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Use, Outcomes and Policy on the Placement of Automated External Defibrillators on Commercial Aircraft for the Management of In-flight Cardiac Arrest: A Scoping Review

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ABSTRACT

Introduction

Automated external defibrillators (AEDs) are increasingly available in public places for the treatment of cardiac arrest. Some commercial aircraft carry an AED, but little is known about international policies and requirements. The aim is to review policy regarding AED placement on commercial aircraft, summarising reported incidence and outcomes of AED utilisation for individuals experiencing an in-flight cardiac arrest (IFCA).

Methods

A scoping review was undertaken. Online databases (Medline and CINAHL) were searched using prespecified terms to identify reports evidencing use, outcome and policy of AEDS for IFCA on commercial aircraft. Reports were screened and data extracted following scoping review extraction methods. Data were analysed to describe incidence of AED use and outcomes following IFCA, and policies regarding AED placement on commercial aircraft.

Results

9 observational studies were identified. 8 reported instances of successful shock delivery using AED. No published reports of safety incidents involving in-flight AED use were found.

7 studies reported survival following AED use: of these, 6 reported administration of a shock for IFCA survivors, whilst 1 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. Only one policy mandating AED placement on commercial aircraft was identified.

Conclusion

Despite the small, retrospective and observational nature of the reports identified, findings suggest in-flight AED use is feasible and associated with improved outcomes from IFCA.

Keywords: cardiac arrest; defibrillators; AED; aircraft; flight

Introduction

An estimated 4.1 billion passengers per annum travel on commercial aircraft.[1] The incidence of in-flight medical emergency events are reported to account for one event per 10,000 to 40,000 passengers,[2,3] with approximately 1000 deaths occurring as a result of IFCA on International Airlines Transport Association (IATA) carriers per year.[3] The German Society of Aerospace Medicine recently published recommendations for commercial flights, including management of IFCA, with basic life support and use of an AED.[4]

Cardiac arrest (CA) is the cessation of cardiac activity, frequently due to sustained abnormal heart arrhythmias ventricular tachycardia (VT) or ventricular fibrillation (VF).[5] By its nature, cardiac arrest can occur suddenly and unpredictably in any environment.

Automated external defibrillators (AED) can portably diagnose life-threatening cardiac arrhythmias such as VF or pulseless VT and administer defibrillating shocks accordingly to restore normal function of the heart.[6] AEDs are widely available and increasingly utilised, often by those with little to no training.[7] On commercial aircraft, there is an expectation that cabin crew should be trained to manage in-flight emergencies including use of an AED where available, and passengers who are health professionals, including paramedics, frequently respond to requests for assistance in such circumstances.[8] In out-of-hospital cardiac arrest (OHCA), VF presents as the initial rhythm in approximately 65% of patients.[9] VF can only be treated effectively with defibrillation and using an AED is time-critical.[10]

Early defibrillation using an AED is a pivotal link in The Chain of Survival, which denotes a series of therapeutic interventions in reaction to an OHCA.[11] It describes four key inter-related steps, which if delivered effectively and in sequence, optimise OHCA survival.[12] The third step in The Chain of Survival is early defibrillation. Defibrillation within 3–5 minutes of collapse can produce survival rates as high as 50–70% and each

minute of delay to defibrillation reduces the probability of survival to hospital discharge by 10%.[13,14] During an IFCA, at least 20 minutes will pass until possible defibrillation without onboard AED, considering the minimum time of flight diversion and landing.[15,16]

Precise in-flight incidence of cardiac arrest remains unknown due to a lack of a mandatory and uniform reporting system and it has been suggested that data is often unclear due to the potential 'negativity through association' airlines or air travel could receive.[17] Between 2008 and 2010, 11,920 reported in-flight medical emergencies suggest an incidence of 16 to 25 emergencies per million passengers, or one medical emergency every 604 flights, with a fatality rate of 0.1 to 0.3 deaths per million passengers.[18] Airline specific studies suggested that severe emergencies, including IFCAs, are increasing alongside traveller numbers, flight durations and increasing life expectancies.[19,20]

In summary, AEDs are deemed effective and beneficial for the successful management of cardiac arrest in public locations, yet the effective management of such events on commercial aircraft is unknown.

