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Casualty Air Evacuation: Sine quo non of combat casualty

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ABSTRACT

Management of combat casualties has always been a challenging task. Armed Forces world over have developed effective casualty air evacuation mechanisms. The history of casualty evacuation dates back to 1870s. The first evacuation of casualty by air was during the First World War. The paper highlights the background and evolution of air evacuation in the world and discusses the Indian Scenario of casualty air evacuation. The casualty evacuation capabilities of the aircrafts in the Indian Air Force (IAF) are highlighted. To ensure prompt casualty evacuation, the Armed Forces have a chain of casualty air evacuation, thus ensuring that the injured reach the health care center in the least possible time. An indigenously developed patient transfer unit (PTU) comprising of a trauma care recovery trolley with a complement of a portable ventilator, multipara monitor, infusion pumps and oxygen system is also discussed. In addition, the paper discusses the aeromedical considerations while evacuating casualties by air and contraindications for air evacuation. The advancements in the field of medical technology and medical care has ensured safe air evacuation of casualties and has reduced the morbidity and mortality of casualties, thus boosting the morale of the troops.

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Introduction

Providing prompt and definitive medicare to patients has been a challenge in the management of combat casualties. The need to minimize mortality/morbidity during military operations/war has lead to Armed Forces across the world to develop efficient casualty air evacuation (CAE) system. It was during

the First World War that the concept of using aircraft for evacuating patients originated. The first evacuation of a casualty by air was that of a Serbian Officer by French Air Force aircraft and the records maintained thereafter has shown a significant reduction in mortality.¹ The availability of modern aerial platforms, both rotary and fixed wing has lead to development of an effective casualty air evacuation system.

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Background and evolution of casualty evacuation

The Romans were the first to develop an army hospital to treat casualties, way back in 270 AD. Baron Dominique Jean Hary, surgeon in Napoleon Army, also called the father of Ambulance Service employed horse drawn wagons (Ambulance Volente) for collecting the wounded from the battlefield to the base hospital during the Italian campaign in 1797.² It was during the Franco-Prussian war of 1870-71 that the first aeromedical evacuation was carried out.³

In Britain the first air ambulance evacuation was done in a De Havilland DH 9 aircraft when a soldier in Turkey was flown to a hospital in 1917.⁴ By 1936 military air ambulance service was functional and the wounded in the Spanish civil war were evacuated to Germany. The use of helicopters for air evacuation was done in Burma during World War II when three British pilots were evacuated. USA used helicopters extensively in Korean War (1950-53). The Vietnam War saw the use of specially trained doctors and medical assistants in helicopter air ambulance. In late 20th century, Israeli Army and Russian Army evolved similar units to provide forward surgical support to military campaign.⁵

Indian scenario

The history of Casualty Air Evacuation in India dates back to 1947 when DC-8 Dakota aircraft was used to evacuate injured soldiers from the Srinagar valley. Since then AN-12, AVRO, AN-32, IL-76 and C-130J aircraft have been used for Casualty Evacuation. Helicopters like MI-4, MI-8, MI-17, MI-26 and ALH have also been used in this role.

The Indian Armed Forces are deployed in difficult terrains, and have to operate under extreme weather conditions, in remote mountain areas, in terrorist affected areas etc. They are called to provide medical support during natural and manmade disasters, where casualty evacuation by road is difficult or impossible.

Indian Air Force (IAF) casualty air evacuation capabilities

The various aircrafts available in the IAF and their casualty carrying capabilities are as follows:

Fig. 1 – Casualty air evacuation in AN-32.

