

## Validity of radiological screening as part of initial medical examination of aircrew.

Wg Cdr DS Chadha #Gp Capt (Retd) GS Sabikhi ##Wg Cdr A Handa\*  
Wg Cdr V Vasdev\*\* AVM RK Ganjoo AVSM VSM\*\*\*

### ABSTRACT

Radiological investigations are required for initial medical examination of aircrew as the clinical examination is not sensitive to detect minor abnormalities. There are conflicting reports regarding the utility of radiological investigations as a screening tool for this purpose. A retrospective analysis of radiological investigations was conducted on the aircrew undergoing initial medical examination at Air Force Central Medical Establishment, New Delhi, between Jan 2004 and Dec 2006. A total of 1786 healthy aircrew underwent screening radiological investigations. The mean age of the study population was  $20.3 \pm 2.1$  years (range 18 - 23 years). Abnormalities were detected in 10.5% (188) of the screening chest radiographs, 4.4% (78) of the cervical spine and 14.4% (258 of 1786) of the lumbo-sacral spine radiographs. Radiological investigations resulted in the permanent disqualification of 6.2% (111) aircrew. The enquiry reaffirms that radiographic screening is a useful tool for detecting asymptomatic spinal and pulmonary abnormalities among the budding aviators.

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**Key Words:** radiological screening, disqualification, asymptomatic aircrew

Any pilot incapacitation in flight has the potential to lead to an accident [1, 2] hence it is mandatory to medically screen all professional pilots, in order to identify those who have, or may be at increased risk of any illness [1]. The rationale for the use of screening tests in the military scenario, where there is a high proportion of single pilot operations, is based not only on ruling out disease but also on perceived benefit to flight safety [3, 4]. For commercial operations, the vast majority are in two pilot aircraft with many advanced autopilot aids. This means that any acute incapacitation is likely to result in an accident in less than 1 in 1000 events, and this should be taken into account when setting medical standards.

In military setting, the respiratory system and spine assume great importance owing to the increased stress of flying high-performance aircraft. Amongst various modalities for screening, routine radiological investigations have been largely

discounted as an effective method of screening for diseases in young asymptomatic aspiring pilots. The vertebral column is relatively inaccessible for clinical examination hence it is mandatory to use radiography as a modality for screening spinal abnormalities. The diagnostic yield of these investigations is variable and is determined by the prevalence of the disease in the given population. The correlation between the radiological findings and the clinical symptoms is not definite hence the validity of carrying out some of these radiological investigations has also been questioned [1, 5, 6]. It is worthwhile looking into the diagnostic yield of

# Classified Specialist Medicine and Cardiology,

\* Classified specialist Medicine and Pulmonology,

\*\*\* Commandant, Command Hospital, Bangalore.

# Classified Specialist Radiology,

\*\* Classified Specialist, Medicine Air Force Central Medical Establishment, Delhi.

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these investigations in a subset of healthy population reporting for evaluation prior to joining aviation duties. In the current study, we sought to determine the frequency of radiological abnormalities in a young healthy pilot aspirant population.

### **Material and methods**

The present study was conducted at Air Force Central Medical Establishment, New Delhi, a premier institute carrying out evaluation of both civil and military aircrew. This study involved retrospective analysis of radiological investigations conducted on the aircrew. A search of our database yielded a total of 1786 aircrew who underwent radiological evaluation between Jan 2004 and Dec 2006. Study population consisted of asymptomatic, active individuals undergoing flight medical examinations for the cockpit and non-cockpit aircrew duties. All the aircrew after detailed medical examination were subjected to following radiological evaluation

- i) Chest radiograph,
- ii) X-ray cervical spine (standing) frontal view and lateral view
- iii) Thoracic spine (lying down) frontal view and lateral view
- iv) Lumbar spine (lying down) frontal view and lateral view

All radiographs were interpreted by board-certified radiologist, and a written report was generated for each examination. The result of each radiograph was reviewed and classified as normal or abnormal. Depending on the abnormality noted on the initial radiological investigation further evaluation was carried out as per the existing protocol of the center. Individuals with an abnormal chest X-ray were evaluated with digital radiography, followed by computed tomography (CT) chest and pulmonary function test where indicated. Those with

spinal abnormalities were evaluated further by functional films in flexion and extension. Findings that were considered normal variants or inconsequential (such as healed fractured rib or clavicle or extra ribs) were categorized as normal. Patients with major abnormalities were assigned to one of two groups: true-positive results (abnormal radiograph in the presence of disease) and false-positive results (abnormal radiograph in the absence of disease). Final disposal of the aircrew was done as per the laid down protocol in Manual of Medical Examination and Medical Boards (IAP 4303).

### **Results**

A total of 1786 healthy aircrew underwent screening radiological investigations, 88.2% (1575) of these were for cockpit aircrew duties and 11.8% (211) for non-cockpit aircrew duties. The mean age of the study population was a  $20.3 \pm 2.1$  year (range 18 - 23 years) with majority of aircrew being male (80.1%).

