Superficial Temporal Artery Aneurysm in a Helicopter Pilot Operating at High Altitude

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BACKGROUND: Spontaneous aneurysm of the superficial temporal artery in a helicopter pilot while operating in the extreme cold climatic conditions of a very high altitude area led to a thorough search for etiological possibilities related to this case.

CASE REPORT: A 38-yr-old military helicopter pilot, while flying at altitudes ranging from 4500 m to 6000 m (15,000 to 20,000 ft) reported with an acute onset of a subcutaneous swelling on his left temple. History and clinical profile did not suggest any traumatic, hematologic, or vasculitic etiology. His inflammatory markers, anti-nuclear antibody, anti-neutrophil cytoplasmic antibodies, complement levels, and whole-body PET scan did not suggest any evidence of vasculitis. Presence of any other intracranial aneurysms was also ruled out. He underwent curative excision biopsy, which showed perivascular inflammation. He was diagnosed as a case of left superficial temporal artery aneurysm. The recovery period was uneventful and the follow-up color Doppler flow imaging of the temporal artery and acute phase reactants was normal.

DISCUSSION: Spontaneous aneurysms involving the superficial temporal artery is a very rare diagnosis. Occurrence of such an aneurysm in a young pilot without any identifiable predisposing factors led the authors to hypothesize a possible etiological combination of environmental and mechanical factors along with aviation stresses with the likely compounding role of the helmet. Management and aeromedical aspects of this unique case are discussed in this paper.

KEYWORDS: spontaneous aneurysm, extreme cold climate, helicopter aviator.

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The Siachen glacier in the Himalayan ranges of the Indian subcontinent has seen military deployment since 1984. Air support is the lifeline at this high-altitude terrain, ranging from 4500 m (15,000 ft) to 6000 m (20,000 ft). Rotary wing aircraft, at the extremes of its operational limits, are flown by pilots defying the adversities of the altitude and the weather. In particular, wind chill effect in those mostly snowbound areas result in local cold injuries on the exposed parts of the body.[4] Another lesser known malady in such cold conditions is vascular thrombosis.[6] This case report discusses the likely etio-pathology of a superficial temporal artery (STA) aneurysm with thrombosis in a rotary wing pilot deployed in this high-altitude area.

CASE REPORT

A 38-yr-old male rotary wing pilot had an acute onset of a swelling (1.5 cm × 0.5 cm) over the left temple, just above the pterion (**Fig. 1**) around 8 mo after his induction into the high mountainous Ladakh region of India. This subcutaneous swelling was gradually increasing in size, pulsatile in nature, and firm on palpation. It was associated with a mild throbbing headache and local tenderness. There was no suggestive history of local trauma, recent history of fever, weight loss, visual disturbance, chest pain, or dyspnea. There were no other relevant clinical findings on examination, which included ophthalmological and cardiovascular evaluation. Color Doppler flow imaging revealed focal dilatation of the left STA with heteroechoic thickened walls and central patent lumen with color

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Fig. 1. Superficial temporal artery aneurysm in the left temporal region.

flow. CT angiography of the head and neck showed focal aneurysmal dilatation of the left STA. Accordingly a provisional diagnosis of left STA aneurysm was made.

He was referred to a tertiary care hospital for further management. His hematological, biochemical, and serological evaluations were within normal limits (**Table I**). The five-gene thrombophilia panel test ruled out any hereditary risk for thromboembolism. Large vessel vasculitis was ruled out by whole-body positron emission tomography imaging. Vascular excision biopsy of the aneurysmal area showed intimal thickening suggestive of occasional thromboses, with narrowing of the luminal diameter and with foamy histiocytes and myxoid degeneration of the media, along with mixed inflammatory infiltrate in the perivascular area without any multinucleate giant cells. This was consistent with small vessel arteritis. He was advised to take oral aspirin 150 mg daily for 1 mo and returned to duty not involving flying.

On review after 6 mo, he was found to have recovered clinically, with a well healed scar at the site of the excision biopsy. His follow-up color Doppler flow imaging of the left temporal region showed normal flow pattern of the remaining branches of the STA without any evidence of aneurysm or thrombosis. The laboratory tests during subsequent follow-up were also normal (Table I), except a positive screening test for antiphospholipid antibodies. However, the confirmatory test for lupus antibodies using lupus anticoagulant dilute Russel's viper venom time was negative, thus ruling out systemic lupus erythematosus. In the absence of any likely causative pathology, he was advised to continue with duty not involving flying for another 6 mo.

Table I. List of Laboratory Investigations During Initial Evaluation and Review.

