

AVIATION TELEMEDICINE: PAST, PRESENT AND FUTURE.

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Abstract

With a billion passengers flying by air each year worldwide – many of them older, many traveling with greater frequency and on longer flights to more exotic locations – the management of health and safety issues in flight has become a key concern for the aviation industry.

Add to those statistics the fact that the health of many travelers is often compromised before they board, and you could have a recipe for disaster – if you're not prepared.

What MedAire has learned from managing the in-flight emergencies of 74 airlines worldwide is that a large percentage of passengers are fully aware of their illnesses – as well as their severity - before boarding the aircraft. Yet, they make the choice to travel, often completely unaware of the impact of altitude on their chronic conditions. In many instances, they expect the airline to provide the same standards of medical care they would find in a metropolitan city hospital.

As a result, airlines must always be prepared, as evidenced by MedAire's management of more than 17,000 in-flight commercial airline medical emergencies in 2006. The figure represents a 13 percent jump from 2005.

With the continued aging of the traveling population, their increased flight habits and increasing onboard expectations, airlines will have to be proactive with the health and safety solutions they provide.

1. Introduction

Telemedicine is the branch of medicine that provides medical care to remote locations where traditional forms of delivery are unavailable or not fully available.

Telemedicine ranges from simple phone calls between doctors and patients to remote surgical operation using robotics and ultra-high speed communication.

From the practical standpoint, telemedicine comprises at least three components: the local resources, the communication resources and the remote resources. The local resources are the actual care provider – the person who is in closest contact to the victim (this could also be the actual victim); his/her training and capacity to follow instructions; and the available equipment and medication.

Communication resources are the framework to transmit data and information back and forth.

Remote resources are the medical advisor and his/her surrounding tools to provide appropriate counseling and sometimes even treatment.

The complexity of each component may vary from very limited to very sophisticated and will determine the quality of the final result.

Commercial airplanes and business jets cruising at high altitudes are occasionally the stage for medical situations [1]. In-flight medical events are rare enough that having a medical person on board every flight is simply not a cost-effective option. But they are frequent enough to require a professional solution [2].

The number of people with access to commercial and business flights is increasing [3], but those people are also bringing aboard, knowingly or not, their pre-existing, underlying medical conditions. The “low-altitude” cabin environment, or chance alone (after all, hundreds of thousands of people are flying at any given moment) could trigger a medical event for those with borderline health status. Passengers are not required, from the regulatory point of view, to be fit to fly, as pilots are.

International aviation regulators are working to guarantee flight travel access to people with disabilities. Among those are not only people with mobility limitations, but also some with impaired vital organ function, as well as those with severe pulmonary disease requiring intermittent or permanent oxygen support.

The changing demographics of the traveling public, increased air traffic, increased aircraft passenger capacity and increased flight length all combine to a growing number – absolute and relative – of medical events over the last 20 years.

There is no reason to believe that this trend will not continue into the future.

As is the case in any other remote location, limited access to a medical professional during a flight makes telemedicine the best choice for handling unwanted, unscheduled emergencies.

The telemedicine model is not unfamiliar to aviation since it roughly replicates the protocols in place to resolve in-flight aircraft maintenance problems. The three basic components are comparable as air crew should be trained to take immediate action in certain conditions, having access to basic tools and troubleshooting algorithms, communication resources and access to remote expertise.

Aircraft designers and manufacturers are challenged to accommodate first-responders who assist with emergencies on board aircraft – taking into consideration storage areas for life-saving medication and equipment, and also treatment areas for passengers. They also must consider communication technologies that allow the crew to effectively work with remote telemedicine teams. To solve these issues, designers and manufacturers must incorporate

new resources into the next generation of their products to support aviation telemedicine.

2. Local resources

Local resources, should be in place to prevent the occurrence of in-flight events as well as facilitate their management when they happen.

2.1 Prevention

Cabin altitude, with consequent hypoxia and gas expansion, is the main factor behind medical incidents on board. Muhm et al. recently published the effects of aircraft cabin altitude and symptoms of acute mountain sickness [4]. Hypoxia is also related to common fainting [5] in predisposed individuals. Although there is no evidence that the current levels of hypoxia are detrimental to the healthy passenger or pilot, it certainly plays a role in those already compromised organisms [6].

The Americans with Disabilities Act, and more recently, Air Carrier Access Act ensured that people with significant physiologic limitations have equal access to air transport, including those for whom the mild hypoxic environment could represent a potentially life-threatening additional risk factor.

For those passengers with cardiac or pulmonary disease, additional onboard oxygen resources are necessary to maintain the fragile balanced medical status of the passenger with borderline heart or lung function.

The advent of portable oxygen concentrators (POCs) has significantly enhanced the quality of life of these patients. By virtue of filtering nitrogen from air, they can deliver up to 95% oxygen. Today’s POCs are lightweight devices operating under AC or battery power.

The FAA recently cleared five different models of POCs to be carried on board commercial and business aircraft.

