In Flight Cardiac Arrest (IFCA) Survival: A Concept Analysis

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Abstract

Background: The number of inflight medical emergencies has risen in recent years, mainly due to more and more of us jetting off each year. Sudden Cardiac Arrest can strike at any time. Managing cardiac arrest in flight is really challenging and the survival depends on many factors. It's been estimated that 1000 people die during commercial flights each year. This study clarifies the concept of Inflight Cardiac Arrest survival by using concept analysis. **Methods:** To analyze the concept, relevant literature was analyzed using Walker and Avant's concept analysis. **Results:** The major antecedents of inflight cardiac arrest are cardiac causes, non -cardiac causes, flight conditions and lethal cocktail. Defining attributes of inflight cardiac arrest survival are in flight attributes, Chain of survival, availability of trained personnel and emergency equipment and remaining flight time to destination. Consequences of inflight cardiac arrest are physiologic consequences of victim and emotional consequences of the victim, family, personnel involved and co passengers. **Conclusion:** Inflight cardiac arrests are increasing in incidence. Lack of a carotid pulse is the gold standard for diagnosing cardiac arrest. Good quality Cardiopulmonary Resuscitation and early defibrillation are key factors for inflight cardiac arrest survival.

Key words: *Concept analysis, Inflight Cardiac arrest, Inflight medical emergency, and Survival.*

Introduction

In-flight medical emergencies (IME) are estimated to occur in approximately 1 per 604 flights, or 24 to 130 IMEs per 1 million passengers. The most common IMEs involve syncope or near-syncope (32.7%) and gastrointestinal (14.8%), respiratory (10.1%), and cardiovascular (7.0%) symptoms. Diversion of the aircraft from landing at the scheduled destination to a different airport because of a medical emergency occurs in an estimated 4.4% (95% CI, 4.3%-4.6%) of IMEs. Protections for medical volunteers who respond to IMEs in the United States include a Good Samaritan provision of the Aviation Medical Assistance Act and components of the Montreal Convention. Medical volunteers should identify their background and skills, perform an assessment, and report findings to ground-based medical support personnel through the flight crew. [1]

Most of the inflight cardiac arrests (IFCA) are reported by the leading newspapers. These are few reported cases of IFCA. In 2017, Alan Bourne boarded his Jet 2 flight to Birmingham from Majorca. Shortly before take-off, Alan suffered a Sudden Cardiac Arrest. Despite trained staff performing CPR, Alan couldn't be saved. [2] Davina Tavener was travelling with Ryanair to Lanzarote with her husband and

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two children. Her husband became concerned when Davina failed to return from the toilet, where it was discovered, she had collapsed. A consultant surgeon was on board, and along with staff attempted to revive Davina, with no success. [3]

A 69-year-old Ukrainian, who had a history of heart ailment and undergone a bypass surgery 20 years ago, was found 'unresponsive and unconscious' in the flight at 1.30 AM. Airport sources said the crew had carried out pulmonary resuscitation, but to no avail. The flight landed at 3:25 AM and the patient was seen by the doctor at the airport. The victim was declared brought dead due to cardiac arrest.[4] A 65-year-old passenger died of cardiac arrest on an IndiGo flight to Chennai. He got fits and succumbed to cardiac arrest. The victim was boarding the IndiGo flight, from Mumbai to Chennai, when he suffered a cardiac arrest in the aircraft. The flight was held up for four hours. The crew on board immediately alerted the ground staff who arranged for a doctor. The victim couldn't be saved.[5]

Lack of a carotid pulse is the gold standard for diagnosing cardiac arrest. As a result of loss of cerebral perfusion, the victim will rapidly lose consciousness and can stop breathing. Near-death experiences are reported by 10 to 20 percent of people who survived cardiac arrest, which demonstrates a certain level of cognitive processes that are still active during resuscitation.[6] Treatment for cardiac arrest includes immediate Cardiopulmonary Resuscitation (CPR) and, if a shockable rhythm is present, defibrillation.[7] Two protocols have been established for CPR: Basic Life Support (BLS) and Advanced Cardiac Life Support (ACLS).[8]