Objective

To review current policy on the placement of AEDs on commercial aircraft and the available evidence regarding use and outcomes of AEDs for IFCA.

Methods

A scoping review was undertaken, using the standard framework developed by Arksey and O'Malley.[21] Arksey and O'Malley developed a six-stage methodological framework: identifying the research question, searching for relevant studies, selecting studies, charting the data, collating, summarizing, and reporting the results, and consulting with stakeholders

to inform or validate study findings. Due to the nature of the study design, ethical approval was not required.

Eligibility criteria

The inclusion and exclusion criteria are summarised in in Table 1.

All study designs referring to the policy and outcomes of AED placement, and their use on commercial airlines for the management of IFCA, published in the English language, were included. On completion of the initial search, a sparsity of empirical evidence was noted. A broad search was performed with all forms of study design considered.[22] Reports focusing on AED placement and use on non-commercial aircraft such as emergency medical helicopters and government aviation were excluded, as were studies reporting AED use by airport medical staff or ground emergency medical services. Finally, studies that reported on the use of AEDs for monitoring purposes only were excluded. The inclusion and exclusion criteria is outlined clearly in Table 1.

Table 1: Inclusion and exclusion criteria for studies included in the scoping review

	Inclusion Criteria	**Exclusion Criteria**
Population	Individuals who experienced an IFCA on a commercial airline	Individuals who experienced potentially life-threatening symptoms on a commercial airline but who did not have an IFCA
Intervention	Placement of an AED on commercial aircraft for the management of IFCA IFCA treated with the use of an AED	Placement, use and outcomes of AEDs for the management of IFCA on non-commercial aircraft Use of AEDs on commercial aircraft for monitoring purposes only

	Outcome of use of AED on individuals who suffer an IFCA Current policy on the placement of AEDs on commercial aircraft	Use of AEDs before take-off or after landing by airport staff or ground emergency medical services
Comparator	Any study design; no comparator necessary	
Outcomes	Outcome of AED use for IFCA	
Study design	Any study design Guidelines and recommendations published by authoritative sources. English language Published 1988 – 2018	Discussion articles Editorials Opinion pieces Non-English language

IFCA: In-flight cardiac arrest, AED: Automated External Defibrillator

Information sources and search strategy

A systematic search of two electronic databases (Medline and CINAHL) was conducted. The search strategy was tested and revised to focus on AED use on commercial airlines after initial searches using the search terms 'defibrillator', 'airlines' and 'cardiac arrest'. Literature on current recommended cardiac arrest management, care pathways and recommended guidance and protocols on resuscitation were identified, looking broadly initially at management and outcomes in public settings before focusing specifically on evidence for placement and use on commercial airlines. This was due to the limited number of published studies available for the latter. The results of early scoping searches also allowed for clarification of the current policies for the placement of AEDs on commercial airlines. In this way, a clearly articulated scope of enquiry was combined with a broad question. The final search strategy included the following search terms: ((Heart Arrest (MeSH term) OR (Arrhythmias, Cardiac (MeSH term) OR "Cardiac Arrest" (keyword)) AND (Defibrillators

(MeSH term) OR "AED*" (keyword truncated)) AND (aircraft (MeSH term) OR "airline*" (keyword) OR "flight" (keyword)). A combination of MeSH headings and keywords was used after noting that this approach resulted in return of a broader scope of articles to consider as appropriate for a scoping review. This approach also followed advice from Colquhoun et al. in their literature review which outlined the correct method of completing searches for a scoping review.[23] Searches were carried out in July and August 2018. Searches were limited to English language reports and articles or studies which were published in relevant peer reviewed journals.

Study selection

A two-stage screening process was undertaken. The first step involved identification of potentially eligible studies, screening by title and abstract. The second stage involved the more thorough assessment of full papers to confirm eligibility for inclusion.