Additionally, more and more people are being diagnosed with a condition called Sleep-Apnea. Those individuals need to utilize mechanical devices during sleep periods to provide Continuous Positive Airway Pressure (CPAP), also working on electrical power. Even though most of the previous devices work on

aviation-approved batteries, future aircraft should be prepared to provide adequate electrical supply that is evenly distributed along the passenger cabin. Such a design would address the growing numbers of individuals who require assistive devices to support their medical conditions, and at the same time eliminate the complexity and occasional safety concerns associated with passengers carrying sufficient batteries aboard aircraft.

2.2 Management

Oxygen systems on aircraft were designed to be used in the event of a decompression. Generators provide oxygen to cover the 10 to 15 minutes required for an aircraft to descend to a safe altitude on loss of pressurization occurs. Also there are oxygen bottles available which can deliver 2-4 liters/min flow rate and are adequate to be used by flight attendants during such an emergency. Neither solution is adequate to handle a medical emergency.

Many emergency conditions happening on board are either precipitated or aggravated by the mild hypoxic environment. Particularly in those passengers suffering from pulmonary or cardiac conditions in which tissue oxygenation is already compromised by underlying disease. High flow oxygen is a minimum and initial requirement when approaching those patients even at sea level.

Emergency high flow oxygen delivery systems must be considered to be standard feature on future aircraft.

Once a medical emergency occurs on board, and after the initial assessment, in most situations it is required to have the victim laid horizontally in the supine position for further evaluation and management.

Lying down, alone, could quickly improve common fainting episodes – known as vasovagal syncope - the most prevalent medical condition presenting on commercial flights, yet still a significant cause for airline medical diversions [7]. Cerebral blood flow immediately improves in the supine position helping to counteract the effect of low blood pressure which underlies these events. The supine

position is also ideal to deliver intravenous medication.

Today the only horizontal surface readily available to accommodate a victim of a medical emergency is the aircraft floor. This imposes a tremendous ergonomic load to the rescuers, who now need to work on their knees, sometimes for extended periods of time. This also entails safety concerns to the victim and makes nearby passengers uncomfortable.

With space limitations on commercial aircraft, creativity must be exercised in order to provide an adequate solution, such as a foldable stretcher that could allow an occasional victim to be evaluated, treated before a safe landing.

Another important recent issue is the transmission of diseases on board aircraft - particularly respiratory infectious diseases. This topic became of special concern after the SARS epidemics in 2003 when there was reasonable suspicion of in-flight transmission [8]. Tuberculosis is another permanent topic of discussion by the health authorities, leading to specific publications from health authorities [9]. The aviation medical community generally believes that the cabin environment doesn't add to the standard risk of transmission of a respiratory disease, but modern aircraft *do* lack an adequate means to isolate the occasional passenger discovered or suspected to be carrying a communicable disease.

Aircraft designers should develop solutions to isolate passengers identified as potentially infectious.

2.3 Equipment and medication

Initial onboard first aid kits – many still used today as a minimum standard (?) – were intended solely for care of those who survive an aircraft crash. This is evidenced by pertinent regulations that require medical kits to be “distributed along the cabin” and in a number proportional to the numbers of passengers carried. Their content was extremely basic and aimed to care for wounds, not diseases.

Over the last 15 years, however, comprehensive medical kits have started to appear on board. The advent of Automated External Defibrillators (AEDs) boosted even

more the initial move into upgrading existing kits to more sophisticated sets of medications and medical apparatus, now designed to address the most prevalent medical situations that can happen on board.

AEDs and a revised content list for medical kits, now requirements by the FAA in the United States, have become a competitive, best-practice requirement for international airlines flying under different regulatory rules.

While the smaller, initial kits required little storage in the cabin, this picture changed with larger, enhanced medical kits, aimed at managing life-threatening medical conditions and avoiding medical diversions. Today, more storage room is needed to accommodate these enhanced medical kits and equipment in a safe and readily accessible way.

2.4 Crew training

The initial training concerns of those involved in commercial and business aviation were focused on flight safety in its strictest sense.

Aviation medicine, for example, focused on flight crew fitness to fly. Regulatory authorities soon defined medical standards for pilots to be able to fly an airplane. The focus was, and still is, the safety of flight operations by guaranteeing the human factor.

It's interesting that passenger health has been an almost-neglected topic for a long period of time, even knowing that the main reason for commercial and business aviation is to move people/passengers from point A to point B.

The first U.S. female flight attendant, back in 1930, Ellen Church, was a registered nurse. She influenced her company, as well as others, to hire nurses as flight attendants, and this was the practice until World War II, when nurses were recruited into the armed forces. The idea apparently was to inspire passengers' confidence, and, because of that, even some early flight attendants' uniforms resembled nurse outfits.

Most flight attendant training is typically devoted to handling minor aviation emergencies, along with their other in-flight activities. In the past, medical training was usually a very short part of the training program.

