Original Article

Congenital abnormalities of spine & flying fitness: evaluation and disposal

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ABSTRACT

A detailed medical evaluation is required prior to accepting aspiring candidates for flying training in the services. X-Ray examination of the cervical and lumbosacral spine to exclude spinal deformities and abnormalities, both congenital and acquired, forms an integral part of the medical evaluation of candidates for flying duties. The human spine is subjected to various stresses during flight, and at the time of ejecting from a fighter aircraft causing an increase in the incidence of cervical spine trauma in flight as well as low backache. A pre-existing spinal defect is likely to pre-dispose the spine to injuries in such circumstances. Evaluation & disposal of congenital abnormalities of spine & flying fitness will be discussed in this paper. Incidence of various congenital abnormalities of spine in candidates in IAF during the period 1986-91 is discussed. Certain lacunae in the evaluation will also be discussed.

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Key Words : Scoliosis, Lumbarisation, Sacralisation, Spina bifida, Block (fused) vertebrae, CT spine, MRI spine

The aerospace environment can be demand ing on an aircrew. Thus those controlling flight need to meet a standard of medical fitness. A detailed medical evaluation is required prior to accepting aspiring candidates for flying training in the services. The standards for the examination are dependent on the nature of the crew duty anticipated. The medical evaluation is aimed at reducing the aircrew wastage during training period by identifying potential aeromedical causes, which may cause such a rejection.

X-ray examination of the cervical and lumbosacral spine to exclude spinal deformities and abnormalities, both congenital and acquired, forms an integral part of the medical evaluation of candidates for flying duties.

The human spine is subjected to various stresses during flight, and at the time of ejecting from a fighter aircraft. Introduction of new generation fighter aircraft has created a high +Gz environment, which is causing an increase in the incidence of cervical spine trauma in flight as well Senior Adviser (Av Med), Med Directorate, Air HQ,, RKPuram, New Delhi

as low backache - a problem, which was hitherto negligible. A pre existing spinal defect is likely to pre-dispose the spine to injuries in such circumstances. Helicopter flying also induces backache among pilots. Therefore, pre-existing spinal deformity, which may aggravate incidence of pain in such circumstances, will be a handicap.

Evaluation & disposal of congenital abnormalities of spine & flying fitness will be discussed in this paper. Certain lacunae in the evaluation will also be discussed.

Existing Policy

Manual of Medical Examination and Medical Boards [LAP 4303 (2nd Edn)] [1] incorporates the following for the spinal conditions :-

History. Past medical history of disease or injury of the spine or sacroiliac joints, either with or without objective signs, which has prevented the candidate from successfully following a physically active life, is a cause for rejection for commissioning. History of prolapsed intervertebral disc and surgical treatment for this condition entail rejection.

Examination. Thorough clinical examination of the spine including shape, movements and local tenderness if any, is to be carried out, mild kyphosis or lordosis where deformity is barely noticeable and if there is no pain or restriction of movement may be accepted. For flying duties, X-ray (AP and lateral views) of cervical and lumbosacral spines must be carried out.

Assessment. The following conditions detected radiologically will disqualify a candidate for Air Force service :-

(a) Granulomatous disease of spine.

(b) Arthritis / spondylosis.

(c) Spondylolisthesis / spondylolysis.

(d) Compression fracture of Vertebra.

(e) Scheurmann's Disease.

(f) Cervical ribs with demonstrable neurological or circulatory deficit.

(g) Any other abnormality, if so considered by the specialist.

Fitness for Flying Duties. For candidates for Flying Branches, under mentioned rules will apply as per Amendment No. 4 to LAP 4303 [2] :-

(a) Spinal anomalies acceptable for flying duties :-

(i) Unilateral lumbarisation of SV1.

(ii) Spina bifida at SV1 or LV5 either alone or together.

(iii) Congenital complete block (fused) vertebrae at one level in cervical or dorsal region.

Note : However, annotation will be made of these anomalies in AFMSF - 2.

(b) Spinal conditions, which will not be acceptable for flying duties :-

(i) Scoliosis more than 15° as measured by Cobb's method.

(ii) Herniated nucleus pulposus.

(iii) Presence of Schmorl's nodes at more than one level.

(iv) Atlanto-occiptal and atlanto-axial

anomalies.

(v) Incomplete sacralisation - unilateral

or bilateral as per amendment No.

8 [3].

Spinal Abnormalities in Candidates in IAF

In a study carried out in IAF [4], X-ray reports on the spinal columns of 1190 male candidates who had reported to IAM, IAF during the period 1986-91 for initial medical examination for their flying fitness, were reviewed. The X-rays included antero-posterior and lateral views of the cervical, thoracic and lumbo-sacral spines. All these candidates were asymptomatic to the time of medical assessment.

This study has revealed that there is a fairly high incidence (69.9%) of spinal anomalies (on radiological surveillance) in apparently normal / healthy / asymptomatic young Indian men. Of these 182 (15.2%) were considered unfit for flying duties. The spinal anomalies detected were further classified into three main groups. Congenital anomalies were the most frequent. Amongst these, spina bifida was most commonly seen, and was followed by sacralisation / lumbarisation defects.

