

Head injury and fitness to fly - Need for a review

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The commonest cause of a head injury is road traffic accident (RTA) and aircrew are no exception. However for aircrew the risk of post traumatic epilepsy always weighs heavy in the mind of the aeromedical/clinical specialist. This paper analyses the risk of post traumatic events (including epilepsy) vis-a-vis the severity of head injury. A comparison of the practices in the IAF with practices of other countries reveals a need for review. A policy based on the severity of head injury is suggested.

Keywords: Aircrew evaluation, post traumatic amnesia, loss of consciousness, epilepsy.

Accidents have become an integral part of our mechanised lives as is evident from the screaming headlines of the morning newspapers. Nearly 700,000 deaths due to accidents are reported in the world every year, many more go unreported [1]. A majority of these i.e., over 50% to 60% are due to road traffic accidents and about 10% due to household accidents. Of these, 60 to 70% result in head injury; 80% of which are serious enough to warrant some medical attention. The flying accident rate in the Indian Air Force (IAF) is around 1.6 per 10,000 hours of flying [2]. All these types of accidents, when resulting in head injury, can lead to loss of trained man power. The injury may also result in long term sequelae, neurological or neuropsychological, which could result in permanent unfitness for flying duties.

In the IAF, we have been dealing with head injuries for a long time. Rao et al [3] had reported 69 cases of head injury and its sequelae for the period 1970-75, while Lakshminaryan [4] reported on head injury and abnormal GTT. The current policy being followed as laid down in the IAP 4303 paras 5.10.12 to 5.10.16 has evolved over the years [5]. However, this policy does not satisfactorily spell out certain criteria for evaluation and disposal as indicated in Table 1.

Policies the world over keep changing to cater to new information and knowledge. Upto 1985, USAF disposal for cases of head injury with a loss of consciousness (LOC) of more than two hours was to return them to flying in 3 months. The policy has since been revised [7]. The criteria for disposal followed in UK seems to be based on the duration of post traumatic amnesia [8].

Table 1. Inadequate criteria for evaluation and disposal of cases of head injury and relevant IAP reference

	IAP Para
How gradual should be the return to flying duties ?	5.10.12
How to determine severity vis-a-vis prognosis ?	5.10.12 & 13
What is the relevance of sequelae and how should they be disposed off ?	5.10.13
How often to record EEG and what are the non-specific abnormalities ?	5.10.15
What are the risk factors for post traumatic seizures (epilepsy) ?	5.10.16 (b)
How long should the observation period be with special reference to post traumatic seizures ?	5.10.16 (b)

Table 2. Details of the type and time of accidents which caused head injuries

Accident	Branch of subjects	
	Flying (n=16)	Ground Duty (n=5)
Type		
Flying	4	NA
RTA	12	5
Time		
Flying	2000h, 1430h, ?, ?	NA
RTA	1950h to 0600h	0600h to 1200h

Table 3. Aircrew : Duration of LOC &/or PTA, classification of severity of head injury (HI) and first flying category

Subject (Service)	Age	LOC	PTA	Severity	First flying category (No. of years from HI)
HS (N)	22	15 min	15 min	Mild	A3G2 (6m)
DS (N)	29	NS	few min	"	Not yet given (1y7m)*
M (CG)	28	few min	nil	"	A2G2 (9m)
Pr (A)	28	"	"	"	A1G1 (4m)
Py (N)	41	"	"	"	A1G1 (1y9m)
D (AF)	48	15 min	NS	"	A2G2 (2y)**
VK (AF)	40	5-6 min	10-15 m	"	A1G1 (7m)
GKS (CG)	26	14 hrs	NS	Mod.	A3G1 (3y)
NRS (N)	35	10 min	6-7 hrs	"	A3G2 (1y2m)
AS (N)	30	5 min	16 hrs	"	A3G1 (2y4m)*
AKS (N)	33	3 hrs	NS	"	A3G1 (1y)
HSA (AF)	43	NS	9 hrs	"	A4G3 (P) (1y) [†]
KSR (AF)	41	NS	5-6 hrs	"	A3G3 (1y7m) [†]
RS (N)	25	2 hrs	48 hrs	Severe	A3G2 (1y3m)
PKP (AF)	38	6 days	NS	"	A4G3 (P) (2y) [†]
KSP (CG)	29	NS	NS	?	A3G1 (2y) [‡]

NS not specified, * gliosis, * immediate seizure, † IC hematoma, ‡ fragments in brain, † neuro deficit, ** Tuberculoma,

[†] Post's

AF = AirForce, N = Navy, CG = Coast Guard

This study of all cases of head injury evaluated at the Institute of Aerospace Medicine (IAM) was therefore undertaken to see if the present system of evaluation and disposal is adequate keeping in mind the available literature and current practices in other air forces.

