

Role of Interventional Neuroradiology in Intracranial and Spinal Vascular Disorder

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Abstract : Interventional neuroradiology (also known as endovascular neurosurgery) is a branch in which minimally invasive diagnostic and therapeutic procedures of cerebrovascular disorders are performed under radiological guidance. The endovascular, minimally invasive approach ensures minimal injury to normal brain as compared to open surgery. With advancement in technology, there has been remarkable growth of this medical speciality and interventional neuroradiologist plays a crucial role in treatment of intracranial and spinal vascular disorders. Diseases like aneurysms, arteriovenous malformations, arterial stenosis and thrombotic vascular occlusion can be treated by endovascular approach.

BRAIN ATTACK “STROKE”

Stroke is third leading cause of death and disability worldwide. The patients who survive this disorder are many times disabled with inability to lead independent life resulting in huge social costs. In India, the incidence of stroke is likely to increase in future because of increasing population, increasing life expectancy and changing lifestyles (urbanization, smoking, salt/alcohol intake, stress, physical activity). WHO estimates that in India the number of deaths from stroke are likely to significantly increase in coming years. Recently, there have been many advances in treatment of patients suffering from this disorder. Interventional Neuroradiology is one of the medical specialities which are playing more and more important role in treatment of stroke.

INTERVENTIONAL NEURORADIOLOGY - INDUCTION

Interventional neuroradiology (also known as endovascular neurosurgery) is a branch in which minimally invasive diagnostic and therapeutic procedures of cerebrovascular disorders are performed under radiological guidance. In these procedures very thin catheters/wires etc. are placed usually through the femoral artery and are navigated within the vessels to the site of the abnormality, followed by diagnostic or therapeutic procedures. The endovascular, minimally invasive approach ensures minimal injury to normal brain, with less complications, better outcome and shorter hospital stay.

Growth of endovascular treatment of cerebrovascular disorders has been slower than as compared with interventions in cardiovascular diseases. Brain is a highly specialized organ as compared to heart and even a small area of cerebral injury can result in marked deficits. Another fact which differentiates stroke from heart attack is short window of time available for any intervention in cases of stroke and high chances of complications if case selection is not appropriate. However, recent advances in implements used for neurointervention such as in catheters, coils, stents, etc. as well as

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in knowledge and attitude regarding brain attack has resulted in rapid growth of the medical speciality of interventional neuroradiology. These procedures are usually performed by trained interventional neuroradiologists who work as a team with neurosurgeons and neurologists.

HAEMORRHAGIC “BRAIN ATTACK”

Intracranial haemorrhage can occur due to hypertension, aneurysms, vascular malformations, tumors, coagulopathies, vasculitides, amyloid angiopathy etc. In every case determination of exact cause is necessary for treatment planning.

One should remember that excluding trauma, aneurysm rupture is most common cause of subarachnoid haemorrhage. Whenever an aneurysm or an arteriovenous malformation is suspected, digital subtraction angiogram (DSA) is mandatory for detection and planning of treatment. At present, CT and MR angiograms are not accurate enough to replace DSA. However, these modalities are used when DSA facilities are not available.

Intracranial aneurysms (Fig.1) : Intracranial aneurysms usually present due to subarachnoid haemorrhage (SAH). Aneurysms can also present due to mass effect, thrombo-embolism or may be discovered incidentally. High morbidity and mortality is seen in untreated patients with SAH, most commonly because of re-rupture of the aneurysm¹.

Although traditionally the aneurysms have been treated by surgery, recent advances have made endovascular treatment of aneurysms feasible as well as safer than open surgery in many circumstances. In fact, a recent randomized, multicentre trial conducted in Europe and North America has shown that long-term clinical results were better with embolization than open surgery².

Endovascular embolization is most commonly performed by placing a microcatheter by endovascular route into the aneurysm followed by occlusion of the aneurysm with platinum coils (Fig.1). Recent advances such as retrievable balloons and intracranial stents enable one to treat aneurysms which were previously regarded as untreatable by this method. Availability to perform 3-D angiograms enables very precise evaluation of these disorders leading to accurate treatment (Fig.1).