Data extraction, presentation and reporting

Relevant data was extracted, presented and reported on a predefined table, adapted from the Cochrane Collaboration Handbook.[24] Results and findings were also presented according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidance, using a table, flow chart and narrative summaries to document key items of information.[25,26]

Quality assessment

According to Arksey and O'Malley, the weight of evidence should not be addressed when presenting findings within a scoping review.[21] The aim instead is to clearly report study

findings so that any potential bias in findings and discussion can be determined by the reader.[21]

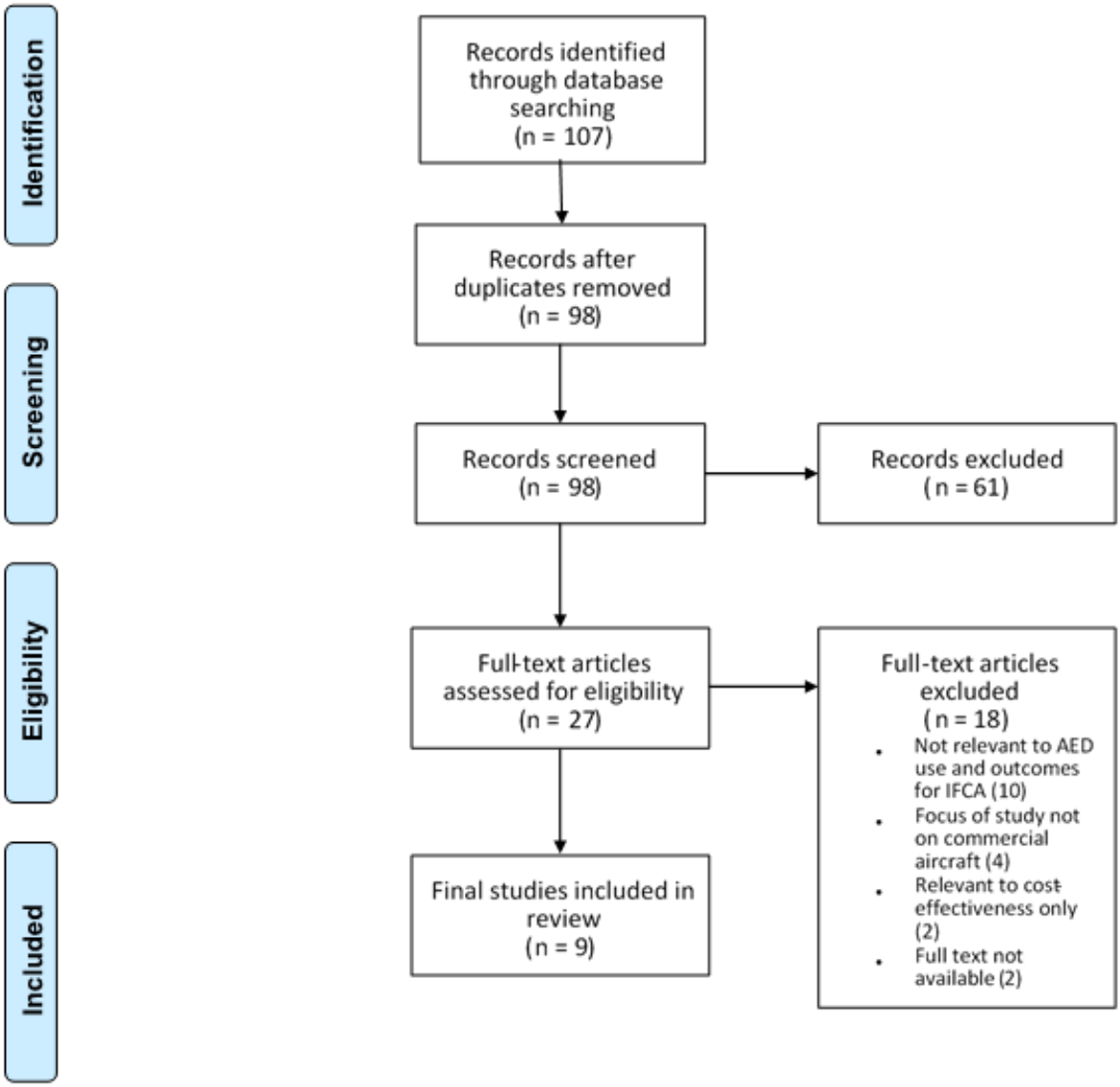
Results

107 records were identified. After duplicates were removed, a total of 98 records remained. Further screening based on title and abstract resulted in exclusion of 61 further records, with 27 full text articles remaining for assessment for final study eligibility. 9 studies met the final inclusion criteria.[2,16,18,27-32] Reasons for the exclusion are outlined in Figure 1. Characteristics of the 9 included studies are summarised in Table 2 and findings outlined in Table 3. One policy paper was identified.[33]

Table 2: Characteristics of included studies

Lead Author, Year, Reference	Region	Method	Sample size	Period of data collection
O'Rourke, 1997, (27)	International	Retrospective study	31 million passengers	Over a 65-month period between 1991 and 1996
Harve, 2009, (28)	Tokyo to Helsinki	Case report	1 passenger	Not specified
Brown, 2010, (29)	America	Retrospective descriptive study	169 passengers	May 2004 to May 2009
Page, 2000, (30)	America	Retrospective study	191 passengers	June 1997 to July 1999
Kesapli, 2015, (31)	Not specified	Retrospective study	10.1 million passengers	2011 to 2013
Hinkelbein, 2017, (2)	Not specified	Retrospective survey study	121 passengers	Not specified
Alves, 2016, (16)	Not specified	Retrospective cohort study	394 passengers	Not specified