Analysis: A total of 21 cases of head injury whose case records were available from Jan 86 onwards were included in the analysis.

Table 2 shows that out of a total of 21 cases, 16 subjects belonged to the flying branch and 12 of them were injured in road traffic accidents. Most of these accidents took place during the night time.

Table 3 gives the breakdown of the 16 cases of head injury in aircrew. The classification of severity of head injury is based on what is currently being followed in the USAF [9].

Table 4 compares the time taken to return to flying status with that of the USAF and UK standards. We find that all three standards are different and this prompted us to look further and analyse our cases from the point of view of investigations, basis of category and the reasons if any for delay in return to flying.

Investigations are an integral and useful part of any assessment which should cover anatomical, physiological and pathological effects of any disorder. In head injury we are interested in noting presence or absence of skull fractures and intracranial or electrophysiological, neuropsychological and metabolic abnormalities. These investigations, if normal also help in the disposal.

Table 5 brings out the yield of investigations usually done in a case of head injury. There is no doubt that the CT scan is of value in detecting

Table 4. Reflighting : Comparison with USAF and UK practice

Air crew	Flying hours (Total)	Severity of head injury	Return to flying after event	Should have returned to flying	
				USAF [7]	UK [8]
HS	77	Mild	6m	1m	2-6 wks
DS	88	"	1y7m	3-5y	"
M	224	"	9m	1m	"
Pr	305	"	4m	1m	"
Py	1715	"	1y9m	1m	"
D	3890	"	2y	1m	PTA NS
VK	4100	"	7m	1m	2-6 wks
GKS	270	Moderate	3y	2y	PIA NS
NRS	470	"	1y2m	6m-1y	8 wks
AS	1500	"	2y4m	2y-5y	4m
AKS	1800	"	1y	6m	PTA NS
HSA	2400	"	Grounded	Grounded	PTA NS
KSR	4000	"	1y7m	2y	8 wks
RS	680	Severe	1y3m	2-5y	9m-Indef.
PKP	3395	"	Grounded	5y	PTA NS
KSP	300	"	2y	NA	"

anatomical abnormalities as well as aiding in the early management and later on, the disposal. The skull X ray has the drawback of inability to detect intracranial abnormalities and is therefore of value when the CT is not available.

Table 5. Details of investigations

Investigations	No of cases	No of tests taken	Yield
Skull X ray	6	7	1
EEG	10	26	+ve in 1 case -ve in rest
CT	5	8	6
Psychometry	10	26	5
GIT	7	25	7

Basics of Category: Head injury is a disability which brings together specialists of different disciplines. The medical board, therefore, has to consider the facts put forward, the category entered by the specialist, correlate with the current IAF policy and award a final disposal.

From Table 6, it appears that the opinion is what matters and not the category. If specialists give opinions describing the functional assessment rather than the medical category, it may bring in more uniformity and ease of medical categorisation.

Delay in return to flying: Lastly we tried to look into whether there was any delay in returning to

Table 6. Final medical category : Recommendations of specialists and medical boards

Subject	Category awarded by Neurologist (N) Neuropsychiatrist (NP), Med Splt (M), Surg Splt (S), Eye Splt (E), ENT Splt (EN)	Category awarded by Med. Board
KSR	A2G1 (E), A3G2 (EN), A2G2 (S), A4G5 (NP)	A4G5
Py	A1G1 (S), A1G1 (NP), A1G1 (N)	A4G2
VK	A1G1 (NP), A1G1 (S), A4G2 (M)	A4G2
MKA	A4G5 (NP), A4G1 (N)	A4G5
M	A1G1 (S), A4G2 (NP)	A4G2
RS	A3G2 (NP), A3G2 (S)	A4G2
SCD	A4G1 (S), A4G2 (NP), A4G1 (N)	A4G1
DS	A2G2 (S), A4G3 (M)	A4G3

Table 7 Delays in return to flying

Reason for Delay	1-3	3-6	6-9	9-12	Total Min	Max
Administrative delay in seeking appointment	1				1	3
Non availability of documents		1			3	6
Procedural lapse	3	3	1		18	33
Interservice delay	1				1	3
Want of medical executive report	1				1	3
Want of specialist opinion	1				1	3
Interpretation of policy		3		2	27	42

flying. The delays could have been either administrative or medical. In Table 7, some of the reasons as evident in the case records have been brought out. It may be added that what is shown is a cumulative duration and not the time delay for any individual case.

Thus, interpretation of the current IAP policy on head injury, delay in sending aircrew to AFCME/IAM and information on the flying requirements, formed the major reasons for delay in returning the aircrew to flying duties.

A review of the current literature available on head injury was taken up in order to see whether anything could be done to reduce the anomalies and improve the system of evaluation without jeopardising flight safety as well as the safety of the aircrew.