Summary of the abnormal findings noted in various radiological investigations is as given in figure 1. Abnormalities were initially detected in 10.5% (188) of the screening chest radiographs, 4.4% (78) of the cervical radiographs and 14.4% (258) of the lumbosacral spine radiographs. Radiological investigations resulted in the permanent disqualification of 6.2% (111) aircrew.

Abnormalities noted in the initial chest radiograph are as given in table I. Prominent vascular markings and hilar prominence was the commonest abnormality noted in (116), and all these aircrew were further evaluated with digital radiographs, chest CT scans and pulmonary function test as per the laid protocol. Final result of these investigations is as given in table II. Of the total 116 aircrew who were noted to have radiological abnormality on the conventional X-ray only 8 were finally confirmed

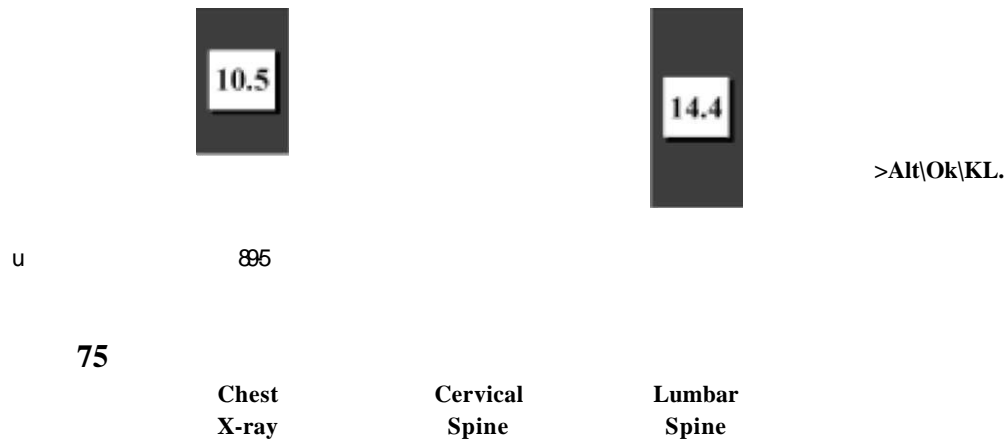


Figure 1: Summary of radiological abnormalities noted in the aircrew

Table I: Findings of the chest radiographs in aircrew

FINDINGS	Male (%)n = 1429	Female (%)n = 357	Total (%)n = 1786	Unfit
Pulmonary fibrosis	10 (0.6)	03 (0.8)	13 (0.7)	13
Pulmonary fibrocavitary lesion	07 (0.4)	03 (0.8)	10 (0.5)	10
Pleural tag	03 (0.2)	NIL	03 (0.2)	-
Prominence of lung markings	40 (2.7)	15 (4.2)	55 (3.0)	04
Hilar prominence	43 (3.0)	18 (5.0)	61 (3.4)	04
Scoliosis (thoracic spine), <14 °	32 (2.2)	09 (2.5)	41(2.2)	-
Miscellaneous	5 (0.3)	NIL	05 (0.2)	-

Table II: Evaluation and final disposal of individuals with hilar and bronchovascular prominence on conventional chest X ray

	Normal (%)	Abnormal (%)
Digital Chest Radiograph (n=116)	96 (82.7)	20 (17.3)
CT Scan Chest (n=20)	16 (75)	4 (25)
Pulmonary Function Test (n=20)	16 (75)	4 (25)

to have significant abnormality. In the rest it was either superimposition of normal structures or variants of normal findings. This eventually resulted in an additional 116 digital X rays, 20 chest CT scans and 20 pulmonary function tests.

Pulmonary fibrosis and fibrocavitary lesions were noted in 1.3% (23) aircrew. All these candidates were declared unfit and were advised

evaluation to establish the aetiology of the radiologic abnormality. In addition chest radiograph also revealed scoliosis in 2.2% (41) aircrew. However it measured less than 14 degrees (Cobb's method) in all the cases and therefore did not merit disqualification for flying duties. Other miscellaneous abnormalities identified were blunting of costophrenic angle, pleural tags, mediastinal shift and loss of thoracic kyphosis.