Aircraft	Sitting cases	Lying cases	In addition to lying
MI-8	23 OR	12	(+2 sitting) without Internal Auxiliary tank
MI-17	15 OR	06	(+4 sitting) without Internal Auxiliary tank
MI-26	82 OR	60	+03 sitting cases
AN 32 (Fig. 1)	50 OR	24	+03 attendants
AVRO HS-748	48 OR	21	+03 attendants
IL-76			
Version-1	38	+72	+4 medical attendants (total 114)
Version-2	07	+80	+3 medical attendants (total 90)
Version-3	12	+32	+1 medical attendants (total 45)
CHETAK	03 OR	02	+1 medical attendant
CHEETAH	03	01	+1 medical attendant, co-pilot seat has to be removed to accommodate stretcher.
C-130	128	97	
C-17	52	36	

Chain of casualty air evacuation

During military operations the casualties have to be evacuated from forward base to secondary/tertiary medical care centers. The chain of evacuation followed is as follows.

Forward area to field hospitals

The casualties from forward posts to field hospitals are usually carried in helicopters (Fig. 2), under supervision of Medical Officers/Paramedics. The transit time is short as these are usually scoop and scoot missions where speed is the essence and patients are at times in unstable condition. Pre-hospital medical treatment may be provided to these patients.

Within theater of operations

Casualty air evacuation is also carried out between field medical facilities/hospital to large medical centers (secondary care centers) within the theater of operations for definitive medical treatment. This is usually under supervised medical

Fig. 2 – Casualty air evacuation from forward area to field hospital.

Fig. 3 – Patient transfer unit (PTU).

care of doctors/nurses. Helicopter/fixed wing aircrafts are used as the duration is usually short (up to 2 h flight). Patients may require in flight critical care management.

Inter theater operations

These are long duration flights, under medical supervision from hospital to tertiary care center. Fixed wing aircrafts are used for such evacuations, e.g. AN-32, C-130 and C-17. They have critical care team with necessary medical equipment during the air evacuation.

Patient transfer unit (PTU)

Movement of unstable patients from forward posts to hospital or inter-hospital transfer of critically ill patients requires onboard monitoring and resuscitation facilities. Patients transfer units (PTUs) have been designed which have portable ventilators (capable on functioning at 15,000 ft and able to provide positive end expiratory pressure), multipara monitors, defibrillator, infusion pumps and oxygen supply, all mounted on a trauma care emergency and recovery trolley.

IAF has developed a PTU (Fig. 3) which has been extensively used to evacuate patients. The requirement of power supply is an issue as the AC electrical current (voltage and frequency) are not compatible with the medical equipment. This has been overcome by using UPS placed in the base of the trolley.

Aeromedical considerations for casualty air evacuation

The factors which affect the Casualty Air Evacuation are predominantly due to the cabin environment of the aircraft. In pressurized aircraft, the cabin altitude is maintained between 5000 and 8000 ft. Unpressurized aircraft (fixed wing and helicopter) usually fly below 10,000 ft. The main aero medical concerns are: (a) Hypobaria (b) Hypoxia (c) Temperature and humidity (d) Vibration (e) Noise (f) Air sickness (g) Acceleration forces.

Hypobaria

Decreased atmospheric pressure due to increased cabin altitude can lead to expansion of gases and also affect the physiological processes. It may also affect the functioning of medical equipment used for monitoring and life support. It is therefore essential that the equipment is certified airworthy.

The volume of gases at 8000 ft is approx. 35% more than that at sea level and expansion of gases in the body cavities e.g. middle ear, sinuses, GI tract, teeth or air due to penetrating injury/post surgery in cranial cavity etc. may cause discomfort or pain.

Hypoxia

The partial pressure of O₂ at 8000 ft is 108 mm of Hg as compared to sea level. The decrease in partial pressure can lead to reduction of oxygen saturation to 90% in a healthy patient. In a hematologically compromised patient, this could be critical and can lead to hypoxemia. Supplemental oxygen is therefore essential to maintain adequate oxygenation.

Temperature and humidity

There might be wide variation in ambient temperature at the enplaning and deplaning airfields. Further, the cabin temperature at cruising altitude of the aircraft also affects the well being of the patients. Low humidity causes dryness of the secretions in the respiratory passages and may compromise respiratory functions.

