Adenosine in difficult aneurysm surgeries: Report of two cases

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Treatment of intracranial aneurysms has evolved over the past few decades, which includes various endovascular techniques, but still a significant number of patients are subjected to craniotomies for clipping of intracranial aneurysms. In spite of advances in surgical techniques for aneurysm surgery, intra-operative rupture can sometimes lead to catastrophic consequences in absence of temporary control. It is often a challenge for the neurosurgeon to apply temporary clips at difficult locations like paraclinoid aneurysms and giant aneurysms.[1,2] In these situations, intravenous administration of adenosine has been successfully used by various groups to produce reversible flow-arrest so that it helps in decompressing the aneurysm sac and improve visualisation to facilitate clip application.[3-6]

We report two such cases of intra-operative rupture of aneurysms where adenosine was used successfully to facilitate clipping in our Institute.

A 50-year-old male presented with subarachnoid haemorrhage due to left posterior inferior cerebellar artery aneurysm (Hunt Hess Grade I, World Federation of Neurological Surgeons (WFNS) Grade I). He was scheduled for surgical clipping of the aneurysm. In anticipation of intra-operative rupture, we planned administration of intravenous adenosine. The patient was placed in right lateral position with external defibrillator paddles in position. The aneurysm ruptured prior to exposure and temporary clip had to be applied on the parent vessel. We administered 18 mg (0.3 mg/kg) adenosine via central venous catheter in a quick bolus with 20 ml of normal saline flush, which resulted in flow-arrest and transient asystole lasting for 20 s. This facilitated further dissection and application of permanent clip to secure the bleeding. Sinus recovery occurred after about 20 s and normal sinus rhythm was restored in 120 s and invasive blood pressure recovered to pre-rupture level in about 3 min. Transient asystole resulted in a bloodless field, which helped the neurosurgeon to quickly gain control of the ruptured aneurysm. The patient did not suffer any cardiological and neurological insufficiency; haemodynamics remained stable and was tracheally extubated after planned elective overnight post-operative mechanical ventilation. We repeated electrocardiograms (ECGs), echocardiograms and Troponin I assay post-operatively at 6 and 24 h, respectively, which were within normal limits.

A 44-year-old female with interstitial lung disease and Systemic Lupus Erythematosus presented with subarachnoid haemorrhage (Hunt and Hess Grade I, WFNS Grade-I) and investigations revealed a large fusi-saccular left vertebral artery aneurysm. We planned treatment by clip reconstruction and anticipated the use of adenosine to facilitate dissection and deal with a possible intra-operative rupture. We followed all necessary precautions like putting the external defibrillator paddles and keeping defibrillator ready with closed monitoring of vitals. During dissection, the aneurysm ruptured. At the time of rupture, the arterial blood pressure was 100/60 mmHg with heart rate of 60 beats/min. Adenosine 18 mg IV was administered as a quick bolus through the central line with 20 ml of normal saline flush. Asystole was achieved for 25 s, during which, the surgeon could clip the ruptured part of the aneurysm. Following asystole, the patient's heart rate recovered spontaneously without any haemodynamic sequelae. The surgeons again requested for a second dose for further clip reconstruction of the fusiform aneurysm. By this time, the patient had suffered a blood loss of about 1.5 l and patient's arterial blood pressure was 96/60 mmHg and heart rate of 70 beats/min with normal sinus rhythm. The second dose of adenosine (18 mg) was administered after about 22 min from the first dose, following which asystole was achieved in 15 s, which lasted for further of 20 s. The patient developed supraventricular tachycardia (SVT) on recovery from asystole with mean arterial pressure of 50 mmHg, which soon progressed to atrial fibrillation (AF) with persistent hypotension; this helped the surgeons to apply permanent clip. Following surgery, AFs continued and so, we decided to deliver synchronised DC shock with 100 J. This led to immediate return of sinus rhythm with arterial blood pressure of 90/60 mmHg and heart rate of 88 beats/min with minor T-wave changes, which recovered fully after about 5 min. Rest of the surgery was uneventful. Volume resuscitation was done with colloids, crystalloids as well as packed red blood cells during the procedure and the patient was kept ventilated electively. Intra-operative and post-operative arterial blood gases

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were checked and found to be normal. Immediate and post-operative ECGs, echocardiography, cardiac Troponin I measured and repeated after 6 and 24 h showed insignificant cardiac abnormality. Computed tomography scan of head was carried out on the first post-operative day, which showed no abnormality. Patient was electively ventilated and extubated after an appropriate period. She was awake, alert and did not have any focal limb deficits. However, she did have lower cranial nerve palsies, resulting in aspiration pneumonia, a subsequent tracheostomy and a prolonged inpatient stay due to lung complications.

