

## A Case of Extensive Healed Burns: An Evidence Based Approach to Aeromedical Decision Making

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### ABSTRACT

This paper discusses the evaluation of a military aircrew with extensive healed burns. The aircrew was a fighter pilot who sustained 35% burns over face, neck, anterior aspect of upper chest, both hands and right lower limb. He developed post burn contracture and was managed by surgical release and split skin grafting. After a ground observation for 02 years, he underwent a comprehensive aeromedical evaluation consisting of a detailed clinical, functional and hot cockpit evaluation and was upgraded to a restricted flying category. In-flight assessment for fighter cockpit was uncomplimentary and hence he was re-streamed to transport fleet. Following a substantial period of observation in an active but lower medical flying category, he was upgraded to full flying status. Dilemma in aeromedical decision making remained in all stages of assessment; during re-fighting, re-streaming to transport aircraft and finally upgrading to full flying status. The importance of an objective clinical and functional evaluation, role of ground based simulators, in-flight assessment in actual flying environment and an evidence based approach for cases of extensive burns in aeromedical decision making has been discussed.

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**Keywords:** Burns, post burn contracture, hot cockpit evaluation, in-flight assessment, aeromedical decision making.

### Case Report

A 36 yr old fighter pilot sustained 35% burn injuries over face, neck, anterior aspect of upper chest, both hands and right lower limb while trying to extinguish accidental fire at his residence in August 2005. The Officer was managed with wound dressing and skin grafting and was awarded a ground category in November 2005. During this period of observation, he developed **post burn contractures** for which he underwent surgical release and split skin grafting. He was observed in non flying category (A4G4) for two years. Subsequently, following a normal clinical and functional evaluation and satisfactory tolerance to heat stress in Hot Cockpit assessment, he was upgraded to a restricted flying category and was asked to review with an executive report on flying including sorties involving G loading. During this 35 minutes sortie for executive report, the pilot had difficulty in turning his upwards and to the right during high G maneuvers. The shoulder strap and

helmet rubbed against the burn site causing irritation of the skin. He also experienced stretch of the skin over right leg and the executive report was uncomplimentary.

To get rid of these effects of post burn contractures, the pilot underwent Y-V plasty of neck scar and flap covering for residual contractures. Following an initial observation on ground for a short period, a detailed clinical, functional and hot cockpit evaluation was undertaken in April 2008 and found satisfactory. He could not be assessed in human Centrifuge as the equipment was unserviceable. He was thus upgraded to restricted flying category and an executive report on flying was asked for to

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assess his ability to withstand in-flight G stress and heat load. During the in-flight assessment, the pilot had difficulty in turning his neck upwards and to the right under high G maneuvers up to 6 Gz. He also had irritation of the skin over the burnt portion due to the helmet.

Based on the uncomplimentary executive reports of the two consecutive in-flight assessments, the pilot was made permanently unfit for fighter aircraft and was recommended for re-streaming to transport aircraft. A fresh executive report regarding his cockpit worthiness on transport aircraft was sought. The executive report on Avro aircraft was complimentary for reaches and ranges of movement including required checks, procedures, cockpit and emergency drills. Following this the pilot was upgraded to permanent category (A2G2) and restreamed to transport aircraft in December 2008. During his subsequent evaluation in May 11, he was found to be completely asymptomatic for a substantial period of more than three years even with active flying of more than 400 hours on transport aircraft. A detailed evaluation did not reveal any evidence of functional limitation. The protocol followed for evaluation of burn injuries was on the same lines as in a case of burns evaluated at this Institute of a naval aviator in 1989 [1]. The pilot was considered for upgradation to full flying status. However, the dilemma met was the assessment of his thermoregulatory response, the ability of the pilot to maintain his core body temperature in times of stress and the effects of the flying condition on grafted skin. As the Hot cockpit chamber at the Institute was not serviceable at the time of this review, an evidence based approach was followed. An extensive review of literature about similar cases was carried out which revealed that patients with less than 60% burns were able to maintain their core body temperature and the grafted skin would be able to thermo regulate

in conditions of thermal stress. In view of the above, the pilot was upgraded to full flying status in transport aircraft.