Management of inflight cardiac arrest:

Management of inflight cardiac arrest is really challenging. Initial assessment includes checking for breathing and pulse. [9] If no pulse or sign of life, start chest compression only CPR, with addition of bag-valve- mask ventilation (BMV) (30 compressions to 2 ventilations when emergency medical kit is available and someone skilled is present. Obtain and apply AED as soon as possible and follow instructions for defibrillation. If no shock is advised, or after a shock is delivered, resume CPR if there is no pulse. if no response to CPR and AED, initiate an intravenous line. Administer epinephrine (0.1 mg/mL) 1 mg intravenously. Instruct flight crew to notify the ground team and pilot. If no shock is delivered, the decision to divert will be influenced by how long ongoing CPR exists without return of circulation. [1]

According to American Heart Association (AHA) the 6 links in the adult out-of-hospital Chain of Survival are:

1. Recognition of cardiac arrest and activation of the emergency response system- Early recognition if possible. For every minute a patient stays in cardiac arrest, their chances of survival drop by roughly 10%.[10]

2. Early CPR with an emphasis on chest compressions- Early CPR improves the flow of blood and of oxygen to vital organs, an essential component of treating a cardiac arrest. By keeping the brain supplied with oxygenated blood, chances of neurological damage are decreased.

3. Rapid defibrillation- Early defibrillation is effective for the management of ventricular fibrillation and pulseless ventricular tachycardia.

4. Advanced resuscitation by Emergency Medical Services and other healthcare providers

5. Post-cardiac arrest care.

6. Recovery (including additional treatment, observation, rehabilitation, and psychological support).

A strong Chain of Survival can improve chances of survival and recovery for victims of cardiac arrest. If one or more links in the chain are missing or delayed, then the chances of survival drop significantly.[11]

Prognosis of out of hospital cardiac arrest

IFCA comes under Out of Hospital Cardiac Arrest. The overall chance of survival among out-of-hospital cardiac arrest, is 6%. For those who have an in-hospital cardiac arrest, the survival rate is estimated to be 24%. [12,13] A study of survival rates from out-of-hospital cardiac arrest found that 14.6% of those who had received resuscitation by paramedics survived as far as admission to hospital. Of these, 59% died during admission, half of these within the first 24 hours, while 46% survived until discharge from hospital. This reflects an overall survival following cardiac arrest of 6.8%. Of these 89% had normal brain function or mild neurological disability, 8.5% had moderate impairment, and 2% had major neurological disability. Of those who were discharged from hospital, 70% were still alive four years later.[14]

A scoping review on Automated External Defibrillator (AED) placement on commercial aircraft, reported incidence and outcomes of AED utilization for IFCA. Nine observational studies were identified. Eight reported instances of successful shock delivery using AED. Seven studies reported survival following AED use: of these, six reported administrations of a shock for IFCA survivors, whilst one study reported deployment of an AED without shock delivery. Overall, survival following in-flight AED use was 9%, with 37% survival reported where patients presented with shockable rhythm. Findings suggest in-flight AED use is feasible and associated with improved outcomes from IFCA.[15]

Materials and Methods

Study design: Concept Analysis

A Concept analysis is a way of examining the structure and function of specific concepts, allowing us to clarify and refine ambiguous concepts in nursing theories. Thus, concept analysis is important and useful for theorists in constructing relationships between concepts, as well as hypotheses and instruments for researching these concepts [16]. In the present study concept analysis by Walker and Avant was used. Walker and Avant's method elucidates the concept by providing antecedents, consequences, and empirical referents. The eight steps included are as follows: (a) Select the concept to be analyzed (b) Determine the aim and purpose of the study (c) Identify all uses of the concept (d) Determine the defining attributes of the concept (e) Construct model cases illustrating this concept (f) Construct additional cases, including borderline, related, contrary, invented, and illegitimate cases (g) Identify the antecedents and consequences of the concept (h) Identify empirical referents.[16]