In the degenerative diseases / past trauma group, the Schmorl's nodes were the most frequent. The postural defects were constituted by a loss of exaggeration of the normal lordosis, scoliosis, and kyphosis.

The lumbar region was maximally affected by congential and degenerative anomalies, whereas postural changes were more frequent in the thoracic zone.

Discussion

When the various congenital defects are considered, the commonest defect of spina bifida [4] at the level of Sacral vertebra 1 (SV1) is relatively innocuous. However, this anomaly in the upper spinal regions is likely to assume a serious significance because it is associated with a narrowing of the neural canal, and may also be accompanied by a herniation of the meninges. The latter may become exaggerated when such a spine is exposed to high +Gz situations, or to ejection forces, and may result in sudden in-flight incapacitation. Sacralisation / lumbarisation (unilateral); affects the geometry of the spine, and increases the torque forces during accelerations with a risk of disc herniation above the level of the anomaly. In a study in the IAF [4], there was noticeable incidence of this anomaly while 5.6% of the rejectees had only unilateral defects. A bilateral defect does not expose the spine to differential torque, thus rendering such a spine relatively safe.

Spinal degenerative anomalies are not compatible with flying. These disturb the normal spinal geometry, and this is likely to be exaggerated on exposure to the ejection jolt, or for that matter to high +Gz in flight. This accounted for the relatively high percentage (65.9%) of this anomaly amongst the rejectees [4].

Incomplete sacralisation (unilateral or bilateral) can precipitate low backache. These pilots are more prone to low backache especially during aviation stresses and where pilot has to sit and use his lower limbs to operate rudder pedals, which

include pelvic rotation and load on the lower spine. Therefore amendment No. 8 [3] stating that incomplete sacralisation (unilateral or bilateral) is not acceptable for flying duties, was introduced in 1992.

Scoliosis

Scoliosis is an abnormal lateral curvature of the spine, with an associated lack of normal thoracic spine flexibility. The resultant change in the structure of the spine affects the response of the spine to both static and dynamic loads. Dynamics of force application have to be evaluated in an individual who is exposed to the stresses of flight. With increasing lateral curvature, the risk of symptoms and injury are increased when the individual is exposed to ejection or other high G forces. For example, one aviator with scoliosis experienced incapacitating back pain while experiencing 6.5 G in an F-4E aircraft [5]. The pilot in the rear seat took control and landed. The patient could not exit the aircraft and had to be lifted from it by rescue personnel. The pain was at the point of maximum curvature of the spine where old degenerative changes were present. Because of concern about the possibility of such incapacitation, current USAF directives preclude flying duties for an individual with more than 20 degrees of scoliosis as measured by the Cobb method [5]. However, in IAF scoliosis more than 15° as measured by Cobb's method is a cause for rejection in candidates.

Spondylosis and Spondylolisthesis

Spondylolysis and spondylolisthesis appear ;o be manifestations of a fracture or cleft in the pars interarticularis of the vertebrae. In spondylolysis, no concomittant vertebral slippage occurs. In spondylolisthesis, the vertebral body involved slips anteriorly on the vertebral body inferior to the affected vertebral body. These defects appear to reduce the ability of the spine to withstand the application of mechanical force. An increased incidence of back pain has been reported in patients with spondylolysis, and high G forces may produce symptoms in an individual with spondylolisthesis. Flyers with rare symptoms may be able to continue flying when they do not have the potential for exposure to high G forces, either during typical mission profiles or during ejections [5]. However, these disabilities disqualify a candidate for Air Force Service in IAF [1].

Other spinal problems

Other conditions, such as Scheurmann's disease (rigid kyphotic deformity of the lower thoracic spine), spondylosis deformans (occurrence of body protuberances on the upper or lower ridges of vertebral bodies), Klippel-Fiel syndrome (fusion and deformities of the cervical vertebrae), significant spinal trauma, and similar conditions also affect the ability of the spine to tolerate increased G forces. As a result, individuals with these conditions should be considered for disqualifications for flying duties when they will be in situations where they may be exposed to increased G Forces [5].

Cervical Spine

The integrity of the cervical spine has taken new dimensions with the advent of the high G environment in contemporary military flying. This part of the spine is considerably more mobile than the rest of the spine. It has a normal lordotic

curvature at the level of cervical vertebra 4 (CV4). This curvature helps in increased flexibility of the spine in this area and gives it a better shock absorbing capacity, while at the same time preserves the rigidity and stability of the cervical spine. When a sudden force is applied to the cervical spine, the curvature disappears, absorbing the jolt. It is apparent therefore that a pre-existing absence of the normal lordosis is likely to make the cervical spine more vulnerable to injury if subjected to a sudden hyperflexion, or hyperextension.

The cervical nerve roots lie in close proximity to the vertebral bodies at the level of the intervertebral discs, and are therefore more likely to be injured by sudden jerks to the spine.