CEREBRAL ARTERIOVENOUS MALFORMATIONS (AVMs) :

AVMs can present with haemorrhage, seizures, focal neurological deficit or can be discovered incidentally. AVMs are usually apparent on CT/MR, but if hematoma is present or the AVM is small it can be missed on these imaging techniques. DSA is the "Gold Standard" investigation to diagnose AVM as well as for treatment planning. Brain AVMs can be treated by endovascular embolization, surgery or by radiation therapy (Gamma Knife). Endovascular treatment is performed by embolization with glue (NBCA, n-butyl 2-cyanoacrylate) through microcatheters placed in the nidus. Disadvantage of surgery is high complication rate in large or deep seated malformations. However superficial small AVMs situated in non-eloquent areas can be treated by surgical method. Gamma knife is useful in small size AVMs but the treatment effect takes almost two years to take place. Combined treatment by using more than one of the methods is done in many cases.

DURAL ARTERIOVENOUS MALFORMATIONS

Dural fistulas are abnormal arteriovenous connections within the dura mater and especially within the walls of the sinus. They are usually acquired in nature many cases occur following thrombotic incidents in the dural sinuses. One should be aware of the fact that dural AVMs with cortical venous drainage have a high propensity to cause cerebral haemorrhage and should be treated as an emergency. They can be treated by transarterial and transvenous endovascular methods.

ISCHAEMIC STROKE "BRAIN ATTACK"

CT is usually the first investigation to exclude the haemorrhage. MRI is more sensitive to detect infarcts, particularly in early stages. Diffusion-weighted imaging is most sensitive in early detection of infarcts. Doppler of neck vessels is usually done to evaluate for any carotid stenosis as the cause of the ischaemia. MR angiography (MRA) or CT angiography (CTA) can also be done to detect extra/intra cranial stenosis. Cardiac evaluation is also done to evaluate for possible source of embolus. DSA is done if stenosis found in non-invasive investigation and to evaluate for causes other than atherosclerosis (such as vasculitis, dissection, aneurysms etc.)

Carotid artery angioplasty/stenting³ (Fig.2) : Carotid artery stenosis is cause of ischaemic stroke in many patients. Significant stenosis of carotid artery predisposes to repeat stroke in spite of medical treatment such as anti-platelet therapy. Carotid artery stenting can be done with limited risks and is an alternative to surgical endarterectomy. Protection devices are also available which have probably reduced the risk of this procedure. Significant stenosis in other arteries leading to brain such as vertebral artery and even the intracranial arteries such as basilar and middle cerebral artery can be treated by angioplasty/stenting procedures.

Arterial Thrombolysis⁴ (Fig.3) : Ischaemic brain attack/stroke can be treated by giving thrombolytic drugs which can open up the blockade so as to save as much of the brain as possible. These drugs can be given by intravenous route if a patient comes to the

hospital within three hours of onset of brain attack. Intra-arterial thrombolysis can be performed by placing a microcatheter in to the blocked vessel followed by injection of thrombolytic drugs (urokinase or t-PA). This selective (intra-arterial) treatment can be given at least upto 6 hours after the stroke in anterior circulation and upto 24 hours in selected cases of posterior circulation stroke. However, to make use of these treatment modalities, patient should reach a stroke centre/hospital within the prescribed timeframe. The earlier the treatment is done, better are the outcomes. New techniques such CT/MR angiography and perfusion imaging can help to select cases most likely to benefit from Thrombolysis and to extend the time frame available from thrombolysis.

Venous thrombolysis⁵ : Venous infarcts due to occlusion of the dural sinuses and the cortical veins are also common in our country. Most of the cases can be treated by heparin. However selected group of patients who are in bad clinical condition or who don't respond to heparin can be treated by endovascular transcatheter thrombolysis of dural venous sinus. The time window from occlusion to recanalization is much wider than in arterial thrombosis and patients can be treated many weeks after the sinus thrombosis.