However, according to Walker and Avant [16] even though they provided eight steps that seems sequential for analyzing the concept, in fact the steps can be iterative. In addition, many previous studies that used the Walker and Avant method also showed flexibility in arranging the steps and laying out the results [17]. Thus, in this paper, Specific layout of this paper is as the following: (a) Select the concept to be

analyzed. (b) Determine the aim and purpose of the study. (c) Identify all uses of the concept. (d) Identify antecedents of the concept. (e) Identify attributes of the concept. (f) Identify consequences of the concept. (g) Identify empirical referents. (h) Construct a model case illustrating this concept. (i) Construct a borderline case.

Data Collection

A literature review was conducted to define the concept "Inflight cardiac arrest- Survival". To find the relevant literature, online databases like Google scholar and PubMed were searched. These literature databases were searched using the keywords "in flight cardiac arrest" inflight medical emergencies", survival after inflight cardiac arrest". 40 relevant articles and few case reports were found; of which 9 articles were excluded as they were literature review in general about all inflight medical emergencies and some guidelines to be followed. Twenty-seven articles were particularly discussing about inflight cardiac arrest and survival. About 5-6 newspaper reported cases about inflight cardiac arrests were also reviewed.

Data Analysis

Relevant studies were read in detail. Characteristics of Inflight cardiac arrest -survival that appeared repeatedly throughout the literature were recorded and categorized into antecedents, attributes, and consequences. Studies were continuously read until achieving informational saturation. Information from reviewed studies contributed to the final decisions for antecedents, the cluster of attributes consequences and empirical referents.

Results

Walker and Avant [16] recommended using dictionaries, thesauruses, and any possible literature to identify the use of the concept. "Inflight cardiac arrest -survival" was not available as a single terminology. Hence it was split into "Inflight", "cardiac arrest" and "survival". Inflight means occurring or provided during an aircraft flight. Cardiac arrest is a sudden loss of blood flow throughout the body resulting from the failure of the heart to pump effectively. It is a rapidly fatal medical emergency requiring immediate intervention with CPR until further treatment can be provided. Cardiac arrest results in rapid loss of consciousness and breathing may be abnormal or absent. [18,19]. The dictionary meaning of survival is "the state or fact of continuing to live or exist, typically despite an accident, ordeal, or difficult circumstances.

Antecedents

Walker and Avant[16] defined antecedents as "those events or incidents that must occur prior to the occurrence of the concept". In terms of inflight cardiac arrest, several antecedents can be shown as leading up to the occurrence of the phenomenon. The **first antecedent is the cardiac causes of cardiac arrest.** Cardiac causes account for 75% of cardiac arrest [4,20,32]. The most common cause of cardiac arrest is an underlying heart problem like coronary artery disease which decreases the amount of oxygenated blood supplying the heart muscle. This, in turn, damages the structure of the muscle. Less common causes include major blood loss, lack of oxygen, very low potassium, heart failure, inherited heart arrhythmias and intense physical exercise.[20]

The second antecedent is the non-cardiac causes of cardiac arrest, which account for about 25% of cardiac arrests. Non-cardiac causes of cardiac arrest may result from temporary disturbances in the body's homeostasis. This may be the result from changes in electrolyte ratios, oxygen saturation, or

alterations of other ions influencing the body's pH.[21]

The third and particularly very specific for IFCA are the flight conditions. IFCA is a relatively rare but challenging event. Atmospheric pressure falls with altitude and above about 10,000 feet, blood desaturation leads to hypoxia. The aircraft cabin is pressurized to maintain an effective altitude below 8000 feet, which provides adequate protection for healthy travelers. With increasing altitude, there is a fall in atmospheric pressure and a decrease in ambient air density and temperature. Ascent to an altitude of 10,000 feet (3048 m) produces a significant fall in the partial pressure of oxygen in the alveoli, but because of the relationship between the oxygen saturation of hemoglobin in blood and oxygen tension, there is only a slight fall in the percentage of oxygen saturation of hemoglobin in the blood. However, hemoglobin saturation falls quickly upon further ascent, resulting in hypoxia with a decrease in an individual's ability to perform complex tasks.[22]