Vibration

Vibration occurs in all type of aircrafts, more so in helicopters. It causes fatigue, can lead to hyperventilation and motion sickness. It can also adversely affect the monitoring of patients. The effects of vibration can be reduced by properly securing the patient and providing adequate padding.

Noise

The raised noise levels in the cabin can interfere with communication between the team members and also with the patients. It also makes auscultation of patients difficult or nearly impossible. Use of visual alarms is useful in such cases.

Air sickness

Some patients are susceptible to motion/air sickness. This is usually aggravated by turbulent weather. An anti-emetic, prior to take off may be given to susceptible patients. For patients who have wiring of the mandibles due to maxilla-facial injuries, facilities/instruments for quick release should be available.

Acceleration forces

The acceleration forces during takeoff act in the horizontal axis. Pooling of blood in the lower extremities and increased intra cranial pressure may occur in the patients depending on whether the head is aft or fore. This has implications in patients who are hemodynamically unstable or have autonomic dysfunction, as they have poor compensatory sympathetic response.⁶

Contraindications of casualty air evacuation

There are very few conditions in which CAE is contraindicated. During operations/war, unstabilized patients may be required to be moved by air. In such instances, a well trained medical in-flight team along with adequate medical equipment for monitoring and treating should be available onboard.

With increase in cabin altitude, the expansion of gas in tracheal and other cuffs during ascent and collapse during descent could lead to disastrous consequences. This can be

overcome by using saline in the cuff in place of air. Certain conditions like untreated pneumothorax is a contraindication as expansion of gas during flight can lead to tension pneumothorax further compromising the clinical condition. Such cases need to be treated and evacuated with a chest drain in situ. The medical condition of the patient may warrant restrictions on the operating/cabin altitude, which has to be briefed to the pilots.

Patients who have undergone surgery of the abdomen or sustained injury to abdomen, the gas in the peritoneum/GI tract expands with increase in cabin altitude and can cause discomfort, pain, and dehiscence of surgical wounds. Restriction on the aircraft cabin altitude obviates these problems to some extent.

Some of the relative contraindications for Casualty Air Evacuation are patients with anemia (hemoglobin <7 g/dl) or acute blood loss with low hematocrit. Cardiac conditions like uncontrolled dysrhythmia, congestive heart failure. Patients with acute psychosis, violent behavior or self-harm will require physical restraint.⁷

Preparations for casualty air evacuation

Prior to the sortie, it is essential that the patient be assessed for in-flight requirements of monitoring, management and requirement for resuscitation. Necessary medical equipment and drugs should be carried onboard. The details regarding flying time, altitude, rate of ascent and descent, weather enroute and diversionary air field etc. should be discussed with the aircrew to cater for onboard supplemental oxygen requirements etc.

The assessment of the patient should include the requirement of oxygen, IV fluids, blood transfusion, nutrition (oral/enteral/parenteral), bladder catheterization/nasogastric tube placement and functioning of chest tube and drains.

The level of monitoring depends on the condition of the patient. Continuous monitoring of heart rate, non-invasive blood pressure (NIBP), ECG, oxygen saturation (SpO₂) are usually required. In addition, some patients may require central venous pressure (CVP), pulmonary capillary wedge pressure, cardiac output, blood sugar, intra cranial pressure and intra-abdominal pressure monitoring.

While transporting large number of casualties, the layout of patients (Fig. 4) in the aircraft depends on various factors. The patients who require no special support or equipment are loaded first in the inner most berths of the aircraft. Any patient

Fig. 4 – Layout of casualty evacuation in a fixed wing aircraft.

who has a limb injured or plastered should be placed with the injured limb toward the middle so that the medical personnel can have easy access to it in any emergency. Patients requiring in-flight care are placed at a level (middle) which is easily accessible to the paramedic. Patients not requiring constant medical attention are placed in the lower or upper levels. Patients on ventilators or requiring intensive care are loaded last.

