

The Role of Respiratory Therapist in Flight Medicine

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Medical military aviation has become a hallmark that has evolved as an important technological advancement tool in today's modern warfare thus continuing to promote success in patient lives through healthcare transportation and the promotion of advanced lifesaving techniques. One of the most important elements in health care aviation is the ability to sustain life in a traumatic patient care scenario where time management is a positive rather than a negative outcome. It is important to equally note that transport can be provided both ground and air evaluation. Whether patients are moved through up armored ground military transport or in combat air- medical evacuation, time is a critical element that should always be factored in.

There are instances and situations when ground transport can be relatively easier, safer and more reliable. This is all based on assessment of situational need and awareness through medical and pilot aeromedical evaluation. Most airlines and private industry fixed wing planes do not have the adequate training for medical personnel needed nor the equipment needed for support in commercial transport. Medical aviation was designed for such situations where the support and care for the transportation can be applied to simple and complex management care. In some situations, mobile patients "or walking wounded" can be transported within regular commercial airplanes where as the more critical or impending patients, take on the air evacuation or ground transport route. Pilots have to determine the type of medical transport needed. Some concerns include environmental challenges necessitating periodic medical evaluation towards the patient safety. Pilots and crew members are experienced in knowing the challenges associated with lower barometric pressure, changes in altitude, wind stability, ventilator or hemodynamic stability of patients, fuel consumption, patient load weight, oxygen levels, humidity and variations in acceleration forces. Such factors can influence challenges in the transporting of patients and such factors make it critical for pilots and crew to review what the best method of transportation can be.

In the transport arena for the military, the medical provider must be physically fit to travel and transport patients. A regular physical training regimen must be taken and passed. Endurance to sustain and know that a high fitness level is required to have adequate endurance for medical care during the intense rigorous hours and cramped environment one must overcome. Providers in the military also take on hypoxic training and in some branches, water evacuation towards self and patient. Medical providers are also taught combative of taking fire and firing upon on fixed wing and rotor aviation. Providers are taught to know the basic of loading and offloading patients with weight and unweighted seats. Direct training including medical care in the black out where night vision goggles are used and no light is imposed in the cabin. These situations are the most difficult because the color of blood cannot be seen in the dark through night vision goggles impeding quick care. In most situations, Military Respiratory Therapist can also provide line placement and without seeing the veins or blood can be difficult in night vision so practicing these techniques are a critical element in training.

Unlike the civilian population, military medics are conditioned to adapt to combative training so the military emphasis a strong relationship with battle readiness and combat medical training. The military requires all medical transport personnel to be physically and in shape for transport. Weight limitation is a critical asset for the flight team. Too much weight added on an aircraft can reduce the trust, lift, time of travel and acceleration. Limited ideal body weight is one of the first challenges one must endure in military flight. For any provider

in the medical aviation career including medical personnel and pilots, participants must undergo a medical readiness qualification. The medical fitness standards and requirements for flight physicals apply not only to military personnel but also to civilian contractors and air traffic controllers. These qualifications are defined into 4 separate categories. These exams and evaluations can be performed by the United States military or civilian flight surgeons, aeromedical physician assistants (APA), aviation medicine nurse practitioners (AMNP), or aviation medical examiners (AME). The primary accrediting body for air ambulance is the Commission on Accreditation of Medical Transportation Systems, which has recommended guidelines for basic life support; advanced life support and special medical care needs. The military trains medical personnel in Fort Sam Houston and Fort Rucker, Alabama.

All military personnel must pass the following organ review. The medical military physical requirements and standards for fitness “for flying duty” may seem to be more restrictive than these general united states armed forces standards. However, it is imperative that qualified personnel with physical and physiological readiness are combat ready when a medical mission is on hand. This assessment to physical readiness including everything from head to toe assessment including physiological testing.

The four types of military aviation classes required for fly rating in the aviation field are listed below:

Class 1: Warrant officer Candidate, commissioned officer or cadet. This information applies to applicants for aviator training, applicants for special flight training programs and non-U.S. Army personnel selected for training at aircraft controls.

