Subrachnoid Haemorrhage (SAH) - What Should We Know?

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Abstract : *Subrachnoid haemorrhage (SAH) is bleeding within the cerebrospinal fluid-filled spaces surrounding the brain which occurs most commonly due to trauma, rupture of intracranial aneurysms is the most common cause of non-traumatic SAH. SAH is always an emergency because untreated ruptured cerebral aneuryms have a bad prognosis. The outcome in these patients can be improved significantly by early treatment. Rebleed due to rerupture of aneurysm is a very important factor, which makes early treatment all the more important. Although, aneurysms have been treated traditionally surgical techniques, minimally invasive method such as endovascular coil embolization is feasible in most of these patients. Management in a centre with a team of doctors specializing in different aspects is important because patients with SAH are prone to secondary complications, like vasopasm and hydrocephalus.*

WHAT IS SUBARACHNOID HAEMORRHAGE (SAH) AND HOW IS IT DIFFERENT FROM OTHER TYPES OF INTRACRANIAL HAEMORRHAGE?

Based on location, the intracranial haemorrhages are roughly classified into intra-axial or extra-axial haemorrhages.

Intra-axial haemorrhage is bleeding within the brain itself. This category includes Intraparenchymal haemorrhage (bleeding within the brain tissue) and intraventricular haemorrhage (bleeding within the brain's ventricles).

Extra-axial haemorrhage is the bleeding that occurs within the skull but outside the brain tissue. It is classified into three subtypes :

Extradural haemorrhage is usually caused by trauma and results from laceration of an artery, most commonly the middle meaningeal artery.

Subdural haemorrhage usually results from traumatic tearing of the bridging veins in the subdural space between the dura and arachnoid mater.

Subarachnoid haemorrhage is bleeding between the middle membrane covering of the brain and the brain itself. Specifically, it occurs within the cerebrospinal fluid-filled spaces surrounding the brain (also known as the subarachnoid space) from some pathologic process. The most common cause of SAH is head injury[1]. The medical use of the term SAH here refers to the nontraumatic types of haemorrhages, which most commonly occurs due to rupture of a berry aneurysm. However, it must be realized that not all SAH are due to aneurysm rupture of a berry aneurysm. However, it must be realized that not all SAH are due to aneurysm rupture and not all aneurysm ruptures are primarily into the subarachnoid space. Subarachnoid haemorrhage due to aneurysm rupture is a very imporant entity to recognize because if not treated early, it has a bad prognosis. However, good grade patients treated in specialized centers have a good prognosis. The annual incidence of SAH varies from 6-10 per 100,000 in different populations[2].

WHY IS TREATMENT OF SAH AN EMERGENCY?

SAH is always an emergency because ruptured cerebral aneurysms continue to be a significant cause of death as well as a health and economic problem which can be significantly reduced if treated early. It is an important cause of mortality and morbidity because young and middle-aged adults are most often affected. Studies to date show peaks at various ages in the 40-70 year range[3]. An estimated 12% of patients die before reaching the hospital[4]. Epidemiological studies estimate that about 40% of those reaching hospital die[4].

Rebleed due to rerupture of aneurysm is a very important factor, which makes early treatment all the more important. With modern surgical and interventional (endovascular) techniques, most of the aneurysm can be treated with reasonable safety. Early treatment reduces the risk of rebleed and facilitates the treatment of vasospasm by increasing the safety of hemodynamic manipulations. The peak risk of rebleed is within the first 24 hours after SAH thereafter the rate declines to 1.5% per day, with a cumulative risk of 19% in the first two weeks[5]. Early treatment in selected cases not only prevents morbidity and mortality due to rebleed but also enables aggressive treatment of secondary complications such as vasopasm and hydrocephalus.

WHAT ARE THE COMMON SIGNS AND SYMPTOMS OF SAH?