The fourth antecedent is 'Lethal cocktail'

Passengers are potentially exposed to increased stress from flying; getting to the airport and gate on time, altered circadian rhythms and lower cabin oxygen tensions, all of which may trigger underlying coronary artery disease and sudden cardiac death .[14,23]

Air travel exposes the passenger to several constraints (like physical constraints, stress) that can be correlated and lead to an inflight medical event, especially for passengers with chronic conditions or fragile health. [24]

Defining attributes of inflight cardiac arrest survival

According to Walker and Avant's[16] methodology, to determine the defining attributes of IFCA survival, the relevant literature was reviewed and then noted and summarized the characteristics that repeatedly appear. The identified attributes are 1. In flight attributes 2. Chain of survival of cardiac arrest 3. Availability of trained personnel 4. Passenger attributes and 5. Remaining flight time to destination**.**

1. In flight attributes

a) Failure to recognize cardiac arrest early

Collapsed passengers may be mistaken for being asleep, leading to a delay in resuscitation attempts, which results in poor survival outcomes.[12] Training aircrew to recognize cardiac arrest (unresponsive passenger who is not breathing) is crucial to early recognition[3,4]. Since aircrew need to respond early and promptly, the first aircrew to identify the cardiac arrest would need to call for help and start CPR. It is, therefore, crucial for airline operators to ensure that all aircrew, and not only the cabin crew-in-charge, be trained and currently certified in CPR and in the use of the AED. For airline operators, it is important that their training be accredited by their own National Resuscitation Councils to avoid any claims from potential litigants of low quality of care rendered. Not all in-flight cardiac arrests are witnessed because cabin crew or fellow passengers might simply assume that the victim is sleeping.[25]

b) Delayed time to defibrillation

Prior to 1990, it was a standard airline practice to divert aeroplanes to the nearest major airport if there was a cardiac arrest on board. Considering that it requires 10–15minutes for even a taxiing aero plane to return to its bay and more than 20 minutes for an emergency landing from cruising altitude, (1) it is not surprising that with VF being the most likely initial

arrest rhythm and its successful reversion dependent on time-sensitive defibrillation, most, if not all these patients, did not survive. With the advent of the AED, airline crew now have the capacity to initiate early CPR and early defibrillation with improved survival rates.[25.30]

c) Cabin environment

The restrictive environment of the cabin may interfere with the management of IFCA, as treatment may be hampered by poor access, restricted space, interference from noise and vibration that makes it difficult to assess pulse and breathing for CPR, and lack of privacy from having to work in a confined space.[13] The lack of space may make it difficult for rescuers to kneel comfortably by the side of the patient to perform standard CPR.[23,25]

2. Chain of survival

A strong Chain of Survival can improve chances of survival and recovery for victims of cardiac arrest. If one or more links in the chain are missing or delayed, then the chances of survival drop significantly.[11]

3. Availability of trained personnel and emergency equipment

Literature review had shown that in the event of IFCA most of the time fellow passengers volunteered to provide the emergency care. The cabin crew must be well trained for early identification and interventions including BLS and use of AED. Minimum requirements for emergency medical kit equipment in the United States include an Automated External Defibrillator (AED); equipment to obtain a basic assessment, hemorrhage control, and initiation of an intravenous line; and medications to treat basic conditions.[1] Variability of the skills in medical volunteers present unique challenges. Though in many airlines the cabin crew are trained for handling IME, their confidence to act quickly and promptly in such emergency situations is questionable, necessitating the real need of periodic renewal of training.[25]

4. Passenger attributes

Reported Shockable Rhythms (RSR) and Reported Non-Shockable Rhythms (RNSR) in the victim are important factors determining efficiency of BLS, use of AED and survival.[24.29]