RECENT ADVANCES

Intracranial Stenting^{6,7} (Fig.4) : Intracranial stenting is done for different purposes such as for stent assisted embolization of intracranial aneurysms, to treat intracranial stenosis and some time even for dural sinuses occlusion/stenosis.

Although extracranial stenting such as for carotid artery bifurcation stenosis have been treated by stent placement, intracranial stenting has gained popularity only recently. This is because of technical difficulty in placing the stents through the tortuous anatomy as well as possibility of devastating complications as the intracranial arteries are different from extra cranial vessels such as coronary arteries. Dedicated intracranial stents have become available which facilitate this procedure to a great degree and one is likely to observe significant growth of these procedures in near future.

In fact, recent data shows that intracranial stenosis is responsible for stroke in a significant number of patients and these patients have high risk of stroke in spite of aggressive medical treatment. Intracranial angioplast/stenting is fast becoming an option of treatment in these cases. In the past, wide-neck intracranial aneurysms were difficult to treat by endovascular method. However, with availability of intracranial stents, stent-assisted coiling is possible in these cases.

Endovascular(Cath/Dsa) Lab

Dedicated angiography laboratories are needed to perform these procedures which should have all the facilities including high quality imaging as well as neuroanaesthesia facilities. There have been advances in technology which makes intracranial endovascular procedures safe and effective.

* **The 3-D technology** allows construction of images in 3-D format, which can be post-processed and evaluated on a separate dedicated workstation. This results in accurate assessment of diseases affecting blood vessels such as

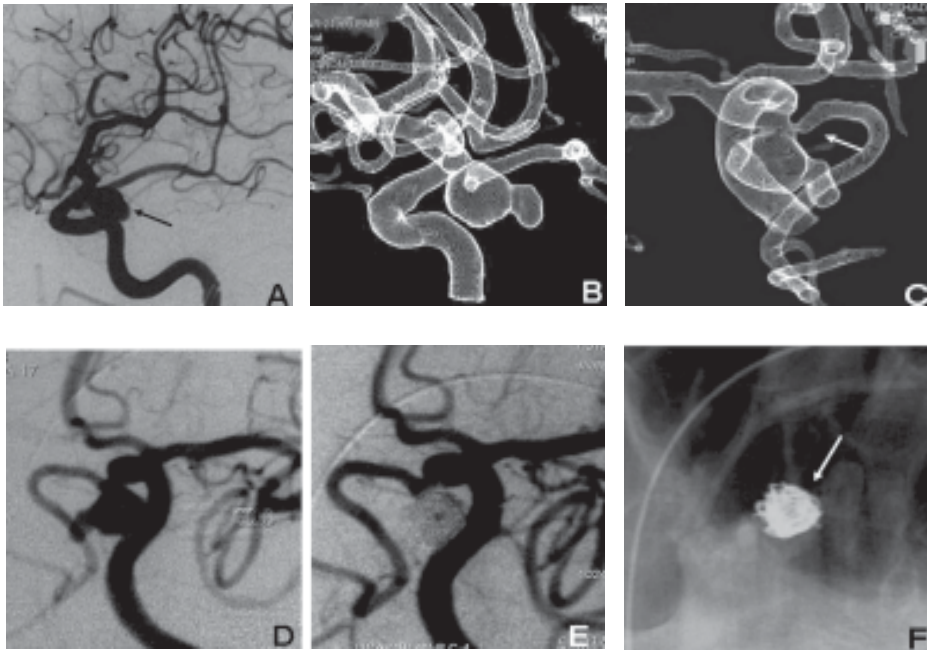


Fig.1 : A 65 year old female presented with subarachnoid haemorrhage due to an aneurysm on posterior communicating artery. The relationship of the aneurysm with the parent artery was not clear in routine DSA (Fig.A) 3-D angiogram was performed (Fig.B) which was then manipulated (rotated) to profile the aneurysm neck and the parent artery (Arrow, Fig.C). After obtaining this information, DSA was performed in the same angulation (Fig.D) followed by embolization with complete occlusion of the aneurysm (Fig.E). Fig. F shows the coil mass

