortical vein at left high parietal area with intimate direct relation to the lesion.
18	Giant aneurysm originating from left anterior cerebral artery.	Better vessel of origin detection and neck evaluation. Assures the presence of rest lumen. Absent evaluation of surround. extra vascular area. Absent characterization for aneurysmal evaluation for thrombosed area.	Absent characterization for aneurysmal evaluation of thrombosed area. "MRA" neck of aneurysm detection. Absent hemodynamic evaluation. Non-invasive study.
19	Megadolicho basilar artery.	Giant tortuous basilar artery without any signs of stenosis thrombosis or occlusion.	Flow-related enhancement along whole coarse of basialr artery which shows extreme tortuousity.
21	Internal carotid artery occlusion.	Better hemodynamic evaluation of collateral pathway and recirculation.	Non invasively diagnosed the lesion without the need for contrast injection.
22	Small saccular aneurysm at right carotid artery bifurcation -0.5 cm in size-.	Better vessel of origin detection and neck evaluation. Assured presence of partial thrombosed aneurysmal area. No hemodynamically different evaluation was noticeable.	Resort to original images was mandatory to re-evaluate lesion. Contrast injection was not more beneficial for the aneurysm lesion evaluation.

Case	Lesion	CATHETER ANGIOGRAPHY	MRA/ + C.I.
28	Giant aneurysm originating from tip of basilar artery.	Better neck of aneurysm detection and evaluation. Assures presence of rest lumen. Absent extravascular evaluation of surrounding area. Absent characterization for aneurysmal chronologic evaluation of thrombosed area.	Absent characterization for aneurysmal evaluation of thrombosed area. "MRA" neck of aneurysm detection. Absent hemodynamic evaluation. Absent definite calcification detection and evaluation "Surgically is important".
31	Left posterior communicating artery aneurysm.	Better neck of aneurysm detection and evaluation. It is 7mm long, directed upward lateral and posterior. Hemodynamically significant cross flow to the left posterior cerebral artery through right posterior communicating a. No other aneurysms are detected.	Original images are better than MIP images. Final image by MIP is not informative compared to original gradient-echo images. Original images showed showed minimal flow detection in the aneurysm. Absent hemodynamic flow evaluation in both images-original & MIP-.
32	Right brain stem arterio-venous fistula.	Multiple enlarged feeders from right cerebellar a. Better evaluation of lesion connection of right petrosal sinus.	No definite nidus area is detected. Contrast injection added additional sort of mapping to the pathway of the lesion.
40	Arteriovenous malformation at right temporal, thalamic & brain stem cisternal area.	Better overall malformation hemodynamic evaluation. The area of the malformation and its arterial supply are definitely demonestrated superiorly in multiple angio lateral, Towen's and oblique views.	MIP images whether in native study or after contrast injection are superior than original images alone, regarding venous drainage pathway.

MRA = magnetic resonance angiography , native study.
C.I. = magnetic resonance angiography , after contrast injection.

ANEURYSMS:

Cerebral aneurysms are reported to be present in 1%-14% of the population [172].

Aneurysms most commonly manifest as acute subarachnoid hemorrhage and as such are a medical emergency. Secondly, they may present as cranial nerve palsies, (cases 18, 22, 28 and 31).

Screening nature of magnetic resonance angiography detected another 2 aneurysms from our cases, 25 and 30, as additional finding to other pathology lesions.

Describing an aneurysm should aim at definition of its vessel of origin, neck of aneurysm demonstration and whether it is thrombosed, partially or totally,. Lastly its effect on the surrounding e.g. mass effect or associated hemorrhage.

In our series are 4 aneurysms -single pathology-: cases 18, 22, 28 and 31. Cases 25 and 30 are double pathology lesions. The first is meningioma and aneurysm. The second is corpus callosum dysplasia in addition to middle cerebral artery aneurysm.

Table XXXVI shows comparative study between SE & MRA regarding the former descriptive criteria for cranial aneurysm detection.

4 from our 6 aneurysm cases were angiographically evaluated i.e. 66%, which are cases 18, 22, 28, and 31.