Hallmark of SAH is sudden severe headache in 80% patients[6]. Sentinel headaches may occur a few hours to a few months before the rupture, with a reported median of 2 weeks prior to diagnosis of SAH. Headache of SAH is usually typical but sometimes is variable as to render the diagnosis difficult. Most common incorrect diagnosis in order of decreasing frequency are systemic infection or *viral illness, migraine, hypertensive crisis, cervical spine disorder such as arthritis or herniated disc, brain tumor, aseptic meningitis, sinusitis and alcohol introxication*[7]. Therefore, a high degree of suspicion should be kept in this condition so as not to misdiagnose it as a more benign cause of headache. Ominous features associated with headache are vomiting (77%), alteration in consciousness (53%), meningism (35%), seizure (20%) or focal neurologic deficit[8]. Physical examination findings may be normal, or the clinician may find some focal neurological deficits. There might be varying degrees of impaired consciousness depending on the grade of the patient.

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Patients usually have nuchal rigidity as a sign of meningism.
The *focal deficit* usually pertains to the vascular territory involved like bilateral lower limb weakness in anterior cerebral artery territory or hemiparesis in middle cerebral artery territory or third nerve palsy in posterior communicating artery territory[9].
Hence, it should be realized that the clinical presentation of a patient of SAH can be anywhere in a large spectrum of presentations. There has to be a high degree of suspicion and such patients should be urgently investigated to prove or rule out SAH. It needs to be emphasized again that this condition should be recognized and treated early to improve the outcome and avoid complications.

WHAT ARE THE INVESTIGATIONS NEEDED?

First investigation in any patient with clinical suspicion of SAH should be CT scan of brain. Every physician should be aware of the fact that CT is much more sensitive for detection of haemorrhage than routine MRI.
Computed tomography (CT) : this test should be the first investigation to be performed particularly to look for presence for bleeding. Most of the cases CT will show evidence of blood in subarachnoid space although one should be aware that 3% of patients might have normal scans within 24 hours of confirmed SAH[10]. CT scan also helps in diagnosis of associated intraventricular haemorrhage, intracerebral haemorrhage, as well as forpresence of mass effect, ischemic changes and hydrocephalus. With passage of time, sensitivity of CT to detect SAH in a patient decreases and by day 5, significant number of patients may have normal CT in spite of presence of bleed and aneurysm[10]. This fact should be kept in mind in evaluation of patients presenting many days after the episode of headache. In patients with indeterminate CT, lumbar puncture or angiography may have to be done.
Lumbar puncture (LP) : Lumbar puncture is done to detect RBCs and xanthochromia as an evidence of SAH. LP is indicated in case where the clinical history is strongly suggestive of SAH with a negative CT[9] or the patient presents many days after the episode with a negative CT scan. It is contraindicated in case of abnormal coagulation profile, increased intracranial pressure and suspected spinal arteriovenous malformation (AVM) or infection at puncture site. It is important to differentiate a *traumatic tap* from SAH. Xanthochromia is a very reliable sign of SAH in CSF obtained more than 12 hrs. after SAH. It is a yellow discoloration of a centrifuged CSF sample due to hemoglobin and its breakdown products released by hemolysis of erythrocytes.
Catheter angiography (DSA - digital subtraction angiography) : This is the most accurate investigations in diagnosis and evaluation of aneurysms causing the SAH. Cerebral angiography is performed once the diagnosis of SAH is made. This study assess the ruptured aneurysm, vascular anatomy, presence of other aneurysms and secondary vasospasm.
This study helps in planning operative/interventional options. Inspite of development of CT/MR angiography, DSA is needed in these cases to detect and assess the aneurysm. In particular, 3-D DSA is most accurate in evaluating assessment of intracranial aneurysms. Catheter angiography (DSA) findings can be negative in 10-20% of patients with SAH. If negative, it is advisable to repeat angiography a few weeks later. Magnetic resonance imaging (MRI) is also performed if no lesion is found on angiography to evaluate for unusual parenchymal pathologies causing SAH like arteriovenous malformation, dural arteriovenous malformation, cavernomas, tumors or vasculitis.
Magnetic resonance imaging (MRI) : Although some reports show that MR can detect acute haemorrhage, CT should always be done first to rule out haemorrhage.
CT/MR angiography : Although MR angiography can detect intracranial aneurysms, its sensitivity in detection of small intracranial aneurysm is poor. CT angiography is performed after intravenous injection of contrast and is a useful procedure for detection of aneurysm and for arterial blockage/stenosis. Although CT angiography has improved significantly in recent times, 3-D DSA remains the gold standard in detection and evaluation of intracranial aneurysms.