Today, however, well-accepted protocols, known as Basic Life Support, are widely taught to flight crew, allowing them to deal with immediate life-threatening events when there is no time to call for additional help. Cardiac arrests, severe allergic reactions, choking and external bleeding are good examples of those conditions. This training emphasis remains a standard today, even knowing that those events are considerably rare relative to the number of passengers flying..

But not all medical possibilities that can arise during a flight can be covered in a simple training course and are certainly beyond the scope of the flight attendants' capabilities and legal responsibilities.

Today many airlines still depend on the help of onboard medical volunteers flying as passengers. They are certainly a local resource during a medical situation, and it is their oath to help others who are suffering.

However, even though most flights have a passenger on board who is a health professional, relying primarily on this resource is not a professional, consistent solution to addressing in-flight medical needs. By comparison, it would be the same as relying on an occasional engineer passenger who volunteers to fix an aircraft system malfunction.

Medical doctors are usually not trained to handle medical emergencies outside the hospital environment. Many are specialists in their fields and unfamiliar, even uncomfortable, in handling situations outside their expertise.

Crewmembers are the only consistent resource for providing medical help to passengers. Crew can work as eyes and hands - assessing passenger's conditions and providing treatment – supported by remote expert medical professionals.

To achieve that goal, a strong, reliable, communication link is required.

3 Communication and data handling

Communication resources are the pathway to delivering telemedicine. High Frequency (HF) communication undoubtedly limits the quality of care that can be provided due to its variable propagation, frequent background noise and

black spots around the world It still plays a big role in today's aviation communication and will continue to do so for a while if one considers the limitation of satellite communications (Satcom) over high latitude polar routes [10].

The removal of Satcom technology seatback in-flight phones also represented an important drawback. Satcom certainly provides a more natural way to communicate when it is necessary to speak to the untrained volunteer and even to a great number of flight attendants not familiar with radio communication.

The presence of a telephone line close to the passenger requiring medical attention truly enhances the capabilities for a better, more direct, communication. Moreover, current security issues prevent the occasional volunteer doctor from entering the cockpit. Without a communication line right at the passenger cabin, every single medical issue to be clarified requires the flight attendant - or even the pilot taking care of the case - to go back and forth between the passenger cabin and the cockpit.

Over the last 15 years, the industry has also witnessed the advent of telemedicine devices specifically designed to help transmit additional medical data in remote locations. These multi-monitors can gather important biological data as temperature, blood pressure, heart rate, blood oxygen levels (oxymetry), electrocardiograms, pictures and videos, among other parameters, and transmit in digital format to ground-based facilities.

These devices also provide a voice channel and an interactive interface enhancing the communication capabilities between the remote and local ends in the telemedicine model.

By having remote access to this improved level of information, doctors can provide better quality recommendations for those actually attending a victim. On the other end, flight attendants should be trained to operate these monitoring devices to help in obtaining the most reliable biological data.

Over recent years, a few airlines flying ultra-long haul flights, polar routes, or both, have adopted these kinds of devices in an attempt to avoid costly diversions and to provide the best possible care when a diversion is not even possible for operational reasons.

High-speed, broadband transmission capabilities, therefore, will be a real requirement to operate these devices in the near future.

4 Remote medical assistance

The advent of well-structured ground-based telemedicine providers in the '80s that cater to the aviation industry represented a milestone in providing medical support for passengers in-flight. It started the telemedicine era for in-flight medical incidents, by adding the third component of the model.

Remote doctors working in their usual environment at the emergency department have the appropriate mindset and skills to provide direction to those facing a medical situation in a resource-limited aircraft cabin.

Doctors who are trained to deal with medical emergencies and who are familiar in providing remote direction, are limited in their ability to deliver high-quality telemedical care only by the quality of the local resources and communication framework onboard the aircraft.

5 Conclusions

Continuous achievements in medicine are extending the life expectancy of the population around the world. As a result, more people are surviving previously incapacitating conditions.

In parallel, aviation also has experienced major developments with large capacity aircraft flying non-stop for longer sectors.

Increasing numbers of in-flight medical events could substantially affect the operation of air carriers and business aviation and should be avoided as much as possible.

Telemedicine is the best cost-beneficial model available and is continually developing.

In the past, lack of access to air transportation by the general population limited the size of the problem of in-flight medical emergencies. Today, global expansion of air transportation and increased life-expectancy, compounded by a progressively litigious environment where liability and accountability are actively pursued, has changed aviation operations.

The future demands for ultra-longhaul flights, increased use of polar routes, and large capacity aircraft used for international and domestic operation). Limited budgets and margins in the airline industry will require that airlines enhance in-flight medical care in order to avoid unnecessary diversions. At the same time, society will require state-of-the-art medical management of in-flight medical events either by legal / liability requirements or by commercial competition pressure.

Enhancing the local resources, via adequate medical kits, equipment, crewmember training and communication capabilities is the way to improve medical management of in-flight medical emergencies.

Designers and manufactures must develop solutions that address oxygen delivery, electrical supply, equipment and medical storage, patient management, patient isolation and medical data transmission.

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