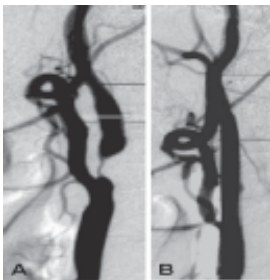


Fig.2: Significant carotid stenosis (Fig.A) in a 60 year old patient with recurrent transient ischaemic attacks was treated by stent placement with complete recanalization (Fig.B)

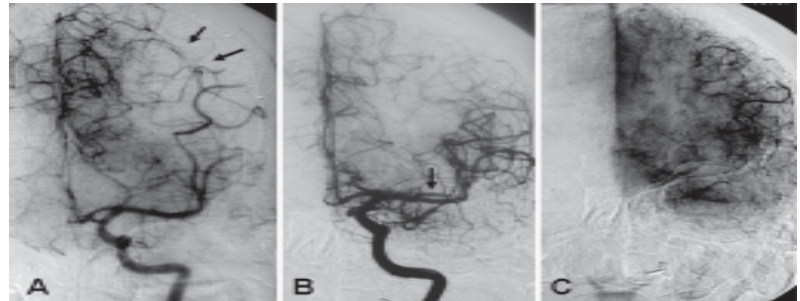


Fig.3 : A 62 year old patient presented with acute hemiparesis. Angiogram showed decreased filling of cortical branches of middle cerebral artery (MCA) with hypoperfusion in the left cerebral hemisphere (arrow, Fig.A). Thrombolysis was performed with microcatheter placed in MCA. Final angiogram revealed recanalization of upper division of MCA (Arrow fig.B) with reperfusion of cerebral parenchyma (Fig.C)



Fig.4 : A 60 year old female presented with syncopal attacks due to B/L intracranial ICA stenosis. The stenosis in right ICA (Arrow, Fig.A) was treated by stent-assisted angioplasty (Arrow, Fig.B) with complete resolution of the symptoms



aneurysms and stenosis, resulting in better treatment planning.

- * **The flat panel DSA technology** helps in having high-resolution images with decreased radiation exposure. This is achieved by using a digital system rather than the older optical systems.

Mechanical Recanalization Techniques in Acute Ischaemic Stroke⁸: One of the problems associated with chemical thrombolysis has been the increased possibility of haemorrhage which increases the complication rate and limits the time period available for recanalization. One of the options is endovascular mechanical removal of clots which can avoid these problems. Result of the Mechanical Embolus Removal in Cerebral Ischemia (MERC I) study, a phase I trial to evaluate the safety and efficacy of mechanical embolectomy in the cerebral vasculature have been reported which showed that cerebral embolectomy with the Merci Retriever was safe and that successful recanalization could benefit a significant number of patients, even when performed in an extended 8-hour time window. In future we are likely to use more and more mechanical devices in acute stroke patients.

Stroke centre⁹: Studies have shown that treatment of the stroke patients in dedicated centres result in significantly improved outcomes. Neurosurgical and neurology units should work as a team with the interventional neuroradiology (endovascular) group. Acute Stroke Unit and, if possible, stroke ICU also result in improved outcomes. Advanced neuroimaging facilities should be available with MRI and CT facilities. Care in stroke units decrease the number of deaths and increase the number of independent survivors. Treatment strategies must be developed in collaboration with other neurological sciences and experienced multidisciplinary teams must be responsible for the handling of patients with vascular CNS lesions.

CONCLUSIONS

- * Neurointerventional radiology plays a major role in management of intracranial vascular disorders.
- * Improvements in imaging, hardware, expertise are occurring and likely to result in rapid growth of this speciality in coming years
- * Endovascular intracranial procedures are potentially risky and therefore proper training, co-ordination with clinical branches and availability of specialized equipment is essential for good outcomes.
- * Dedicated stroke centres with neurologist, neurosurgeons, interventional neuroradiologists and diagnostic radiologists working as a team result in better outcomes.

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