WHAT ARE THE VARIOUS TYPES OF TREATMENT OF INTRACRANIAL ANEURYSMS?

Aneurysms can be treated by endovascular and surgical techniques. The primary goal of treatment is complete, permanent and safe aneurysm occlusion.
Surgery : Surgery has been the conventional method of aneurysm treatment. Surgery entails direct exposure of the aneurysm, the parent vessel(s) and surrounding structures. The aneurysm is then secured by the placement of a metalic clip along the neck thereby excluding it from the circulation. Problems with surgery include invasiveness and trauma to normal brain parenchyma. Surgery has an edge over endovascular method in cases of large haematoma or hydrocephalous where a decompression would always benefit the patient[11].
Endovascular Coiling of Aneurysms : In this treatment a microcatheter is placed from one of the leg arteries in to the aneurysm, which is then occluded with coils (usually detachable platinum coils) so as to prevent repeat bleeding. A recent randomized, multicentre trial conducted in Europe and North America has shown that long-term clinical results were better with embolization than open surgery in certain subset of patients[12]. Endovascular treatment and is usually the treatment of choice of patients with surgically poorly accessible aneurysms (posterior circulation, cavernous ICA aneurysms), in patients with medical risk factors and in patients with poor clinical status after the bleed.
Therefore, it is most important to have physicians with expertise in both treatment methods in any centre treating patients with SAH.

WHY IS IT IMPORTANT TO MANAGE SUCH PATIENTS IN SPECIALIZED CENTRES?

Concept of stroke centers, stroke units, stroke team and stroke ICU : A comprehensive stroke centre is defined as a facility or system with the necessary personnel, infrastructure, expertise and programs to diagnose and treat patients who require a high intensity of medical and surgical care, specialized tests, or interventional therapies. This kind of a centre has :

* Stroke team/physicians
* Diagnostic techniques such as MRI, CT (with CT angiography), Digital subtraction Angiography (DSA) and transcranial Doppler
* Surgical and interventional therapies well established surgical