## **Discussion**

Burn injuries are not uncommon in military pilots. Cases of extensive burns may have serious aeromedical implications which may affect flight safety and operational efficiency. Among the important aeromedical implications are the loss of permanent functions due to structural deficits and effects of post burn contracture such as pain, tenderness and restriction of movements, which would affect performing the flying task. Ability of the burnt areas to affectively thermoregulate specifically under conditions of heat stress and clinical behaviour of the grafted tissue in adverse flying environments are of prime importance. Further, constant friction of the aircrew equipment assembly on the burnt tissue can result in discomfort and distraction while executing the flying task. Thus, aeromedical evaluation of such cases must be highly objective with detailed clinical and functional assessment. The evaluation should also include examination of the aircrew under simulated heat stress to assess thermoregulatory functions of the burnt areas. Extensive burns with contractures are also required to be evaluated in the Human Centrifuge to assess full ranges of joint movements under simulated acceleration stress. An in-flight assessment provides evidence towards his ability to execute emergency ground escape and perform all assigned flying tasks in actual in-flight environment. In addition to these objective assessments, an evidence based approach on currently available scientific literature would serve as a valuable guideline for aeromedical decision making and disposal of such cases. The case discussed above had 35% burn injuries. The details of clinical and functional evaluation, hot cockpit

assessment, centrifuge evaluation and evidence based approach to re-flight the aircrew to full flying status is discussed below.

### ***Clinical assessment***

An overview into the physiological effects and clinical findings in the case for correct assessment of burnt area, the depth of the burn wound, the effect and long term complications of burn injury was of prime importance for disposal of the case. The assessment of the burn area was done by an approximate clinical rule in wide use the 'rule of nines' [2,3]. The areas involved were of differing burn depths. The skin graft had well taken up with no signs of local infection. There was no local photosensitive reaction, keloid formation or hypertrophic scars at burn site. The regional effects was of prime concern in the case as long standing muscle compartment syndrome with circulation being compromised would have lead to ischaemic fibrosis and contractures. The pilot had developed contractures in the neck which were relieved by YV plasty. There were no associated complications of Curling's Ulcers, severe weight loss, deep vein thrombosis or pulmonary embolism during evaluation of the pilot.

### ***Functional Evaluation***

A detailed functional evaluation of any such case is of prime importance as this would determine the optimal performance of the pilot in cockpit. Functional evaluation was done as follows:

- (a) **Range of movements at all joints involved in the burn injury:** The pilot was found to have complete range of movements at all joints involved in the injury i.e cervical spine, shoulder joint and ankle joint. Assessing the range of movements of the joints involved in the burns is critical as it will determine the ability to reach and fully apply the controls in the cockpit. The movements may be restricted in such cases due to contractures, keloids etc. Further unrestricted movements at the joints will aid the pilot in easy ingress and egress from the aircraft.
- (b) **Power of the muscles:** The power of the neck muscles involved in this case was assessed with power being Grade V/V. The power of the upper limbs were assessed by hand grip dynamometry and found within normal range. Post burn complications involving muscles may be a major complication and needs a detailed functional evaluation wherein wasting of muscles, contractures and power of the muscles involved in the area involved must be carefully assessed. Fully functional action and power of muscles is a must in a cockpit as it would determine the operation of controls, performance of AGSM in a fighter cockpit and prevent easy fatigability in long duration sorties in fighter, transport and helicopter flying.
- (d) **Helmet mask compatibility:** This was checked for as the burn had involved his neck also. The pilot complained of irritation of skin over the neck due to the helmet during evaluation and flying for his executive report as well. The pilot was hence recommended to be fit for transport aircraft only. Checking of helmet mask compatibility becomes important in cases of burns involving head and neck. Development of contractures, keloid, irritable or photosensitive skin may pose a problem with proper fitment of mask and helmet. A constant rubbing of helmet or the harness system over the burned skin may cause discomfort to the pilot and lead to further complications.

### **Centrifuge evaluation:**

Post burn contractures depending upon their location and severity may be associated with restriction of movements of a particular joint. Involvement of muscles may hamper performance of proper AGSM. This may become significant during exposure to acceleration stress and thus such cases need to be subjected to centrifuge evaluation to assess the effects under simulated G loading. In the present case, centrifuge evaluation could not be carried out as the equipment was unserviceable.

### ***Hot cockpit Assessment***

In order to assess the thermoregulatory response to burns, Hot cockpit assessment was done for the case wherein the pilot was exposed to simulated heat stress of 40 degrees dry bulb temperature with 50% humidity for 40 minutes in the Hot Cockpit. Heat Accumulation Index, Heart Rate and Sweating response was assessed to evaluate his tolerance to heat stress [1]. A hot cockpit assessment is of vital importance in burn cases to evaluate thermoregulatory responses, the ability to maintain his core body temperature in times of stress and the clinical behavior of grafted skin under simulated heat stress.

### ***In-flight Assessment***

Once the case becomes asymptomatic, the clinical and functional examination does not reveal any significant limitation, an in-flight assessment is required to be carried out. The in-flight assessment is intended to evaluate the ability of the aircrew to execute flying task in actual flying environment and emergency ground escape. The ability to reach, grasp and operate the aircraft controls is assessed. In addition, the ability to withstand the heat load and in-flight G-stress is specifically looked for.