From the previous tables we see that contrast injection was not indicated in T1-weighted images for evaluation of cerebral aneurysms. While in MRA images, it can differentiate between lumen thrombosis and slow flow in an aneurysm.

Detection of vessel of origin was to big extent equivocal in SE & MRA images (6 detection in 6 cases). The multiplanar capability of MR is highly advantageous in detection and identification of vessel of origin in SE as well as MRA images. In addition to that, utilizing small slice thickness, 1mm, in MRA adds to its high definition of lesion area particularly for small sized aneurysms.

The final diagnosis of vessel of origin detection were in the following sequence; A1 segment of left anterior cerebral artery (case 18), right internal carotid artery bifurcation (case 22), left carotid artery at posterior communicating artery origin (case 25), tip of basilar artery (case no.28), M2 segment of left middle cerebral artery (case 30) and the left posterior communicating artery (case 31).

SE images are highly descriptive of different stages of aneurysmal thrombosis compared to MRA native images. In SE images, they were with the following criteria; 1 no definition, 3 good definition and 2 optimal definition. While thrombosis criteria definition in MRA native images were; 2 no definition, 3 good definition and 1 optimal definition.

In case 18, the giant size of the aneurysm did not facilitate identification which segment of the left anterior cerebral artery, the aneurysm originates from. Catheter angiography proved that the aneurysm originates from A1 segment of the left anterior cerebral artery.

In giant aneurysms, case 18, MRA images showed not uncommon intermediate signal intensity. This signal intensity although frequent for giant aneurysm, yet it does not describe the chronological process of thrombosis in an aneurysm.

We have also to mention that in differentiating thrombus from slow flow, MRA images are more informative. In case 18, there was an area of increased signal intensity in SE images. It could either a thrombus or residual lumen area. This area on MRA after contrast injection showed signal enhancement and thus describes a residual lumen of the aneurysm. This fact was another time documented after catheter angiography i.e. the presence of rest lumen. General hemodynamic evaluation of case 18 is better in catheter angiography. Delay of contrast arrival in left pericallosal is noted. No cross flow is detected from the other side.

A drawback of inflow MR angiography, that it is virtually impossible to distinguish between high signal clot from flow unless comparing with other SE images or referring to catheter angiography... Contrast injection in FISP images is not always advantageous in this subject.

In case 22, catheter angiography was superior than original images for neck of aneurysm evaluation. No more new hemodynamic information could be detected after catheter angiography compared to MRA original images. A local complication after catheter angiography was reported, bleeding happened due to early patient mobilization and a local hematoma developed.

In MIP family images, we could not at all visualize the aneurysmal lesion. We had to resort to original images to evaluate our case. Contrast injection did not add any more information to native MRA images.

In case 28, the multiplanar capability of MR utilized performing coronal MIP images with better visualization of the basilar artery aneurysm. Intraluminal signal behavior in the basilar artery was not homogenous along the whole lumen in MRA native images. A fact attributed to complex nature of flow in tortuous vessels. Calcification detection, which is surgically important to plane placing of surgical clips, failed also from MR study. Hemodynamic evaluation of flow delay in basilar artery compared to internal carotid circulation is detected after aortic arch angiography in this case.

In case 30, the screening nature of FISP images showed a silent small aneurysm in middle of M1 segment of left middle cerebral artery.

In case 31, catheter angiography showed significant cross flow to the left posterior cerebral artery through right posterior communicating artery. Also in this case, original MRA images were more informative than final MIP images. Neck of aneurysm proper evaluation was superior in catheter angiography.

26	36	38	40
d	s+d	d	d
-	+	+	+
+	+	++	+
++	+	++	++
-	-	-	-
+	-	+	++

ARTERIOVENOUS MALFORMATIONs

To evaluate detection of AVMs and their prescription, certain radiological criteria should be fulfilled with the applied technique to judge the capability of this new imaging modality in lesion identification..

In describing AVMs, these criteria are depiction of feeding arteries, nidus detection and size estimation, draining veins and lesion location..

Another 2 characters are very important in describing AVMs, which are hemorrhage detection and hemodynamics of the angioma.