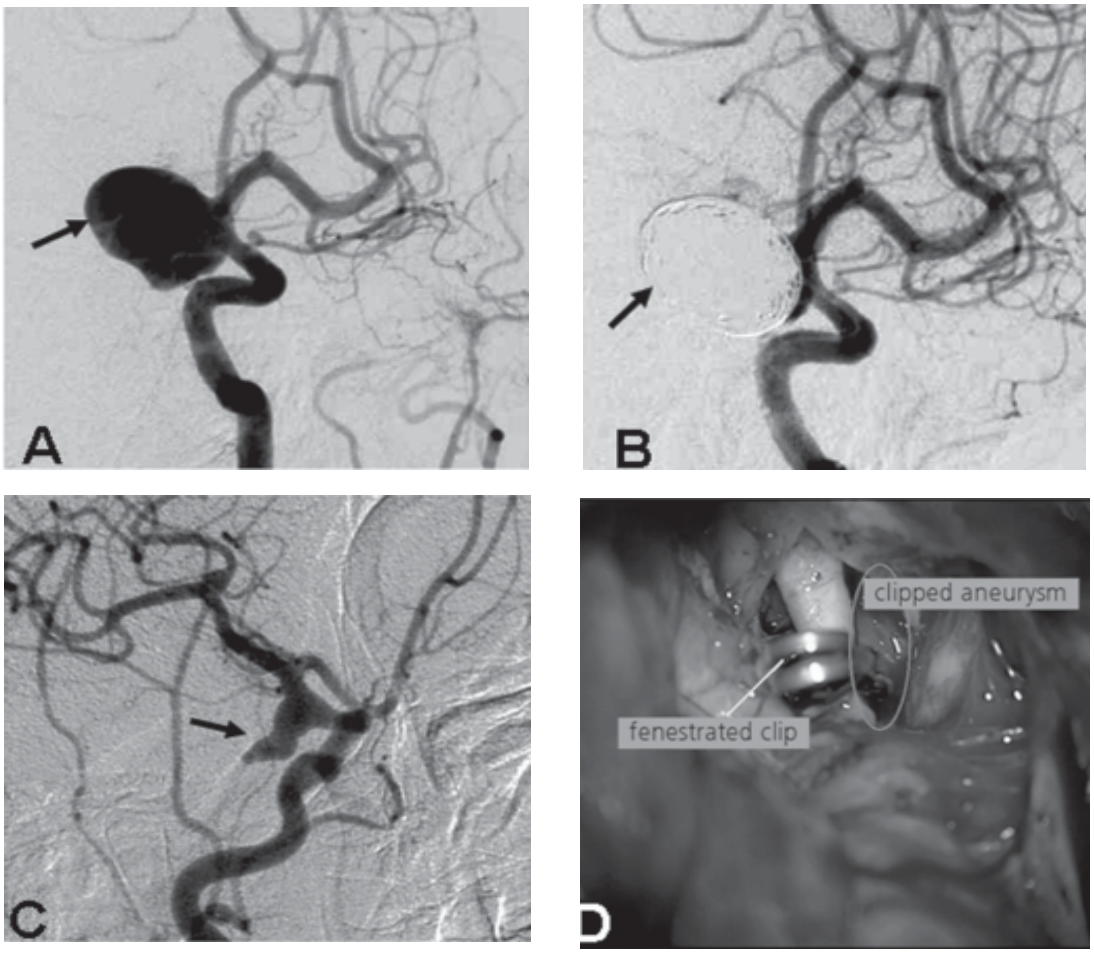

Fig.1 : Case 1 (Fig. A&B) - A 45 year old female presented with sAH due to alarge internal carotid artery aneurysm (arrow Fig. A). The aneurysm was embolized with almost complete occlusion (Arrow, Fig.B). Case 2 (Fig. C & D) - A 62 year old female presented with SAH due to a broad neck aneurysm of ICA (Fig.c). Due to unfavourable anatomy for embolization the aneurysm was clipped (Fig.D). Both aneurysms were treated with a gap of few days in our hospital. The decision making in both cases was made collectively by team of surgeon as well as interventional neuroradiologist

procedures such as hematoma removal, clipping of aneurysms as well as interventional neuroradiology and endovascular therapy

* Infracture such as Stroke ICU, neurosurgical ICU, and round-the-clock interventional and surgical facilities.

Studies have shown that patients treated in stroke centers have better outcomes as compared to patients treated in regular hospitals[13]. This holds true even for patients, which are managed medically and not treated by advanced interventional/surgical treatments. Results of both surgery and intervention are also largely dependent upon the expertise of the treating physician.

Management in a centre with a team of doctors specializing in different aspects is important because patients with SAH are prone to *secondary complications*, which can cause delayed onset of worsening after SAH. These include :

(i) Cerebral ischemia due to vsospasm - Symptomatic vasospasm is narrowing of vessels that have resulted in cerebral ischemia with clinical symptoms and signs[14]. Angiographic vasospasm is arterial narrowingdemonstrated on angiography after SAH and overall incidence of this is about 50%[15]. Almost 60% of patients with thick clots develop moderate or severe angiographic vasospasm in at least one major artery; (ii) Hydrocephalus; (iii) Hyponatremia; (iv) Hypoxia/hypotension from cardiopulmonary complications; (v) Systemic sepsis, meningitis and (vi) Cardiovascular complications - such as ECG abnormalities are quite common in these patients. Usually, they may be associated with underlying cardiac damage manifest as contraction band necrosis and elevated cardiac enzymes.