5. Remaining flight time to destination

Because flight diversion may require interruption of CPR and may impact flight safety, the volunteer rescuer, cabin crew, flight crew, and medical consultation services should discuss the possible outcome and operational considerations before recommending a diversion for a patient with a non-shockable rhythm.[25.30]

Consequences

Walker and Avant [16] defined the consequences of a concept as the outcomes or results of the occurrence of the concept. The consequences of IFCA are mainly the physiologic consequences of victim, emotional consequences of the victim, family, personnel involved and co passengers.

a) Physiologic consequences of victim

Some victims may experience chest pain, shortness of breath or nausea immediately before entering cardiac arrest. Additionally, an elevated heart rate and feelings of light-headedness may occur.[19] If not intervened by CPR and defibrillation, cardiac arrest typically leads to death within minutes. [26] If CPR is successful, complete recovery is not

guaranteed as many survivors experience an array of disability including partial paralysis, seizures, difficulty with walking, speaking, or memory, limited consciousness, or persistent vegetative state and brain death. [27] It depends on how early the IFCA was identified and chain of survival was initiated.

b) The emotional consequences of the victim, family, personnel involved and co passengers.

Literature review revealed mix of emotions. In the event of successful survival, it's a moment of happiness and gratitude for the victim, family, personnel involved and co passengers. It remains a unique memorable experience in their lives. In contrary in the event of an unsuccessful survival it always remains a sense of grief and leaves a pain in memory of everyone involved. All IFCA, especially in case of unsuccessful survival is an opportunity for the airline authorities to check on their preparedness for similar incidents in future and to fill gaps if any.

The concept analysis of IFCA Survival according to Walker and Avant model is shown in figure 1.