Peterson, 2013, (18)	International	Retrospective study	744,000 passengers	January 2008 to October 2010
Hung, 2010, (32)	International	Retrospective cohort study	4,068 passengers	2003 to 2008

FIGURE 1 Search Results



Use of AED and outcomes for the management of IFCA

9 studies were found that specifically referred to the use and outcomes of AEDs on commercial airlines for the management of IFCA.[2,16,18,27-32] A shockable rhythm suitable for treatment with an AED was reported in 8 of the 9 studies.[16,18,27-32] A total of 551 confirmed cases of IFCA were identified in which an AED was reported to have been deployed 525 times.[16,18,27-29,31,32] A treatable shockable rhythm was identified on AED application in 138 cases.[16,18,27-32] 7 of the 9 papers reporting on IFCA provided data on outcomes of AED use

on flights.[16,18,27-31] 47 cases of survival associated with AED use were identified.[16,18,27-31] A shockable rhythm was present in 26% of patients. Overall, survival from IFCA with AED use was 9%, with a survival rate of 37% reported for patients with shockable rhythm on application of the AED. Reported AED use and outcomes are summarised in Table 3.

Table 3: Use and outcomes of AEDs on commercial aircraft for the management of IFCA

Reference	Number of confirmed IFCA cases	Number of times AED was confirmed as having been deployed for IFCA	Number of reported incorrect or inappropriate uses of AED	Number of cases in which an AED shock was administered	Number of individuals who survived after AED use
O'Rourke, 1997, (27)	27	27	0	6	2 (survival reported based on confirmed discharge from hospital. Both cases involved administration of a shock and were witnessed collapses)
Harve, 2009, (28)	1	1	0	1	1 (survival reported based on confirmed discharge from hospital. Individual case required 21 shocks with the patient initially found in an unconscious state)
Brown, 2010, (29)	40	40	1 (in one instance, a shock was not given despite the AED	14	6 (survival reported based on confirmed return of spontaneous