Table XXXVII compares between SE & MRA regarding the previous mentioned criteria to evaluate properly MRA as a new imaging modality.

In our series are 10 cases of AVMs, cases 2 ,3 ,7 ,8 ,12 ,17 ,26 ,36,38 and 40. Four of these cases were angiographically examined which are cases 2 ,3 ,7 and 40.

In case 2, contrast injection in MRA series defined 3 draining veins of the arteriovenous malformation. These veins were totally absent in native MRA images. Catheter angiography findings were similar to that of MRA after contrast injection. No additive information were detected.

In case 3, due to the huge size of the AVM occupying most of the cranial hemisphere, the additive nature of MIP images were not much advantageous is showing morphology of feeding artery or draining veins.. Pseudostenosis sign in MIP images were indicative of high flow lesion. Catheter angiography showed, see table XIII page 197, multiple feeders of the AVM with multiple early shunt areas not seen in MIP images in addition to superior hemodynamic lesion evaluation.

In case 7, catheter angiography findings were parallel to contrast MRA evaluation. Additionally we detected significant hemodynamic steel phenomenon from left posterior cerebral artery to the lesion.

In case 8, location of AVM in right sylvian fissure was alone informative of feeding artery definition.

In case 12, although the AVM is deep seated, yet MRA images properly defined that it feeds from right M3 segment, A3 segment and probably from the right superior cerebellar artery. It showed also a definitely hypertrophied M3 and A3 (hemodynamic benefit).

In case 17, central AVM post-embolization thrombosis is better visualized in SE images more than MRA images.

In case 26, we visualized in native MRA images clearly that the AVM is drained by left transverse sinus in addition to poor visualization of feeding artery, this may denote a sharing fistulous element in the malformation or multiple sharing small feeders.

In case 38, the feeding arteries are mostly the cerebellars, their definition and identification is better assessed in small MIP volume than large volume or we have to refer to original MRA images to define them.

In case 40, the overall understanding of the AVM drainage is superiorly seen in MIP contrast images in combination with careful analysis of MIP native images with better overall malformation hemodynamic evaluation. MIP images whether in native study or after contrast injection are more informative than original images alone, specially regarding venous drainage pathway. Multiple angio lateral, Towne's and oblique views showed better arterial feeders with equivalent hemodynamic information. No areas of thrombosis in catheter angiography were detected as well.

IN SUMMARY, <u>main</u> feeding artery visualization detection in standard SE images were 3 non definition; 6 good definition and 1 moderate definition. While it was in native MRA 1 non definition; 5 good definition; 3 moderate definition and 1 optimal definition. In contrast MRA it was 2 non detection; 5 good detection; 3 moderate detection i.e. in favor of native study. Additional small arterial feeders are found in cases 3 and 7 after catheter angiography.

Nidus detection was better after contrast injection in MRA.

Draining vein detection in SE images were 5 non detection, 5 good detection, while in native MRA were 5 non detection, 4 good detection and 1 moderate detection. This value is better found after MRA contrast injection, 2 good detection, 7 moderate detection, and 1 optimal detection i.e. superior after contrast injection. Catheter angiography in small AVMs did not give additional valuable information than MRA, not to mention that MRA should be properly performed, case 2.

None of the evaluated cases in this study had an associated hemorrhage.

The nidus in 3 of our cases were superficial, 5 deep and 2 located both superficial and deep..

MRA definitely enhances the overall definition, orientation and visualization of cranial AVMs compared to SE. This is due to its flow sensitive nature in addition to thin slices examination acquisition. Yet, we have to mention that small arterial feeders are better detected in catheter angiography. If an AVM is of huge size, the additive nature of MIP degrades many of its mapping nature. Small volume, targeting, may solve this but then we may face the problem that less information would be in our slap or the need to perform another slap. Catheter angiography is essential to detect and evaluate hemodynamic effects of AVM lesions on other cerebral areas. This character could be achieved with slab saturation MRA, yet it needs additional time and proper slab positioning.