Discussion

Head injury is a significant contributor to death particularly in the first half of life. The problem of assessing initial severity has largely been overcome using the Glasgow Coma Scale. But assessing eventual outcome especially the possibility of developing post traumatic seizures has not been addressed fully. This assessment becomes more relevant in the flying environment.

In 1980, Annerggers et al [9] reviewed 2,747 civilian patients in the Rochester area and they classified their head injuries. They were able to show on follow up of these cases that, when all

types of head injury were taken into consideration, the incidence of late seizures one and five years after the trauma (0.5-1.4%) was not more than the normal prevalence of seizures in general population. However, when they viewed the incidence of late seizure as per their categorisation of head injury, a different picture arose, as shown in Table 8.

It has been argued that initial severity is not an absolute indicator of the subsequent reversible deficit. The period of PTA should be taken into account and PTA of > 24 hrs should be classified as severe head injury. Measurement of PTA, i.e., the period between injury and return of continuous memory has been used to classify severity and predict outcome [10-14]. Ernsting has recommended the minimum period to keep aircrew off from flying duties correlated to the duration of PTA [8]. He, however, cautioned that where the risk of post traumatic seizure was higher than 15% it is advisable to keep the pilot off flying for one to three years.

What, therefore, is the risk of post traumatic seizure after head injury? In a study of 150 cases of closed head injuries evaluated at IAM, Dham et al found that 1.5% had a chance of going into PTE [15]. They based their risk strategy on Jennet's classification, i.e., LOC > 2 hr and PTA > 48 hr [16]. Mathematical formulae for assessing the risk do exist [12, 17, 18, 19] but cannot replace the physician's judgement. The risk factors to be taken into account were brought out by Firth [20].

Table 8. Incidence of late seizures

Category of head trauma	Children		Adults		Total	
	< 1 yr	5 yrs	> 1 yr	5 yrs	< 1 yr	5 yrs
Severe	5.6	7.4	7.7	13.3	7.1	11.6
Moderate	0.5	1.6	1.0	1.6	0.7	1.6
Mild	0.0	0.2	0.1	0.8	0.1	0.6

It is also known that if post traumatic seizures were to occur, 5% occur in the 1st week, 75% occur in the 1st year and 85% in 2 years [21]. We can conclude therefore that if the risk factors for post traumatic seizures are present, the minimum period off flying should be 2 years. However, based on the classification of head injuries by Annegers et al [9], those with the severe forms of head injury require to be off flying for a longer duration.

In the present series, period of LOC or PTA was not available on record for eight aircrew. In two cases this was more than 24 hrs; one of them has been returned to flying with no seizure recurrence, while the other was permanently grounded. The number is too small to draw any conclusions.

The role of investigations in a case of head injury is of paramount importance not only in the management but also in the rehabilitation. Return to flying requires that the aircrew should have no anatomical nor functional deficit and should therefore be assessed on the actual problem as well as the potential problem.

The CT scan is the most readily available investigation for the head injury and, if done within 48 hrs of the injury, is of value in initial management and later disposal [22]. This was true in our series as well. By providing information about the intracranial structures, it is more useful than the skull X ray [23]. Anatomical clearing up of the intracranial abnormality helped restore early flying category in five cases.

The value of EEG in head injury is not to be scorned but its yield even in an epileptic population is at best 50%. Its value in head injury therefore is circumspect as it is not a reliable predictor of post traumatic seizures [23]. It should be taken after the acute phase in the course of the disability and when the aircrew is being considered for return to flying duties. The EEG

record should include routine activation procedures like sleep, hyperventilation and photic stimulation. Currently more sophisticated tests such as ambulatory EEG, video-recorded EEG and computerised EEG [24] are available.

Psychological testing is of great interest to us in aviation as one uses all the areas of the brain to fly. The areas more susceptible to damage in head injuries are the frontal and temporal lobes, the corpus callosum and the brain stem. These are difficult to be assessed clinically. Psychometric analysis are more valuable in this context. Serial psychological testing has revealed that most recovery occurs within six months [25]. The psychological tests being done at IAM are part of the WAIS. Currently more specific and localising tests for lobar functions are available. Our series shows that aircrew with severe head injury showed no correlation with the psychological tests while cases of mild or moderate injury were kept off flying as the tests were abnormal. A confounder in all these cases was the fact that they were invariably seen 3-6 months after the injury.

Studies done at NIMHANS using the psychometric test designed by them have proven to be of benefit. The same may be obtained and used in a prospective trial.

The head injury arena concerns many specialists whose opinion and category is based on current knowledge in that speciality. It is our feeling that if only detailed opinion on functional status is given by the specialist, the medical board would be able to categorise the aircrew based on the current IAF policy and the above opinions.