			advising the user to do so)		circulation. All cases required administration of a shock)
Page, 2000, (30)	11	11	0	11	6 (survival reported based on confirmed discharge from hospital. All cases required administration of a shock)
Kesapli, 2015, (31)	13	5	0	4	2 (specific details on survival not reported. Both cases required administration of a shock)
Hinkelbein, 2017, (2)	Not reported (the specific number of IFCA incidents from the reported number of 54 in-flight medical emergencies was not reported)	Not reported (the specific number of times that an AED was deployed for IFCA was not reported. However, the AED was reported as used 13 times overall)	Not reported	Not reported	Not reported
Alves, 2016, (16)	394	394	Not reported	96	22 (survival reported based on confirmed discharge from hospital. All cases required administration of a shock)
Peterson, 2013, (18)	35	24	Not reported	5	8 (survival reported based on confirmed return of

					spontaneous circulation and survival to hospital admittance. An AED was used for all survivors.)
Hung, 2010, (32)	30	23	Not reported	1	Not reported

IFCA: In-flight cardiac arrest, AED: Automated External Defibrillator

Policy regarding placement of AEDs on commercial aircrafts

Only one policy was identified, from the Federal Aviation Administration, advising the mandatory placement of AEDs on commercial airlines.[33] The US Federal Aviation Administration (FAA) is the national authority with powers to regulate all aspects of civil aviation.[34] The FAA, in agreement with the American Heart Association (AHA), introduced mandatory requirements for all US-based commercial passenger aircraft with at least one flight attendant to carry on-board AEDs in April 2001. Airlines were given three years to place AEDs on all domestic and international flights and to train airline staff accordingly. By 2004, AEDs had been placed throughout American commercial fleets, with the necessary crew training also completed to ensure that the AED could be used and maintained correctly by airline staff if required.[29] No equivalent policy was identified from the European Aviation Safety Agency (EASA) or the International Civil Aviation Organisation (ICAO).

Despite the evident lack of international consensus on the implementation of a universal policy on AED placement on commercial airlines, many airlines have voluntarily decided to follow the recommendation of the various bodies. Individual airline carriers have shown initiative regarding the placement of AEDs on their commercial fleets, choosing to introduce AED on their aircrafts of their own accord. In 1991, Qantas Airlines was one of the earliest

airlines to introduce AEDs throughout their aircraft fleet and was also the first large-scale airline to adopt the AED as part of the on-board resuscitation equipment for cardiac arrest.[27] Also, Singapore Airlines introduced AEDs on all their passenger aircraft in 1997.[15] In 2018, Barden[35] outlined a list of commercial airlines who were contacted to enquire if an AED was available for use on their aircrafts for flights from the UK. The author obtained this information by contacting the airlines directly to request a response to this query. Table 4 outlines the response from the various airlines.

Table 4: What airlines carry Automated External Defibrillators on flights from the UK?

Commercial Airline	Confirmation of Automated External Defibrillator placement on aircraft?
Air France	Yes
Air Lingus	Yes
Air New Zealand	Yes
Aegean	No
Aeroflot	No response
Alitalia	Long-haul only
All Nippon Airlines	Yes
British Airways	Yes
Cathay Pacific	Yes
easyJet	Yes
Emirates	Yes
Etihad	Yes
Finnair	Yes
Japan Airlines	Yes
Jet2	Yes
KLM	Yes
Korean Air	No
Lufthansa	Yes
Norwegian	Yes
Qantas	No response
Qatar	Yes
Ryanair	Yes
SAS	Yes
Singapore Airlines	Yes
Swiss Air	Yes
Thomas Cook Airlines	Yes

TUI	Yes
Virgin Atlantic	Yes
Wizz Air	No response

Barden[35]

Discussion

This scoping review found a limited number of published reports of the use and outcomes of AED placement on commercial aircraft for the management of IFCA.[2,16,18,27-32] Evidence suggests that AEDs are beneficial in-flight to maximise chances of survival following IFCA.[16,18,27-31] However, the limited amount of published data and retrospective nature of the studies identified for the purposes of this scoping review preclude definitive conclusions to be drawn. From the limited literature available for review, the following findings emerged.