ARTERIOVENOUS FISTULA

In cases 13, 26, 32 and 34. In these cases we found that native MRA images were informative regarding either showing part or most of the venous pathway of the lesion.
The fistulous nature of the lesion permits the high pressure arterial system to visualize its self at least in the first segment of the draining veins, more than its visualization in the AVM. This is due to absence of saturation effect of veins in arteriovenous fistula.

Case 13 represents a special solely case of vein of Galen aneurysm. In native MRA images, we saw properly the aneurysm. Contrast injection was not more informative. The central area of the aneurysm showed signal loss in native MRA images due to high flow. Diagnosis of the aneurysm was equivocal in MRA images as in SE images.

In case 26, there was poor definition of the artery responsible for the lesion in native images. We could define only the abnormal venous vasculature draining in the left transverse and sigmoid sinuses. Contrast injection did not add more valuable information other than better delineation of the already defined venous circulation.

The same general principles apply in cases 32 and 34. In case 32, native images showed partial drainage through right petrosal sinus and straight sinus.
Contrast injection MRA showed additional drain through right vein of Rosenthal, terminal end of right internal cerebral vein towards vein of Galen.. Catheter angiography showed better lesion connection to right petrosal sinus.

In case 34, native images show part of the drainage along the brain surface bilaterally to reach the area of the superior sagittal sinus and drain in it.
Contrast injection showed the main drain through the straight sinus.

CAROTIDO-CAVERNOUS FISTULA

The arterialized nature of the superior ophthalmic vein in case number 11, did not require contrast injection. Native MRA images alone were conclusive in the diagnosis. Yet, detailed information of the fistula was labelled only after catheter angiography. Multiple connections are documented to petrosal sinuses, inferior ophthalmic vein and ? connection to other cavernous sinus.

DYSPLASTIC VENOUS ANOMALY

Cases 1 and 23.

In both cases, the gradient-echo 3D slices defined properly the nature of the lesion when compared to SE images.

Native MRA images were completely normal in both cases. A fact attributed to saturation effect. Contrast injection defined properly the nature of the lesions and showed multiple dilated medullary veins converging to the central draining vein in case number 1. While it showed a single dilated draining vein in case number 23

OCCULT VASCULAR MALFORMATION

Case number 16. This case presented with an external SE examination and negative catheter angiography study showing intraparenchymal hemorrhage in subacute stage in aim to evaluate nature of the lesion, follow-up and possible underlying cause.

Standard SE examination was performed. It showed an area 1.5#1.5 cm lesion lying typically at the grey-white matter junction surrounded by blood in different stages of degradation. Native MRA was negative in detecting the nature of the lesion. Contrast injection showed an ascending cortical vein at left high parietal lesion with intimate direct relation to the lesion. No vascular structure was detected in the lesion. Diagnosis could be either dysplastic venous anomaly or cavernoma associated with hemorrhage.

TUMOR VESSEL STUDY

In our cases, we studied 5 different intracranial tumor cases. These are cases 6 , 9, 10, 24 and 25. Three parameters are of radiological interest to asses tumor vessel study. These are vascular supply of the tumor, vessel displacement and neo-vascularity detection. Tumor size may play a role in better vascularity detection.

TableXXXVIII

Criteria	SE										MRA										CATH.ANGIO.	
	T1/C.I.					T2					native					C.I.						
Case no.	6	9	10	24	25	6	9	10	24	25	6	9	10	24	25	6	9	10	24	25	6	10
Tumour size	1x1	1x1	4x4	5x5	4x4																	
Vascular supply	-	-/-	-/-	-/-	-/-	-	-	-	-	-		-	-	+	-	-		+	+	-	++	++
Vessel displac.	+	-/-	+/+	+/+	+/+	+	-	-	+	+		-	-	+	+	++		-	+	++	+	++
Neovasc.	-	-/-	-/-	-/-	-/-	-	-	-	-	-		-	-	-	-	-		-	(+)	(+)	++	++

- = -ve, + = +ve, (+) = not definite

- = no definition/detection + = good definition/detection

(+)= good with caution ++ = moderate definition/detection

Table XXXVIII shows a comparative study between SE & MRA whether native or after contrast and catheter angiography of the 5 examined cases regarding previous mentioned criteria.