Conclusions

After going through our documents, the current literature and world practices, we would like to recommend the following:

- (a) Change in the existing IAP guidelines/policy. This policy should take into account, the gradation of severity of head injury vis-a-vis the disposal as already discussed.
- (b) CT scan should become a mandatory requirement in all cases of moderate and severe head injury.
- (c) Proforma for CNS cases in which head injury will form a part wherein LOC or PTA must be recorded.
- (d) Review the neuropsychological assessment both at IAM and AFCME.
- (e) All head injury cases should be asked to report to IAM after hospitalisation/sick leave for the purpose of prospective studies and formation of a data base.
- (f) The policy suggested by the authors, as given below needs to be considered for early implementation.

Suggested policy

Head injury: All cases of head injury are to be evaluated before they are permitted to resume flying duties. Evaluation procedures are to be based on the severity of head injury. In all cases meticulous recording of LOC and PTA will be done and the severity of head injury will be based on the same as given below.

- Mild - LOC and/or PTA < 1 hr
Moderate - LOC and/or PTA > 1 hr < 24 hr
Severe - LOC and/or PTA > 24 hrs

All cases of head injury should have a CT Scan done within the first 48 hr and in-patient monitoring for a minimum period of 48 hr. EEG, neuropsychiatric evaluation and neurophysician's evaluation are to be done in all cases during/after hospitalisation. All head injury cases regardless of their branch will be referred to IAM/AFCME

for evaluation immediately after hospitalisation/sick leave when recovery from other disabilities is considered necessary.

All cases of head injury will be graded into mild, moderate or severe cases according to the following criteria.

- (a) Mild : LOC and or PTA < 1 hr.
: CT normal EEG normal.
: Psychometry normal. BSL-F and PP after 75 gm glucose normal.
: Neurological and neuropsychiatric evaluation normal.
- (b) Moderate : LOC &/or PTA >1hr <24 hrs.
: CT shows linear fracture skull-outer table only. No intracranial lesion.
: EEG normal, psychometry normal / abnormal.
: Neurological and Neuropsychiatric evaluation normal.
- (c) Severe : LOC and/or PTA >24 hr and/or.
: CT - depressed skull fracture.
: Contusion brain.
: Intracranial haematoma / haemorrhage.
: Penetrating wound.
: CSF rhinorrhea / otorrhea.
: Neurological deficit.
: EEG abnormal.
: Psychometry abnormal.
: Neuropsychiatric evaluation abnormal.

Return to flying will be based on the following:

- Severity of head injury
- Normality of investigation
- Risk of post traumatic seizures
 - H/O of febrile seizures
 - Family H/O epilepsy

Early epilepsy (1st-7th day)
Depressed fracture skull vault
Penetrating head injury with retained fragments
Intracranial hematoma/haemorrhage
Persistent neurological deficit

1. *Mild head injury*

Return to flying :

Minimum 2 wks maximum 1mth. Neurological and neuropsychiatric examination normal

CT scan, EEG, Psychometry normal

Category A4G4 during the period of investigation.

Category A1G1 when evaluation normal

2. *Moderate head injury*

Return to flying:

(a) Neurological and neuropsychiatric evaluation normal

CT normal, EEG normal, psychometry normal. No risk factors for post traumatic seizures.

Minimum period of observation 6 mths during which category to be upgraded from A4G4 to A1G1

(b) Neurological and neuropsychiatric evaluation normal

CT scan shows linear fracture outer table only EEG normal, Psychometry normal

No risk factors for post traumatic seizures

Minimum period of observation 1 year
A4G4 to A2G1 6 mths; A2G1 to A1G1 6 mths or A4G4 to A1G1 1 yr.

3. *Severe head injury*

Return to flying:

(a) Neurological and neuropsychiatric evaluation normal

CT normal, EEG normal, psychometry normal. No risk factors for post traumatic seizures

Return to flying after 2 yrs - dual 6 mths solo 6 mths

Total duration after event 3 yrs

(b) CT shows: Depressed skull fracture and/or intracranial hematoma/haemorrhage initially and clearing up within 3-6 months without residual deficit/gliosis

Neurological and neuropsychiatric evaluation normal, EEG normal, Psychometry normal. No risk factors for post traumatic seizures, Return to flying after 3 yrs - dual 6 mths - solo 6 mths, total duration after event 4 yrs.

(c) CT initially abnormal, normal after 3-6 mths.

EEG normalised, psychometry normalised
Risk factor (s) for post traumatic seizures present Return to flying after 5 yrs

No solo flying

No instructional duties with ab-initio pilot

Change to Tpt/Hpur stream

4. *Flying not permitted*

Early or late seizure occurs, persistent neurological deficit, penetrating head injury with retained fragments.

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