HOW SHOULD A TEAM OF DOCTORS BE FORMED TO TREAT SAH AND WHO ARE THE INDIVIDUALS INVOLVED IN TREATMENT OF SAH?

As outlined above a team of doctors and support staff enables best outcome in these cases. **Specialists** involved in treatment of

patients with SAH include :

* ***Neurosurgeon*** **-** performs surgical treatments such as hematoma evacuation, aneurysm clipping, arteriovenous malformation excision and endarterectomy for carotid artery stenosis
* ***Interventional neuroradiologist*** **-** Interventional neuroradiology/endovascular surgery is a branch in which minimally invasive diagnostic and therapeutic procedures of cerebrovascular disorders are performed. These procedures are carried by very thin catheters/wires etc. placed through groin vessels to reach the site of the abnormal vessels. This minimally invasive approach ensures minimal injury to normal brain, with less complications, better outcome and shorter hospital stay.
* ***Diagnostic neuroradiologist*** **-** specializes in diagnosis of stroke using modalities such as CT, MRI and Doppler etc.
* ***Neuroanaesthetist*** and critical care physicians.
* Nurses trained in management of stroke patients, physical therapists.

WHAT ARE THE LIKELY FUTURE DEVELOPMENTS IN TREATMENT OF SAH?

* **Advances in endovascular treatment (embolization) of intracranial aneurysms -** The technology of endovascular techniques is improving and evolving all the time.

Stent/balloon-assisted coiling : The endovascular tratment of cerebral aneurysm poses technical challenges in wide-necked aneurysms. Stent placement across the neck of the aneurysm has been used in these cases to prevent prolapse of the coils outside the aneurysm (Fig.3). Many stents meant for intracranial use are being introduced and in future use of these devices is likely to increase. Many compliant balloons are also available to perform coil placement in wide neck cerebral aneurysms[16].

Coils - Wide ranges of coild shapes and sizes (including 3-D and 2-D) and much softer coils have been introduced to improve the range and effectiveness of the device. Unlike the bare metal coils initially available for endovascular tratment of aneurysms, bioabsorbable polymeric coils, have been introduced which promotes healing inside the aneurysm and may prevent recanalization[17].

Advances in technology : The advances in DSA (Digital subtraction angiography) technology which makes this kind of procedure safer and effective are :

The 3D technology[13] allows construction of 3-D images format, which helps in accurate assessment of diseases effecting blood vessels such as stenosis, aneurysms and vascular malformations.

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 systesms.

Genetics : Genetic factors play an important role in pathogenesis of SAH and intacranial aneurysms. The different incidence of SAH in different parts of the world and different type of populations indicate the role of genetic factors. Elastin and collagen type 1A2 are most promising of all the genes because allelic association with intracranial aneurysms has been shown for them. However, genetic variations only explain a small proportion of all th factors involved in intracranial aneurysms[19]. In future, genetics screening may help in detecting patients who are more prone to have aneurysms as well as to predict the patients more prone to rupture of aneurysm.

CONCLUSION

* SAH is a bleeding in subarachnoid space which is most commonly due to rupture of intracranial aneurysms
* Untreated patients have a very bad prognosis. However if reated early can lead to cure with a favourable outcome. Treatment is an emergency because early recognition and treatment can prevent a wide range of complications including rebleeding. Therefore, a high degree of suspicion is mandatory to diagnose these patients.
* Multidisciplinary teams in stroke centers including neurosurgeons as well as interventional neuroradiologists best perform treatment.
* Minimally invasive method such as endovascular coil embolization is feasible in many of these patients.

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