The enhanced ability to produced high +Gz forces applied at very high onset rates (2-10 G/s), as well as to sustain them at higher levels, presents an additional stress to the spine. This effect is compounded by the headgear with its mounted appendages, and the oxygen mask. Fighter aircraft operate in a dynamic environment that often requires a nearly constant vigil of all sectors surrounding the aircraft. Abrupt +Gz loading in a defensive or offensive maneuver frequently applies a significant load to the cervical and lower spine, in direction other than axial or neutral. This, in turn, can cause loss of head control or failure of a musculoskeletal component of the spine. It has been noted that flexion and extension injuries are produced at approximately 50% of the loads, which cause axial compression failure.

This problem may assume more serious proportion in the future by the introduction of helmet mounted electro - optical devices, which would add to the weight of the helmet and thus increase the spinal loading.

Incidence of soft tissue cervical injury and cervicalgia of more than 50% in the fighter aircrew has been reported in many studies [6, 7, 8]. A survey in IAF [9] amongst pilots flying MiG 29 and Mirage 2000 aircraft revealed an incidence of cervicalgia of 64% and 80% respectively for the two groups, as compared to an incidence of 54% for those flying an older generation of aircraft (MiG 21).

One study revealed that a staggering 88% of senior fighter pilots had moderate (grades 3 & 4) disc degeneration in the C3 - 4 disc, as compared to 36% of controls using low - field magnetic resonance (MR) thereby concluding that chronic exposure to the high +Gz environment can cause cervical disc degeneration [10].

Two clinical cases of +Gz associated degenerative cervical spinal stenosis caused by dorsal osteophytes in fighter pilots have been reported [11] with the help of MRI.

Spinal malposture, poor seat design and vibrations are considered to be the causative factors for backache in aircrew flying helicopters. The incidence of backache among the helicopter pilots of Indian Air Force was found to be 48.4% [12].

Loss of Cervical Lordosis

To a large extent, the trauma of hyperflexion produced during high +Gz maneuvers is absorbed by a straightening of the spine because of the temporary loss of the lordosis produced by the contraction of the spinal muscles, and the support

of the cervical ligament. However, if the cervical spine has a pre-existing loss of this protective lordosis, then it is likely that it may be subjected to severe trauma involving the vertebrae, the intervertebral disc and / or the cervical nerve roots.

Many candidates (who are assessed for their fitness for aircrew duties) reporting of the boarding centers are found to have loss of cervical lordosis without any history of recent trauma, spinal disease etc. Some subject's spine is found restored partially with the expected lordosis after a repeat X-ray (lateral view of the cervical spine) a few days later. Only they are declared fit provided the spinal movements are full and painless. Candidates with radiological evidence of loss of cervical lordosis with restricted spinal movements are declared permanently unfit for flying duties. X-ray of spine in flexion and extension is useful in ruling out organic causes for restriction of cervical spinal movements in apparently normal subjects with loss of cervical lordosis. Presently, there is no method to quantify the loss of cervical lordosis.

There have been a number of reports on the injury to cervical spine in current aviation medicine literature. There are no comments on the state of the cervical spine before the injuries had occurred. Thus, it is not certain that pre-existent absence of cervical lordosis was in any way responsible. Delahaye and Auffret [13] do mention that protection offered by the lordosis is helpful while considering aircrew status. IAP 4303 does not make any special reference to the problem of cervical lordosis at the time of medical examination for aircrew selection.

CT Scan / MRI - Spine

CT scan and / or MRI scanning of spine have been made mandatory in the Indian Air Force following an ejection [14]. These investigations are very useful to highlight and assess details of injuries to the joint - facets, transverse process, articular surfaces, ligamentous support and soft tissue. This information should be correlated with clinical features of ejectee pilot before a final disposal is decided.

The spinal cord is a longitudinal structure and this limits the precision of sitting for transverse axial imaging methods such as CT. MRI does not have this limitation because it can easily be applied in any plane, including the optimal sagittal axis [15]. The advantages of MRI are particularly apparent for non-invasive elucidation of myelopathy thought to be of discogenic orgin and in atypical radicular syndromes or spinal pain. The longitudinal images and display of the intrathecal contents are of particular importance in such cases [15].

Plain X-rays are commonly normal in acute disc prolapse, but there is narrowing of the affected disc or altered alignment of the spine due to muscle spasm. Assessment of lumbar canal stenosis by plain X-rays is subject to many inaccuracies. CT and / or MRI allow much more reliable assessment of disc prolapse as well as canal stenosis [15]. MRI produces no harmful radiation, it can safely be repeated as needed and is thus preferable to CT scan. MRI examination would be useful in fighter pilot's periodic medical check-ups in order to reveal acquired degenerative spinal stenosis.

Conclusion

The potential for acute or chronic spinal injury to spine exists in fighters as well as helicopters. Candidates reporting for initial medical evaluation at the boarding centers should undergo MRI scan of the spine along with the plain X-rays. In the absence of a baseline CT / MRI scan, it is difficult to attribute an observed finding in the post-symptom CT / MRI to long - term +Gz stress / helicopter flying. It will also help in screening out candidates with a congenitally narrow spinal canal for the fighter flying.

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