Adenosine is an endogenously occurring nucleoside analogue, which reduces heart rate and prolongs conduction through the sinoatrial (SA) and atrioventricular (AV) nodes, acting on cardiac A1 receptor to decrease cyclic adenosine monophosphate (cAMP). It has an ultra-short half-life <10 s, secondary to reuptake by red blood cells and vascular endothelial cells. It is the drug of choice in treating SVT and its action is usually self-limited.[7,8] Adenosine has been used successfully by various investigators to facilitate intracranial aneurysm clipping.

The first series by Luostarinen *et al*., reported its use in 16 patients with intra-operative aneurysm rupture, out of which 5 were basilar artery aneurysms.[9] Guinn *et al*., reported a series of 27 patients who underwent craniotomy for aneurysm clipping using adenosine to induce transient asystole and decompression of the aneurysm to facilitate clip application.[10] They concluded that it is a reasonable alternative method when temporary clipping of proximal vessels is not desirable when used with appropriate safety precautions. The investigators of these two series felt that in addition to basilar artery aneurysm, paraclinoid, ophthalmic and some anterior and posterior communicating artery aneurysms close to the skull base are technically very challenging for the surgeons due to limited surgical corridor, which prevents the circumferential view of the neck of the aneurysm sac and application of the temporary clip. The series reported by Bebawy *et al*., included 24 patients for intracranial aneurysm surgery, among which a large number were internal carotid artery aneurysm.[11] They felt a temporary clip application was difficult in these cases due to close proximity of the carotid bifurcation in middle cerebral artery and anterior cerebral artery. They concluded that adenosine is a good option to provide brief periods of flow arrest for facilitating aneurysm-clip ligation with apparently low neurologic and cardiopulmonary morbidity where temporary occlusion is impractical and technically difficult. Based on their data, Bebawy *et al*., recommended a dose of 0.3-0.4 mg/kg of ideal body weight (IBW) to achieve approximately 45 s of profound systemic hypotension, in aneurysm patients receiving balanced anaesthetic technique. The hypotension resulting from adenosine administration outlasts the circulatory arrest, which helps in defining the surgical anatomy of aneurysm and clip application. The circulatory arrest softens the aneurysm, which allows for better visualisation of the neck, particularly in large aneurysms and dissection of the dome of the sac. Thus both the duration of hypotension and transient asystole helps in clip application in surgically difficult situations. Most of these studies suggest a dose of 0.3-0.4 mg/kg of adenosine provide about 30-60 s of hypotension and bradycardia, which generally correlate with the time for clip application.[9-11]

Cardiac dysrhythmia have been reported after adenosine administration; Bebawy *et al*., reported two patients who experienced transient and haemodynamically stable AF. Guinn *et al*., reported no such complication in their series. However, one patient with prolong hypotension after rapid re-dosing of adenosine required brief closed chest compression to restore blood pressure. Although none of the case series of adenosine administration of intracranial aneurysm reported the requirement of temporary pacing, it is a routine recommendation to apply external pacing pad after induction of anaesthesia to be prepared for this potential complication. There is a 4% incidence of temporary heart block in a large case series (n = 98) describing adenosine-induced asystole for endovascular aortic aneurysm repair.[12] Guinn *et al*., reported transient ST depression, which was self-limited in one patient. Minor elevations of troponin levels post-operatively without clinical or echocardiographic evidence of cardiac dysfunction was also seen in two patients in the series by Bebawy *et al*., Guinn *et al*., recommends adenosine re-dosing only after patient has returned to pre-adenosine haemodynamic stability. They also advocate to be prepared for potential complication of serious systemic hypotension with application of pacing pads and availability of vasopressors. Careful patient selection in regard to reactive airway disease, cardiac history (coronary heart disease, valvular heart disease, dysrhythmias and conduction abnormality) should be taken in account. We noted one significant complication after re-dosing of adenosine, which was AF with persistent hypotension and required treatment.

Our brief experience, along with recent published series suggests that adenosine-induced flow arrest is a useful and at times life-saving modality during aneurysm surgery Anticipation of its use, necessary pre-operative precautions and close collaboration between the neurosurgeon and neuroanaesthetist is vital for its successful application. Larger case series are needed to document the safety and efficacy of adenosine in aneurysm surgery and to ensure wider acceptability.

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Quick Response Code:	Website: www.jnaccjournal.org
	DOI: 10.4103/2348-0548.124857