Class 2: Student aviators work through the training and then after beginning time and training, rated Army aviators, DAC pilots, contractor pilots (unless they have an FAA Class 2 Medical Certificate), Army aviators returning to aviation service, other non-U.S. Army personnel.

Class 2F/2P: Flight surgeons, APAs, AMNPs, those applying for or enrolled in the Army Flight Surgeon Primary Course.

Class 3: Non-rated crewmembers, nonrated medical personnel selected for aeromedical training, soldiers and civilians who participate in regular flights in Army aircraft but who do not operate aircraft flight controls, Army civilian contractor non-rated crewmembers that do not have an FAA Class 3 Medical Certificate or DD Form 2992.

Class 4: Military air traffic controllers (ATC) and civilian ATCs are required to meet Class IV OPM standards.

The Air Force has been successful in transporting patients based on the longest distance in the current war. The Army and Navy also had medical transport teams based on the Combat Support Hospitals, Forward Surgical Teams and Protection Response Teams but it was the Air Force that stems high effective casualty air evacuation. In the military, the CASAEVAC was established to support medical transport as soon as patient load was needed to move injured or critically ill patients out of the zone. A highly efficient casualty air evacuation (CASAEVAC) system can exceed the general in hospital standards of care available at field medical units and even transport unstable patients with one or multi- organ dysfunction. This has become the hallmark for air transport for multiple wounded patients. With this title, many challenges will be reviewed to outline the challenges of transporting the injured for the best outcome for patient transport.

One of the most important challenges associated with military aeronautic transport knows patient safety. In recent years including the Iraq and Afghanistan War, Military Medical flights are associated with the increase need to get patients in and out of hot zones that can be hazardous or combative. Safety is a priority not only for the patient but for the crew who is removing the patient from the combat zone or location. Situational awareness need must be a strong priority and the evaluation of patient and crew safety is critical decision that needs to be met. In some areas, challenges externally from besides the environment could be the extreme dangers of the location. Areas known as hot zones have cause crashes in Vietnam as helicopters landed to try and save patients knowing the enemy is near. These areas are typically taking fire or being fired upon. Usually, a secondary helicopter is attached to the primary one where it overshadows the location and landing zone.

Logistics, Pilots visual awareness, Intelligence and Military Air Traffic (Troop Operational Command) controllers all work together to determine the need for flight aeronautic evacuation. The location where the air transport is going to occur also needs to be evaluated.

Similar to safety in fixed wing or rotor transport, the weather can be a factor in movement so challenges associated with environmental concerns can be a big issue. Snow, Desert Heat, Rain, High winds can affect acceleration, pitch duration of flight due to thrust, power and duration of flight limiting its capability and success. Heavy winds can impact the rotors from spinning or can be difficult to sustain height, aviation and speed. Such factors are critical elements when accessing the need for preparatory movement so adequate preparation and safety are critical.

A second challenge associated with air transport for military medical personnel is timing. Timing is an essential need and often due to patient load, triage and duration of flight, timing can be a factor that often presents itself as limited. In the military, the movement of companies, patients and conditions are based on the ability to get in and out of locations quickly. Unlike passenger airlines, the military helicopter, Blackhawk or the fixed wing cargo flights have a heavy load and the ability to carry more than just one passenger. In such situations, military equipment, cargo loads and ammunition can be associated with transport of medical personnel to support the transfer of patient care from one location to another. With this in mind, the timing of getting a patient to its destination is dependent on the mission on hand. Some missions become essentially a priority over the patient and can interfere with timing. Carrying extensive amounts of medical equipment can cause the load to be heavier. The heavier the load, the harder it is to lift and the longer it is to get to a destination because thrust is impeded.