Generally MRA is still of limited capability regarding tumor vascular study and it is not at all comparable to catheter angiography in evaluation of tumor lesions. We do not have in MRA an arterial phase, capillary phase or venous phase.

Major vessel displacement using MRA could be oft detected rather than full prescription of vascular supply detection. 2 of the cases did not show at all any vascular displacement while another 2 showed displacement out of 4 total evaluations. While vascular supply were not at all seen in 3 cases and only 1 case showed poor definition of its vascular supply.

Neovascularity detection differs permanently from its definition in comparison to catheter angiography. It is actually a combination of 2 factors. Noevascularity detection(a) in addition to areas showing increased enhancement due to blood brain barrier destruction(b)..

Neovascularity is still poor in MRA due to slow flow at the capillary level in addition to inadequate resolution capability of the present voxel size.

The overall vascular definition of the tumors was generally easier and better in large sized tumors than small sized ones.

Additional criteria that may add to MRA tumor study is its role in the differential diagnosis from other vascular lesions. In case 6 in native SE images, the lesion criteria was either a meningioma of the right sphenoid ridge or a middle cerebral artery aneurysm. Native MRA showed a normal artery which is slightly compressed and displaced by the tumor lesion.

Case no.	SE parenchymal lesion detection	SE vascular evaluation	MRA Native	MRA C.I.	Cath.Ang.
4	Putamen infarct"lenticulo striate artery region	-ve	-ve	not done	not done
5	MCA territory infarct	-ve	+ve	+ve	not done
14	Multiple infarctions in terrio-toreis of basilar/cerebell.aa	basilar a. -ve cerebell.aa -ve	basilar +ve cerebell.aa-ve	not done	basil.+ve cerebell.+ve
15	Hypoplastic verteb.a,iatrogenic multiple infarct in territories of thalamus/brain stem i.e. PCA	verteb a -ve basilar a -ve post cereb -ve	verteb a +(+)ve basilar a -ve post.cereb -ve	not done	not done
19	Megadolichobasialr artery	+ + + ve	+ + + ve	+ + + ve	+ + + ve
20	Sylvian fissure infarct, territory of MCA	MCA -ve	MCA +ve	not done	not done
21	old infarct in territory of MCA	Int carot. -ve MCA -ve	Int carotid+ve MCA -ve	not done	Int car.+ve hemody.++ve
27	cingulate gyrus,genu,head of caudate nucleus infarct i.e.ACA	-ve	absent A1 left ACA	+ (+) ve	not done
29	infarct in territory of MCA	Int carot. +ve MCA -ve ACA -ve	Int carot.+ve MCA +ve ACA -ve	Int carot.+ve MCA +ve ACA -ve	not done
33	Bilateral thalamic infarcts	-ve	-ve	-ve	not done
37	MCA territory infarct	Int carotid a+ve MCA -ve ACA +ve	Int carotid+ve MCA +ve ACA +ve PCA ectatic+ve	Int carotid+ve MCA +ve ACA +ve PCA ectatic+ve	not done
39	PCA territory infarct	PCA -ve	PCA +ve	not done	not done

VESSEL PATENCY STUDY

MRA vessel patency study compared to SE examination was done in the following cases 4, 5, 14, 15, 19, 20, 21, 27, 29, 33, 37, and 39. They are totally 12 cases. Catheter angiography was additionally performed in 3 cases -25%- 14, 19, and 21.

Table XXXIX shows comparative study between vascular lesion detection in SE & MRA and catheter angiography. In SE examinations we evaluated parenchymal lesion seen in contrast to vascular lesion detection and both were evaluated against vascular lesions detection in MRA and the examined cases using catheter angiography.

From table XXXIX, we can depict that MRA has a good accuracy rate of detecting vascular patency disorders and it has an optimal correlation with SE study. This fact is true if the examined vessel has also a high percentage of visualization in native MRA images.e.g if the causative lesion is due to thalamostriate artery disorder, then we should not expect a high possibility of detection in MRA images.