The in-flight assessment offered substantial

evidence in cockpit worthiness in the present case. The initial assessments in the fighter cockpit revealed that the pilot had difficulty in turning his neck upwards and to the right under G-loading up to 6 Gz. He also had irritation of the skin over the burnt portion due to friction and rubbing of the helmet and shoulder straps over the burnt areas. Based on these assessments on two different occasions, he was not found compatible with fighter cockpit and hence was re-streamed to transport aircraft in which the in-flight assessment was satisfactory.

### ***An approach based on scientific evidence***

After a long period of observation, this pilot continued to maintain his clinical and functional status even with active flying and thus he was considered for full flying status. The dilemma met was the assessment of his thermoregulatory response, the ability to maintain his core body temperature in times of stress and the effect on grafted skin, as the Hot cockpit chamber at the Institute was not functional at the time of this review. Hence an evidence based approach was made based on the available scientific literature.

Shapiro et al in their study on ten subjects with deep second and third degree burns divided them into two groups Group A with 45-55% burns and Group B with 20 to 30% burns. These subjects were exposed for 3h to 40°C dry heat and 50% humidity. The authors concluded that there was increased compensatory sweat response in Group A. This group however had higher rectal temperature, heart rate and skin temperature as compared to Group B [4]. Wilmore et al in their study on the effect of ambient temperature on heat production and heat loss in 7-84% burn cases concluded that subjects with more than 60% burns were unable to maintain core body temperature and during cold there was a compensatory increase in metabolic rate to maintain core body temperature

[5]. Thus, it was concluded that our pilot with 35 % burn would be able to maintain his core body temperature in case of hot environment by compensatory increase in sweating and in cold by compensatory increase in metabolic rate. However, the dilemma still remained about thermoregulation under heat stress and the behaviour of the grafted skin.

Austin et al in their study on thermoregulation in burn patients during exercise assessed patients with 30 to 40% burns and those with more than 60% burns after exercising on cycle ergometer for 30 minutes at dry heat of 35°C and 60% relative humidity. The authors concluded that there was no intolerance to moderate exercise in patients with more than 60% burns and the rise in heart rate and temperature was similar to that in unburned subjects. The authors in this study brought out that vascularity was equal in healthy and grafted skin and decrement in the number of active sweat glands in grafted skin was compensated by increased sweating from this skin [6].

Craig et al in a study on vascular and pseudomotor response of grafted skin concluded that during heat stress grafted skin had minimal vasodilatation with compensatory sweating from the healthy skin which maintained core body temperature. Cutaneous vasoconstriction response was preserved in grafted skin which aided in maintaining core body temperature [7]. Scott et al also reported similar findings in their study to assess the effect of direct and indirect cooling of grafted skin wherein they concluded that thermoregulation in cold exposure occurs by cutaneous vasoconstriction [8]. Histochemical and histological studies of scar tissue by Xiao bing Fu et al showed presence of residual sweat glands and regeneration of active sweat glands in scar tissue which aid in thermoregulation [9]. Seth et al in a case report on heat stroke in marathon runner with 49% burn

brought out that for compensatory sweating to maintain normothermia normal skin should be in the range of 50-70% [10]. Based on the above mentioned studies, following inferences were drawn:-

- Patients with 30- 40% burns are able to maintain core temperature.
- Compensatory sweating occurred in healthy and grafted skin.
- Vascularity in healthy and grafted area remained same.
- Such patients were able to thermoregulate under heat stress.
- Grafted skin is able to thermoregulate in cold stress
- Sweat glands (though minimal) do exist in grafted skin.
- Presence of 50-70% healthy skin aids in thermoregulation.

Based on the above evidences in literature and considering the fact that the pilot had completely healed burns with no significant functional restrictions and uneventful 03 years of observation in active flying category, he was upgraded to full flying status.

## **Conclusion**

This case report is intended to stress upon the importance of an objective clinical and functional evaluation, role of ground based simulators, in-flight assessment in actual flying environment and an evidence based approach for cases where well laid out guidelines are not always present. Role of proactive thinking and intervention is mandatory for evaluation and correct disposal of the aircrew to aid him in regaining his flying status.



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### Answers to Aviation Medicine Quiz from page no. 48 to 52

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| 1. (iv)   | 2. (iii) | 3. (iv)  | 4. (iv)   | 5. (iv)  | 6. (iii) | 7. (iv)  |
| 8. (iv)   | 9. (iv)  | 10 (ii)  | 11. (iii) | 12. (iv) | 13. (ii) | 14.(iii) |
| 15. (iii) | 16.(ii)  | 17 (iii) | 18. (ii)  | 19. (ii) | 20. (i)  |          |