As patients are transported from sea level to higher altitudes where there is a lower barometric pressure can have stressors in the body and composition of the thorax. Ventilated patients can have problems with volume delivery when the plane ascends higher creating a partial pressure change due to altitude. Patients that are intubated can develop atelectasis because as barometric pressure decreases in altitude, the partial pressure reduces the oxygen supply creating the ineffective ability to sustain adequate eupnea. Also, in altitude, patients tend to have a lower compliance in volume because the lungs might under expand creating possibly VILI. The NIH (2010) from Med J Armed Forces India states "Compliance can be impeded by the thoracic forces imposed by the barometric pressure associated with volume. Increases in altitude with associated decrease in atmospheric pressure imposes two major stressors – hypoxia and gas expansion in body cavities. Usually, a military medical transport fixed wing plane can fly with 25000 to 30000 feet and even higher with a cabin altitude of 5000 to 8000 feet." In the military, it is common to fly higher due to the distance needed to travel and the destination. In some instances, it is also based on security and air zones. At 8000 feet, the partial pressure of inspired oxygen is around 108 mmHg which is adequate to maintain an oxygen saturation of over 90% in a healthy individual. You still have 21 percent room air but the pressure has begun to change around your lungs. With the changes in barometric pressure, you start to become more hypoxic so the higher you go, the more issues imposed to oxygenation can be seen.

Decreasing barometric pressure challenges oxygenation through partial pressure issues. A change in partial pressure use of oxygen can be detrimental to a patient even with the slight lung condition. Any alterations such as shunt; ventilation perfusion mismatch can create havoc on patient care. Respiratory Therapist need to be aware of patient history, diagnosis, medications administered and the appropriate techniques needed to treating patients with certain diseases. Most people with some respiratory condition can begin to struggle but cannot compensate due to overall disease process or traumatic issues. Most non-pulmonary patients can use hyperventilation as a compensatory mechanism or pursed lip breathing to overcome the condition that is presented but in most situations, patients are sick and could ultimately end in acute ventilatory failure where they are hypercarbia.

Most patients that are transported through military aviation poses some category of life threatening condition. Patients would not be transported on a fixed wing or rotor in a combat situation unless it is often a critical element that imposes a life-threatening intervention quickly. A critically ill patient that requires transport in the military with pulmonary or non-pulmonary respiratory compromise might suffer from severe hypoxemia. This issue can impede their lungs and create inflammation to an already deadly compromise causing ventilation perfusion mismatch. An untreated tension pneumothorax has been associated as one of the strongest contra-indication to CASAEVAC

transport. The NIH (2010) from Med J Armed Forces India states “A change from sea level to altitude of 8000 feet will inflate the volume of trapped gas by approximately 35%”. The inflation can cause a possible high pleural space volume creating a high degree of a possible tamponade to the patient’s heart. This situation high altitude change can cause volutrauma and barotrauma to the lungs and can impede gas exchange creating a ventilation perfusion mismatch. This condition can also cause the heart and cardiac output to hemorrhage if severe enough and can cause issues with bleeding. In some situations, patients on mechanical ventilators with high levels of PEEP or high levels of supplemental oxygen would not get the adequate needs or measurements applied due to pressurized difference in the lungs which are all dependence on the barometric pressure and temperature. Decreased in barometric pressure can lead to volume expansion in some patients that can be detrimental if their ventilators are not pressure compensated. Clinicians must be very careful in mortaring not only volume ventilation needs but pressure regulated needs.

If a patient is being transported with high-low endotracheal cuff pressures and are intubated, the expansion of air in the tracheal tube at higher altitude can cause ischemic tracheal mucosal necrosis. Other concerns or challenges would be the over inflation creating mucosal tears, bleeding, or even the possibility of a leak of air to the cuff during descent could cause a loss of tidal volume. Most transport providers in the military tend to replace endotracheal cuff air with saline to avoid this situational event. Due to the speed of the plane, some military maneuvers require a quick movement from left to right, up and down creating a gravitational forces and challenges. The gravitational force can impose a pooling of blood in areas of the heart and lungs that can impede gas exchange and create a shunt. Gravitational forces can also cause blood pressure issues or even centralized pooling of blood in areas that are not dependent for survival. Areas can also cause a pooling the head and if patients are loaded head first, blood can pool in many areas of the body away from the heart creating swelling and edema. In most situations, normal hemodynamic patients can compensate when gravitational pull is applied but if blood loss was factor, patients can decompensate quickly due to blood volume due to shift of gravity with blood.