**Table III: Findings of the spinal radiographs in aircrew**

Findings	Cockpit aircrew		Non cockpit aircrew		Unfit
	Male (%) n = 1218	Female (%) n = 357	Male (%) n = 211	Female (%) n = NIL	
<b>Cervical Spine</b>					
Partial loss of lordosis	60(5)	06(1.6)	02(1.0)	-	-
Kyphosis of cervical spine	01(0.1)	-	-	-	-
Prominent pedicles CV7	03(0.2)	-	-	-	-
Congenital block vertebrae	01(0.1)	-	01(0.5)	-	-
Cervical ribs	02(0.2)	02(0.5)	-	-	-
<b>Lumbar Spine</b>					
B/L complete lumbarisation	14(1.1)	-	03(1.5)	-	-
Incomplete lumbarisation	03(0.2)	-	-	-	03
B/L complete sacralisation	13(1.1)	-	02(1.0)	-	-
Incomplete sacralisation (unilateral+bilateral)	66(5.4)	02(0.5)	08(3.7)	-	76
Loss of lordosis (partial)	21(1.7)	06(1.5)	05(2.3)	-	-
Scoliosis < 14 °	19(1.6)	01(0.2)	-	-	-
Spina bifida (LV5 & SV1)	78(6.4)	10(2.8)	06(2.8)	-	-
Fracture transverse process	01(0.1)	-	-	-	01

Salient findings of the radiological investigations of the spine are as given in table III. Partial loss of the cervical lordosis was the commonest abnormality noted in 68 (3.8%) aircrew; none of these aircrew had restriction of the neck movements and were hence declared fit. Cervical rib was noted in 4 (0.2 %) aircrew, all were declared fit as none of them had any associated neurovascular compromise.

Lumbar spine X-ray showed abnormalities in 14.4% of aircrew. Spina bifida of LV5 and SV1 was noted in total of 94 (5.2 %) aircrew (88 in the cockpit and 6 in the non-cockpit aircrew) and they were all declared fit for aviation duties. Incomplete sacralisation was noted in total of 76 (4.2%) aircrew (68 in the cockpit and 8 in the non-cockpit aircrew). All of these aircrew except for the 8 candidates for non cockpit aircrew duties were declared unfit for aviation duties. Partial loss of the lumbar lordosis was noted in 32 (1.8%) aircrew; none of them had restriction of the back movements and were hence

declared fit. Bilateral lumbarisation and sacralisation was noted in 17 (0.9%) and 15 (0.8 %) aircrew and all of them were awarded full flying medical category.

### Discussion

The feasibility and success of screening examinations for flight duties are dependent on several principles. The conditions being sought should be important to assess the fitness for aviation duties. The screening test should be sufficiently accurate and have the least possibility of harm to the person. In addition, the costs of evaluation, treatment, disqualification, or retaining the pilot on active duty with the disorder should also be estimated and risk benefit analyzed.

The World Health Organization has recommended that chest radiographic screening is not required for aviators except in those exposed to occupational lung hazards [7, 8]. Cox et al [4]

reviewed 3500 chest radiographs in healthy persons screened for flight duty, and found abnormality in 107 (3%). Fifty-five of these were subsequently found to be false positive. In the study by Schenk et al [9] 2000 aircrew were screened by chest radiography and only five (0.26%) were abnormal, none of abnormalities resulted in disqualification for flying duties. These figures from studies in western population are in contrast with the high incidence of radiological abnormalities in our study. These may be due to difference in the disease pattern in our country compared to the West. High incidence of pulmonary fibrosis and fibrocavitary lesions noted in the current study lend support to the continued usage of this modality for screening. Therefore, chest radiograph is still a mandatory requirement in initial medical examination of aircrew especially in countries where there is high prevalence of pulmonary tuberculosis.

High rate of false positivity was noted on the conventional chest radiographs in the present study, as compared to the published literature [9]. Majority of these abnormalities were not found on repeat digital chest radiographs. There is need to replace the conventional radiograph with the digital radiography at institutions carrying out initial medical examination of aircrew, to prevent wastage of time and resources.

The clinico-radiological correlation is not definite in spinal disorders. This problem is further compounded when we extrapolate the clinical significance of radiological abnormalities from patients to a population of healthy, asymptomatic adults in order to predict their future functional status. Most common spinal abnormality noted in the present study was scoliosis and straightening of the spinal curvature which did not lead to disqualification of any candidate from flying duties. This is akin to what has been noted in other studies

done in the young asymptomatic adults [8, 10, 11].

Even though, neck pain in high performance fighter aircraft pilots receives much attention, spinal disorders leading to low back pain are reported to be twice more common in fighter aviators [12]. Association of lumbar spine abnormalities with low back ache has been controversial. In a study from Israel done in young army recruits (more applicable to the present study) spina bifida, left-sided scoliosis, hemi-lumbarization, sacralization and hemi-sacralization, Schmorl's nodules or mild degenerative changes were not associated with low back ache [11]. Iwamoto et al found spondylolysis to be a significant risk factor for low back pain in rugby players, there was no direct relation between sacralization (partial or complete) and low back pain [13, 14]. Unilateral asymmetrical lumbar sacralization was the commonest abnormality leading to disqualification of the aircrew in the present study. This disorder has been shown to increase the torque forces leading to disc herniation of lumbosacral spine [15].

## **Conclusion**

Radiographic screening is definitely useful for detecting asymptomatic spinal and pulmonary abnormalities which place the aviator at high risk for adverse consequences during flying duties. Digital radiographic screening with its better resolution is a superior tool and leads to optimal utilization of resources.

**Conflicts of interest:** None identified.

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