Patients who present in a shockable rhythm during an IFCA have a higher chance of survival when an AED is present.[16,18,27-31] Despite the overall incidence of IFCA being reported as relatively uncommon during a commercial flight, its occurrence amongst the papers considered within this scoping review was noteworthy. The studies reviewed show that effective diagnosis and management of a shockable rhythm associated with an IFCA is possible when an AED is used, with positive outcomes of survival shown to be directly attributable to the use of an AED.[16,18,27-31]

Swift identification and management with the use of an AED in-flight is an opportunity to prevent premature death from IFCA.[16,18,27-31] However, survival for a passenger who suffers an IFCA with a non-shockable rhythm is unlikely even if an AED is present. The literature reviewed showed that for incidences of IFCAs that occurred in flight in which patients were noted to be in a non-shockable rhythm on application of the AED, death was reported in the majority of cases.[16,18,27,29-31]

With the exception of the FAA, who mandate the placement of AEDs on commercial flights,[33] there is no current internationally agreed policy on the placement and use of AEDs on commercial aircrafts. This highlights the need for international consensus on AED placement on commercial airlines.

There is a lack of recent definitive evidence regarding the use and outcomes of AED placement on commercial airlines. Randomised trials, considered the 'gold standard' of scientific evidence, would be impracticable in the IFCA setting. However, given the FAA has mandated AED placement and formal recording of in-flight AED use since 2004,[33] there is potential to analyse years of experience of AED implementation. Findings from 15 years of standardised reporting could inform future policy of aviation authorities in non-USA jurisdictions.

Implications for practice and research

Despite the remit of a scoping review neither inherently nor explicitly involving quality assessment of included studies,[21-23,25] and the potential for reporting bias, the implications for both current and future practice and research should be considered. It is important to acknowledge that controlled prospective trials, including randomised controlled trials, would typically be more likely to influence both current and future practice. However, these would likely be impracticable and unethical when considering the overall evidence that defibrillation is a highly time-critical intervention. The withholding or substitution of an AED (e.g. with a sham device) would potentially create further harm and would be unethical. Similarly, the professional and practical requirements of a large randomised trial study in the setting of commercial air transportation would likely be costly and difficult to implement.

The collection of data in relation to the outcomes of AED use on commercial aircraft also needs to be considered. Due to the intrinsically transient nature of the aviation industry, the follow-up of patient outcomes becomes problematic when the ultimate health status beyond a certain point becomes out of reach.

Recommendations for further research

Further analysis of the data collected on AED use and outcomes should be considered since the implementation of the FAA policy in 2004 (this is likely to be the world's largest data set on IFCA and AED use). This could include a comparison of outcomes from IFCA between airlines with and without AEDs on board. Also, qualitative research may be beneficial to help identify perceived barriers to the implementation of AEDs on airlines that do not currently provide these devices. Finally, the economic effects of universal AED placement on commercial aircraft could be explored.

Strengths and Limitations

A structured and methodical approach was followed based on guidance for carrying out a scoping review.[21-23,25] A systematic review was not undertaken as this topic was much broader in scope than what would be covered in such a review. Primarily, the studies included in this review were retrospective in nature, where data was collected without control groups or stringent criteria to facilitate useful comparison.[2,16,18,27-32] Qualitative synthesis was used without detailed critical appraisal which is consistent with methods for a scoping review. It was decided to include all study designs in order to search widely across the research literature as recommended.[21-23,25]

Conclusion

This scoping review afforded the opportunity to identify and describe existing evidence regarding current policy on the placement of AEDS on commercial aircraft, and the use and outcomes of AEDs for the management of IFCA. There is currently an absence of internationally agreed policy on the placement of AEDS in-flight on commercial aircraft. Data describing the use and outcomes of AEDs on commercial aircraft are limited, and prone to bias, but nonetheless suggest an important role for AEDs on aircraft. Although literature on this specific topic has been shown to be limited, evidence of a wider context highlights the significance and value of immediate access to an AED, including in public locations in which treatment may otherwise be hampered and delayed due to location or circumstance. This is applicable to the commercial aircraft environment.

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