Challenges with brain injuries are another factor that needs to be addressed in the military. Many patients transported in longer durations suffer from traumatic brain injury. In a severe issue with head injuries, gravitational pull on acceleration, deceleration or banking of the plan and take off can cause ICPs to increase quickly and give rise giving a higher increase in morbidity to these patients with gunshot wounds. Therefore, patient positioning is a critical skill needed for any military transport and location to patients with the type of severity is also important depending on fixed wing or rotor heliports. The reason for this is based on the knowing the plane, take off, pull and gravitational directional change. Securing patients in military transports is as critical. Without proper positioning and securing patients, instruments and equipment can easily be thrown from one area to another. This is an important skill often discussed and taught continuously. Loose equipment such as suction tubes, syringes and drugs should be placed back in its proper location after being utilized to avoid injury to the patient and others.

Environmental challenges and concerns can create issues for patient assessment. Noise, movement, shaking and vibrations, apart from causing fatigue, nervousness and anxiety can contribute to motion sickness and interfere with communication. A task for knowing non-verbal and verbal skills are critical elements for air transport. Clinicians must rely on knowing their parterres tasks as well as their won to support patient care activity. Taking a blood pressure and listen to breathe sounds cannot be done in a helicopter or military flight for reason for increase decibel levels. The noise level in many of the currently used transport aircrafts approach 90 decibels, similar to that of a helicopter, which is approximately 2000 times louder than heart/breath sounds. It is important to understand and t knows the ability for the use of Doppler’s, leads and continued assessment of patient. Alarms cannot be heard on the ventilator or equipment so knowing the gradual numbers and changes in values are critical. Continued assessment done every 5 - 10 minutes is an important factor towards the safety of medical transport.

Due to the barometric changes, humidity becomes an important factor. Most patients who are intubated lose humidity due to isometric boundary challenges (absolute humidity) already. In most situations, a HME can be utilize to support at least 80% of the inspired humidity with the use of an HME. However, the more critical patient’s might need a heated humidifier instead of a water Passover due to the in-

creased dead space, weight and changes in pressure that can incur with transport. Avoidance of liquid humidification is often not applied in short transport. The reason for this is that the vapor pressure to create the gas is impeded due to barometric increase. The higher the altitude, the more difficulty it is to create vapor so a heated circuit or HME are often a better choice. Because of the decreased humidity, situational awareness is assessed routinely because respiratory secretions tend to dry up resulting in atelectasis and blockage of tracheal tubes. With tracheal tubes possibly being blocked, assessment is an essential tool and the use of capnography is a great element. Providers also look at the challenges associated with the internal auricles of the ears. The ear drums are also affected causing some blockade of drainage in these areas. Some patients have balance issues while other has nausea and vomiting due to vertigo changes. Finally, one of the biggest challenges faced is the loss of oxygen creating hypoxemia and hypercarbia. As patients move higher in altitude, there is a tendency to become hypoxic and hypercarbic due to partial pressure challenges. They tend to stop breathing and get sleepy. If they are on medications, be cautious as you go higher as this can enhance respiratory depression due to altitude changes. This is one of the biggest concerns for military transport patients. In military aircrafts, oxygen is given to support the changes in altitude however, without adequately knowing the distance, movement of altitude; patients might be exposed to high levels of CO₂. It is important that during medical transport, end tidal CO₂ is used to monitor these patients.

In a study by the NIH (2010) from Med J Armed Forces India, researchers have identified several challenges and issues associated with military air transport which fell under the several categories. These include environmental problems, problems associated with monitoring and other miscellaneous situations.

The challenges associated with environmental problems stem from everything exposing the patient detrimental condition. These include the creating hypoxia, increased PCO₂ for narcosis due to elevation in altitude, loss of intravenous lines, lack of blood flow due to clogged drainage due to humidity, accidental extubations, increased volume of air filled cuffs, nauseas, motion sickness and air filled abdominal distention. Other includes vibrational turbulence, patient, and anxiety and temperature changes. For the mechanical ventilated patient, issues include increase VILI, airway obstruction due to humidity changes, increased airway pressure, and neurovascular compromise.