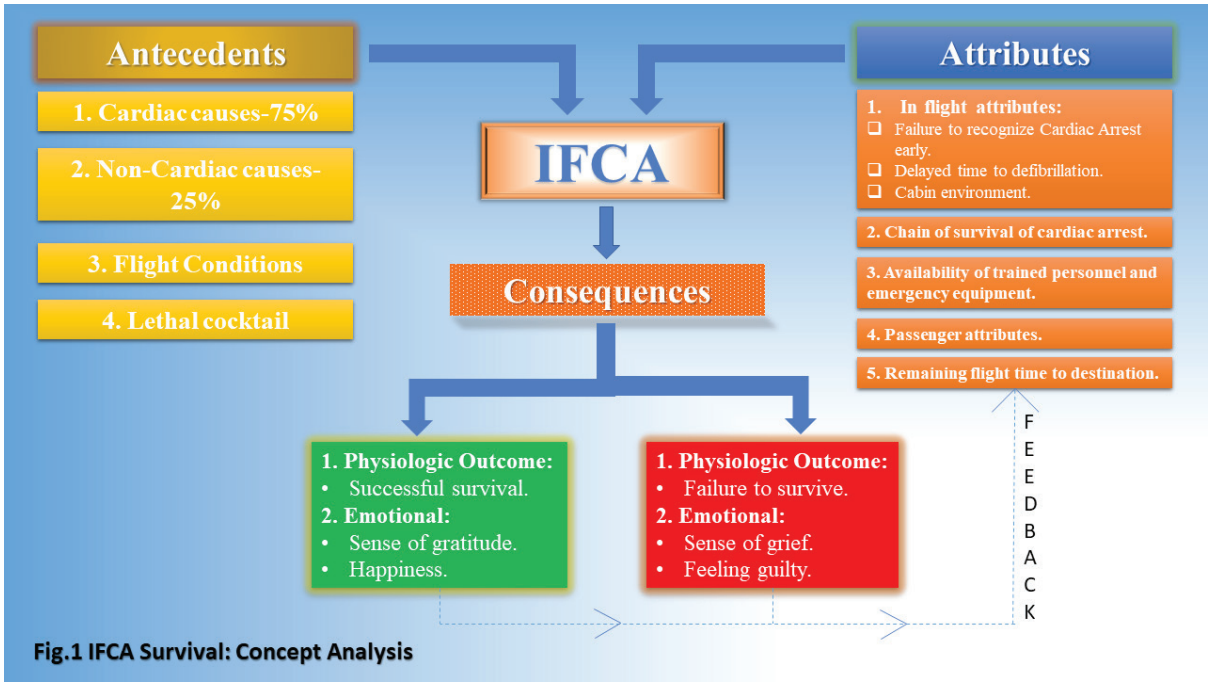

Fig.1 IFCA Survival: Concept Analysis

Empirical Referents

Empirical referents are the categories of actual phenomena that make us measure and recognize its existence or presence. Once identified, the empirical referents are useful in regard to developing the instrument since they are developed based on theoretical analysis of the concept [16]. In case of cardiac arrest absence carotid pulse is the golden standard to confirm the diagnosis.[11] Studies have reported empirical referents of cardiac arrest as unresponsiveness, no movement or response, absence of respiration (apnea), no pupil reflex, agonal respiration, irregular and sporadic breath, labored or noisy breath, gurgling or gasping sound, absence of detectable carotid pulse, not measurable blood pressure, arrhythmia, ventricular fibrillation, and asystole.[28]

Model Case:

On 10th October 2021, the author provided emergency care for an IFCA victim, wherein the efforts turned out to be fruitful in saving the life of a 48-year-old male passenger. He was a case of post covid lung fibrosis and pulmonary thrombosis travelling for further medical care. The passenger along with his friend boarded the flight. While boarding itself he was having intermittent cough and was receiving oxygen by nasal cannula. Almost 1-hour 15min before landing, the friend seated beside found him unusual and tried to wake him up. Overhearing this, the author who was occupying a near seat rushed to the passenger and found him unresponsive, carotid pulse was not palpable and the victim was not breathing. Immediately chest compressions were started and alerted the cabin crew. Meanwhile the cabin crew asked for more medical assistance. Two passengers who identified themselves as staff nurses volunteered. The victim was made to lie down in the aisle and cardiac compressions were continued. It was challenging to kneel and give chest compressions in the constricted space. One of the cabin crew was instructed to raise up his both legs as to promote blood supply to vital organs. By keeping the brain supplied with oxygenated blood, chances of neurological damage are decreased. His oxygen saturation was 40%. The oxygen cylinder was changed with new one and chest compressions with BMV was delivered at a ratio of 30:2. Later one more passenger who identified as a staff nurse joined the team. Compressions and BMV continued for around 25 minutes and the passenger regained pulse rate and started to breath spontaneously. Vital signs after 45 minutes were as follows; Heart rate of 102 bpm, RR of 16/ Min, BP 120/70 mmHg and Oxygen saturation 94% with 5 L of oxygen. The victim was fully conscious with no neurological deficits. The client was given adequate emotional support about his health. Upon landing, an ambulance was arranged, victim was examined by a medical doctor, and was transferred to hospital. The victim was hospitalized and discharged home after 10 days of treatment with advice to continue low levels of oxygen intermittently for couple of weeks and follow up.

Borderline case

A passenger on board Air India's AI 906 from Lagos (city in Nigeria) to Mumbai died. An airline official said that the passenger was unwell and was seen to be restless before he collapsed. A doctor on board along with crew, who are trained to handle such medical emergencies, made an all-out attempt to revive the person, aged 42, who had collapsed, through resuscitation but all their efforts went in vain. He was declared dead on board by the attending doctor. [29]