INITIAL EVALUATION	RESULT
Hematology	All within normal limits
Hemogram	
Erythrocyte Sedimentation Rate (ESR)	
Prothrombin time (PT)	
Activated Partial Thromboplastin time (aPTT)	
Fibrin Degradation Product	
D-dimer	
Fibrinogen	
Biochemistry	All within normal limits
Blood sugar levels	
Renal Function Tests	
Liver Function Tests	
Serum Electrolytes	
Viral Markers	Negative
HBsAg	
Anti HCV	
HIV 1 & 2	
Other serological tests	All within normal limits
C-Reactive Protein (CRP)	
Anti Nuclear Antibody (ANA)	
Anti Neutrophil Cytoplasmic Antibodies (ANCA)	
Complement level (C3)	
Complement level (C4)	
Thrombophilia panel	Negative
REVIEW AFTER SIX MONTHS	**RESULTS**
Other serological tests	All within normal limits
C-Reactive Protein (CRP)	
Complement level (C3)	
Complement level (C4)	
Immunoglobulin G (IgG)	
Immunoglobulin A (IgA)	
Immunoglobulin M (IgM)	
Thrombophilia screen	All within normal limits except positive antiphospholipid antibodies for lupus antibodies. But the confirmatory test using lupus anticoagulant dilute Russel's viper venom time (LAC dRVVT) was negative
Protein C	
Protein S	
Anti thrombin III	
APCR with Factor V Def plasma	
Lupus Anticoagulant	
A. APTT-LA screening test	
B. LAC-dRVVT confirmatory test	

DISCUSSION

The superficial temporal artery is the terminal branch of the external carotid artery and one of the main supply vessels to the scalp.[3] It is the most frequent site of traumatic aneurysm of the face because of its anatomical location.[10] Interestingly, 166 of 186 cases of STA aneurysm were pseudoaneurysms as per an exhaustive search of Medline and Cochrane databases from 1861 to 2010.[16] Such pseudoaneurysms occur as a consequence of an injured vessel wall, through which blood flows to form an extravascular hematoma which freely communicates with the intravascular space.[11] Most of the reported cases were on the anterior branch of the STA. This is mainly attributed to anatomical reasons such as lack of cushioning at the site where the artery crosses from the temporalis to the frontalis muscle and due to the tethering effect of the fascia at this level, which limits any lateral displacement of the artery in response to tangential forces.[8,10] In addition the shearing and crushing forces imparted by the projection of the bony ridge in the galea aponeurotica formed by the fusion line of deep and superficial temporalis muscle fascia on the STA may also contribute to this pathological process. The mechanism of injury is either a partial transection of the artery, severe contusion, or necrosis of a part of the arterial wall.[8,14]

Spontaneous occurrence of STA aneurysm without any obvious trauma mandates that alternative hypotheses of pathogenesis be considered in this case. This pilot was regularly flying a helicopter at altitudes more than 4500 m (15,000 ft) and sometimes even up to 6000 m (20,000 ft). Pilots flying at such altitudes are faced with physical and physiological stresses due to high velocity winds, extremely low temperatures (average minimum temperatures −50°C during winter and −15°C during summer), and unusual turbulence, apart from reduced atmospheric pressure and hypobaric hypoxia.[4] Since the helicopter is being flown at the extremes of its performance envelope, the cabin air conditioning system is literally rendered ineffective, leaving pilots susceptible to ambient weather conditions.[4] Even though the aircrew wear personal protective clothing, including a helmet, part of the face below the forehead remains unprotected from direct exposure to extreme cold temperatures (**Fig. 2**).

Exposure to high altitude is considered an important component for thrombogenesis. Almost 30 times higher risk of spontaneous vascular thrombosis was reported among young male soldiers following a mean stay of over 10 mo at altitudes from 3000 to 6500 m (9843 to 21,325 ft).[6] Several acquired and genetic factors are also known to predispose to thrombus formation by interacting with environmental factors:[12]

Congenital

- Factor V mutation
- Prothrombin mutation
- Increased levels of Factor VIII, IX, XI, or fibrinogen
- Antithrombin III deficiency
- Protein C deficiency
- Protein S deficiency
- Fibrinolysis defects
- Homozygous homocystinuria

Fig. 2. An aviator in personal protective clothing, including helmet.

Acquired

- Prolonged bed rest or immobilization
- Myocardial infarction
- Atrial fibrillation
- Tissue injury (surgery, fracture, burns)
- Cancer
- Prosthetic cardiac valves
- Disseminated intravascular coagulation
- Heparin-induced thrombocytopenia
- Antiphospholipid antibody syndrome
- Cardiomyopathy
- Nephrotic syndrome
- Hyperestrogenic states (pregnancy and postpartum)
- Oral contraceptive use
- Sickle cell anemia

Nevertheless, in this case any inherent risk factors—prothrombotic states[6] and connective tissue disorders[11]—which could predispose to arterial thrombosis were ruled out during the initial evaluation and subsequent follow-up. Further, the arterial biopsy report from the affected area had shown perivascular inflammation but did not indicate any specific arteritis.