Problems associated with monitoring the patient include the inability to listen to lungs sounds due to high decibel ranges. The spinning of rotors blades make it difficult to listen to sounds speech or alarms. The inability to hear heart sounds and the inability to hear patient comments, pain grade or even the use of SPO₂ cannot be accurate at times. Listening to various alarms were difficult not only in hearing but in seeing as well. If the mission called for night transport, patients are often moved in the dark and the use of night vision goggles can become an issue. Audio alarms were silenced if evacuation required removing patient in hot zones. Many of the electromagnetic devices interfered with the blue force tractor avionics equipment and monitors. Ventilators were limited if bellows were applied due to the volume. Modes of ventilation might not be accurate due to pressure changes. If you are using flow limited IV drips, this can be limited if the attitude went farther away the earth's surface so pumps are often required. Space is limited so patients are packed fully with all instruments within the gurney or stretcher. Inaccurate reading from blood pressure cuffs, SPO₂ and some IV drips due to barometric changes in altitude and the inaccurate reading of tidal volume in mechanically ventilated patients were challenges that need to be assessed routinely.

Other miscellaneous problems include the lack of oxygen (hypoxia) for long durations. Due to the amount of oxygen on hand, concentrators are not often utilized and E cylinders are applied but limited to time and flow. Suction is also limited to manual use. The tight cramped quarters created issues on patient care work location. The duration of flight on a small space could be extensive and painful. Immediate intubation would require knowing where your equipment is at and to have it accessible and ready. Multiple patient cares is done with no duration of breaks. Fluids body parts, drainage of bile, excretions and exsanguinated blood spill in the floors of the cabin transport mechanism. Blood could scatter due to changes in altitude and rotational spins creating blood borne pathogen issues. The risk of weapons discharge can be a factor as well. Safety of live rounds, weapons or fragments are exposed routinely during the flight. Secondary to fire fights, the medical evaluation transport team is often a target for the enemy.

Challenges can be seen in hemodynamically unstable patients. These pertain to certain patients with low hemoglobin, bleeding disorders, gunshot wounds to the abdomen and how that affects the VO_2 , PaO_2 , PAO_2 , DO_2 and the CaO_2 on the patient. The dissociation of curve shifts creating a lower oxygenation shift. These issues create hemodynamic instability and can further damage lungs. Patients with pneumothorax or unstable spinal injuries are an element that needs special precaution. In most situations, these patients would be difficult to fly because of the changes of pressure and the constant bouncing causing more damage to the spinal cavity.. Patient with eye trauma that can create a worse off condition possibly leading to blindness due to the small vessels and vasoconstriction due to the increasing in altitude. Very similar, patients with increased ICP can create challenges with CPP, increase ICP due to bleeds and MAP challenges.

The United States law governs some protection for disabled personnel flying in fixed wing transportation. The Air Carrier Access Act applies only to U. S. national airlines, not foreign air carriers. A disabled passenger switching to a foreign carrier may not receive accommodations unless a "Code Share" agreement is in place. This could be a challenge for medical patients and personnel in commercial airline but in government airlines or military flights, the laws support movement for multiple destinations and this is all based on situational awareness and movement needs for life sustaining support. Some airlines that carry medical patients do support equal movement and support with medical patients even with multiple carriers. The Air Carrier Access Act is a commercial agreement between carriers where a single flight may have multiple flight designations. That is the airplane itself may be operated by one airline while simultaneously carrying the passengers ticketed as if they were on another airline. Several of the major U.S. carriers participate in these agreements and the Air Carrier Access Act would then apply [1-6].

In conclusion, there are many challenges associated with military aviation and flight medicine. All flight medicine is difficult and situational awareness is a critical element that must be consistently reviewed. Respiratory Therapist in the military that have aviation as a career choice has taken on a role equivalently risky and needed. The demand is great and the expectations are even greater. Military Respiratory Therapist is unique and it is important to understand the mission on hand. In quote yielded by John F Kennedy "As we express our gratitude, we must never forget that the highest appreciation is not to utter words, but to live by them". These men and women risk their lives not for themselves but to save their brothers and sisters.

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