Discussion

IFCA survival is a real challenge. There is lack of detailed studies on IFCA Survival. Majority of the available studies are on the antecedents and predisposing factors. According to US Federal Aviation Administration (FAA) 177 of the events occurred on the aircraft (either in flight, at the gate, or while taxiing), 10 events occurred on the ground and one event occurred when the victim was en route to the airport. Of the 177 events that occurred on the aircraft, 119 were thought to be of cardiac origin, Sixty-four of these 119 passengers were reported as having died. For the remainder,42 passengers had unknown dispositions and 10 passengers were reported as having survived. Significant predictors for survival-to-hospital were reported shockable rhythm (RSR) and remaining flight time to destination. The study results showed that the percentage of RSR cases

was 24.6%. The survival to hospital admission was 22.7% (22/97) for passengers in RSR compared with 2.4% (7/297) in the RNSR group. Survival-to-hospital from IFCAs is best when an RSR is present. Good quality CPR and early defibrillation are key factors for IFCA survival.[30] In the present model case, the remaining flight time was around 1 hour 15 minutes and the victim received timely good quality CPR from the fellow passengers who identified themselves as nurses.

In the present model case, emergency medical equipment was available, but the crew was not confident to perform the resuscitation. Another study also reported similar finding. A study on retention of CPR and AED skills, first aid knowledge and perceived levels of confidence among cabin crew twelve months after recurrent training was done. The 35-cabin crew undertook a mock resuscitation scenario using the AED and bag-valve-mask carried in the medical kit. Of the 35 subjects, 33 subjects failed to use the bag-mask correctly, 18 performed chest compressions at the incorrect site, only 13 achieved the correct compression depth, only 20 placed the AED pads correctly, and the average time to first shock was 110 seconds after commencement of the resuscitation. While theoretical first aid knowledge was high, the participants held low levels of self confidence in their CPR and AED skills.[31] The results of this study indicate that cabin crew may not have sufficiently high levels of skill to manage a cardiac arrest adequately. This suggests that existing approaches to training of cabin crew require further investigation and modification.

Evaluation of the model case reveals the antecedents as non-cardiac cause (post covid lung fibrosis), flight conditions and lethal cocktail. During the management of the present model case, emergency equipment like ambu bag and mask and assessment tools like aneroid sphygmomanometer, stethoscope and pulse oximeter were available. Which really helped in providing the emergency care. Kneeling to provide chest compressions in aisle was really challenging. Though cabin crew were present and helped in shifting the victim down to the aisle and elevating the lower extremities, their competence in acting promptly in delivering CPR is questionable. Availability of other three staff nurses was a blessing to perform monitoring of oxygen saturation, changing the oxygen cylinder and to give emotional support to the victim. The cabin crew need to be given periodic training on BLS and ACLS.[30] Many passengers fly at a time in an airline and taking all measures to safeguard the lives of passengers is crucial. Availably of AED in airplanes is essential. One study reported that equipping helicopter emergency medical systems (HEMS) with mechanical chest compression devices MCDs may be beneficial, with non-trauma patients potentially benefitting more than trauma patients.[32]

Most arrests were bystander-witnessed and presented with a shockable rhythm. Pre-EMS therapies including cardiopulmonary resuscitation and AED application were common regardless of arrest location.[33] IFCAs are a subset of out-of-hospital cardiac arrest (OHCA). Prognosis for non-shockable rhythms is very poor. The best chance for non-shockable rhythms is good quality CPR or no cardiac arrest. Diverting for non-shockable rhythms might be futile and risks probably outweigh any benefit.[34]

Implications

All aircrafts to be supplied with emergency medical kit including AED and supplies for emergency assessment and resuscitation. Cabin crew to be trained and currently certified in CPR and in the use of the

AED. Cabin crew need to be given follow up training on managing IME to improve their confidence to act in similar situations. At times there may not be any medical personnel on board, wherein life of the victim will solely be in the hands of the crew.

Conclusion and Acknowledgement

The Present study is an eye opener to understand the concept of survival following inflight cardiac arrest. Availability of trained personnel and initiating good quality CPR is the key to survival. Cardiac arrests can happen any time. Resuscitating a victim of IFCA is an unforgettable experience for the healthcare workers or volunteers. The author is thankful to the cabin crew and volunteering staff for their timely support.

Conflict of Interest: The author does not have any conflict of interest**.**

Source of Funding: Nil

Ethical Committee clearance is not necessary since the data from previous published studies in which informed consent was obtained by primary investigators.

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