Lessons learnt from handling mass casualties during exercises

Besides actual casualty evacuation, simulated CAE exercises involving mass casualty situation and demonstration of actual movement of casualties from the disaster area to a tertiary care center using fixed wing platforms (Avro, AN-32, IL-76, C-130J) along with PTU have been conducted.

Lessons learnt during these CAE exercises are as follows.

- (a) Regular training of personnel helps in availability of trained manpower during an unforeseen event/disaster. Frequent practice by inflight nursing team on the various aspects of air evacuation, helps in smooth conduct of such operations. Prior training and practice of loading/unloading drills by stretcher bearers under the guidance and supervision of the load master of the aircraft ensures that the casualties are loaded and unloaded as per priority. The drill of placing ambulances close to aircraft ensures prompt and safe movement of the casualties from the tarmac to the tertiary care hospital.
- (b) Success of a mass casualty exercise needs synchronized activity of all the agencies involved. Conducting joint exercises with the three services and civil agencies helps in defining the roles and responsibilities of each one of the agencies. The joint exercises have paved a way ahead for hands on experience and have helped in handling the actual situation of mass casualty evacuation in a better and coordinated manner.
- (c) It is essential that a preliminary meeting and coordination with the technical crew of the aircraft be carried out. The layout plan of the air ambulance helps in planning and earmarking the lying casualties as per the priority of evacuation and also the site of the injury. Allotment of casualty berth number facilitates orderly loading and unloading of casualties. While evacuating the casualties by air the casualty card should be tied to the shirt of casualty on the side of the injury. In addition, the priority band should be worn on the forearm on the side of injury (which should be facing the aisle for better access and management).
- (d) Most of the aircrafts do not have a facility for providing oxygen to the patient. Oxygen for patient based on the number of casualties needs to be carried in-flight by the nursing team. The total weight of the medical equipment being carried by the nursing team also needs to be communicated to the aircrew to plan for deciding the number of casualties that can be carried. There is a need to carry airworthy oxygen cylinders along with the PTU to ensure that there is no compromise on aerospace safety.
- (e) Situations where Rapid Action Medical Teams (RAMTs) are deployed the medical and ordnance stores which are envisaged to be used for providing essential inflight

Fig. 5 – Aeromedical container.⁸

medical care should be carried. These should be easily displayable, manageable containers like light weight crash carts/cloth hanging zip bags, with pigeon holes etc.

- (f) The stretchers used during CAE should be lightweight aluminum stretchers with semicircular handles at the ends. The stretchers should also be provided with at least two straps to secure the casualty to the stretcher with velcro similar to the ones provided in the spinal board.
- (g) In case of CAE at night, it should be ensured that enough lighting at the tarmac close to the aircraft is made available to ensure smooth loading and offloading of casualties. Inflight lighting should be made available so that emergency procedures, access to IV lines and close monitoring of casualties can be carried out.
- (h) It is important that the names and other details of the casualties from the base of transfer are conveyed via electronic means to the receiving hospital. The details should include the name and particulars of the patient along with priority, medication, treatment given at the enplaning base. The information should be available to the casualty reception team at the hospital so as to institute prompt medical care to the patient.

Future of casualty evacuation

The future of Casualty Evacuation is in aeromedical containers (Fig. 5). They can be loaded/unloaded in a short time. They can be configured as per requirement i.e. number of patients requiring intensive care or otherwise. They have necessary medical equipment to monitor and treat the patients including oxygen supply and power back up.

The use of unmanned aerial vehicle is also on the anvil and would be useful for evacuation from forward posts.

Conclusion

Casualty air evacuation offers advantages of speed, access to patients in difficult terrain, and ability to transport patients over long distances. With the advancement in medical equipment and specialized training of medical personnel,

there are very few patients who cannot be evacuated by air. This has drastically reduced the mortality and morbidity of casualties and has greatly enhanced the morale of the soldiers. In the last few decades casualty air evacuation has changed the way military operations are planned and conducted.

Conflicts of interest

The authors have none to declare.

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