Laboratory experiments elsewhere had demonstrated reduction in arterial wall compliance[5] and increased arterial stiffness[9] on exposure to cold temperatures. Conspicuous histological changes were reported in the arterial media and the intimal layers after exposure to freezing cold temperatures.[2] Repeated freezing is known to result in thrombus formation in some of the experimented vessel specimens.[2] It is important to consider here that even physical injuries such as mechanical trauma can cause vasculitis.[11]

The dilemma of pathogenesis prompted the authors to analyze the likely factors beyond the environmental ones. Exposure to undesirably high levels of whole body vibration is a known fact in rotary wing operations.[15] The vibration of the overhead gear system is transmitted primarily through the seat, which is often of a higher magnitude at high altitude, specifically so in turbulent weather. This pilot had been frequently flying operational sorties lasting nearly 2 h, including using night vision goggles (NVG) when required. As compared to the Gallet™ helmet weighing 1.3 kg, the addition of NVG and counterweight assembly increases the total weight borne on the head to 2.54 kg. This increased weight on a pilot's head aggravates the stresses on the musculoskeletal system of the head and neck, which in turn could result in pressure effects on superficial vessels. Another major factor is the location of the center of gravity of the helmet-head combination, which can shift forward from its ideal location due to the additional weight of the NVG-mounted helmet despite the counterweight. The center of gravity shift and increased loading on the neck and upper spine produced by helmet-mounted devices in turbulent conditions can result in relative motion of the helmet over the head.[7]

Review of the literature, though sparse, mentions the pathogenesis of aneurysm following shear and vibration stresses.[1,13] The endothelium responds to shear stress through various pathophysiological mechanisms such as synthesis and secretion of nitric oxide, growth factors, and metalloproteins, depending on the kind and magnitude of the shear stresses. Specifically, a high grade of shear stress can cause arterial remodeling and expansion of vessel wall diameter, so that shear stress values return to their normal limits.[13] Although the effects of shear stress on the arterial wall were mostly based on internal hemodynamic changes, the literature is silent about the effect of external shear stress on the superficial arterial wall, except a case of pseudoaneurysm of the parietal division of the STA secondary to iatrogenic head injury by Gardner traction.[10] Vibration stress on the arterial wall demonstrated significant changes in the elastin component of the vessel wall, which later manifests as post-stenotic dilatation in the long term.[1]

In this particular case, it is postulated that the formation of the aneurysm of the STA could have occurred due to sustained compression of the snug-fit helmet, shear, and vibration stress due to the helmet and the type of aviation activity, respectively, on a stiff superficial arterial wall due to prolonged exposure to freezing temperatures. In addition, the inherent anatomical factors mentioned earlier, such as lack of cushioning at the site of crossing of the artery from the temporalis to frontalis muscle, the tethering effect of the temporalis fascia, and the mechanical effect of the bony ridge at the origin of the temporalis muscle could have contributed to vasculitis, formation of thrombus, and subsequent aneurysm.

Risk assessment for aeromedical disposition of this case is based on: 1) possibility of further complications or recurrence of the thrombotic episodes and, if so, likelihood of in-flight incapacitation due to the same; 2) suitability of operating in high altitude and extremely cold climatic conditions; 3) requirement of medication for prevention or treatment and their likely side effects with implications on aviation safety, including performance; and 4) a period of grounding before considering return to flying duties.

It is evident that STA aneurysm and thrombosis is a very rare diagnosis and recurrence of the same once treated is not reported.[16] In this case, postoperative healing of the excision site was adequate without any sequelae. The scar had healed well and other branches of the STA were noted to be patent during subsequent reviews by the specialists. In the absence of known inherent prothrombotic risk factors, chances of spontaneous thrombotic episodes without environmental or mechanical influences are deemed highly unlikely. However, the influence of environmental factors such as extreme cold climatic conditions and high altitude resulting in thrombogenicity cannot be ruled out.[6] Moreover, the chances of the mechanical stress of shear and the vibration of the snugly fit helmet on the stiff arterial wall of the forehead due to cold exposure causing vessel wall damage and thrombosis is still likely. Therefore, it is prudent that this individual not be exposed to potential environmental influences of high altitude. However, this pilot can be considered for flying with NVG at lower altitudes under observation, despite similar mechanical effects, since the likelihood of sudden in-flight incapacitation is unlikely. Therefore, in this case, the duration of the observation period under the nonflying category depends on the complete healing of the surgical excision wound and duration of complete prothrombotic work up.[6]

The unique environmental and operational challenges in aviation sometimes result in rare medical conditions such as STA aneurysm, which may require extensive aeromedical deliberations before deciding the disposition. The authors recommend that this pilot be allowed to fly helicopters except in high altitude and extremely cold climatic conditions after 6 mo of observation on the ground. Thereafter, once he returns to operational flying duties, he needs to be followed up for mechanical effects of likely aviation stresses and the helmet (including mounted devices) on the superficial blood vessels of the head in the near foreseeable future.

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