Medical Events on Board Aircraft: Reducing Confusion and Misinterpretation in the Scientific Literature

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INTRODUCTION: A topic in aviation medicine that attracts much attention from the scientific community as well as from the media concerns medical incidents on board commercial airline flights. It was noticed that many papers on the subject were written by authors whose specialization was outside that of aviation medicine and that they sometimes made basic errors concerning the application of scientific principles of the subject. A review was undertaken to determine if there were any patterns to the observed errors and, if so, to consider whether recommendations might be provided that could reduce their frequency.

METHOD: A literature search was undertaken of MEDLINE using PubMed for English-only articles published between January 1, 1974, and February 1, 2019, employing the following search terms: air emergency, air emergencies, air passenger, air travel, aircraft, airline, aviation, commercial air, flight, and fitness to fly. In addition, other relevant papers held in the personal collection of the authors were reviewed.

RESULTS: Many cases of misinterpretation or misunderstanding of aviation medicine were found, which could be classified into eight main categories: references; cabin altitude; pressure/volume relationship; other technical aspects of aircraft operations; regulations; medical events; in-flight deaths; and automated external defibrillator.

CONCLUSION: Papers were identified as having questionable statements of fact or of emphasis. Such instances often appeared to result from authors being unfamiliar with the subject of aviation medicine and/or the commercial aviation environment. Simple steps could be taken by authors to reduce the future rate of such instances and recommendations are provided.

KEYWORDS: air emergencies, commercial aviation, air travel.

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A topic that attracts attention from the scientific community (as well as from the media) concerns medical events on board commercial airline flights. Those who write about the subject may not be fully aware of the physiological principles of flight in the lower air pressure levels of cabins of commercial aircraft, the choice of medical equipment carried on board, the mechanisms of transmission of disease on board, the regulations relevant to commercial aircraft, and aircraft operations in general. In some cases, information provided may be inaccurate and conclusions reached that appear unjustified. Peer review does not always prevent statements of possibility in one paper being referred to as statements of fact in another.

Aviation medicine is a specialized subject that is rarely covered in depth during medical school training, or in mainstream medical and surgical postgraduate specialties. Physicians writing about it who have not had specialist training may, therefore, not be fully aware of the principles and practices involved. This paper reviews the literature to evaluate the prevalence of inaccuracy and confusion in papers addressing aviation medicine and related topics, and identifies subject areas, with examples, which do not seem to have been fully understood by their authors. We suggest ways for how pitfalls may be avoided.

METHODS

A literature search was undertaken of MEDLINE using PubMed for English-only articles published between January 1, 1974, and February 1, 2019, employing the search terms: air emergency,

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air emergencies, air passenger, air travel, aircraft, airline, aviation, commercial air, flight, and fitness to fly. From these we then selected papers that discussed in-flight medical incidents. Other relevant papers held in the personal collection of the authors were included in the review. Of the 100 papers reviewed, 47 were found to have a variety of anomalies, which are discussed below, with examples.

RESULTS

References

The incorrect use, misinterpretation, and misquote of references prompted the writing of this paper. The original source document should ideally be the basis for any analysis, to prevent repetition of error and/or misinterpretation. If unavailable, this should be stated.

In the 2002 Gendreau et al. paper "Responding to medical events during commercial airline flights," the authors mentioned "Transmission of tuberculosis, influenza, measles, *smallpox* [emphasis added], cholera, and enteritis aboard commercial aircraft has been reported."[21] It is true that transmission of such diseases on board aircraft has been shown, except for smallpox, as a review of the relevant references show. The references cited were from the Select Committee on Science and Technology of the United Kingdom House of Lords[65] and from a paper by Kenyon et al. on "Transmission of multidrug-resistant *Mycobacterium tuberculosis* during a long airplane flight."[35] The first reference[65] does not mention smallpox and the second reference[35] is not the source document concerning possible smallpox transmission. Kenyon et al.[35] cites Ritzinger,[57] which is also not the source reference. However, it is in Ritzinger's reference list that we find the original source[8] for possible smallpox transmission on board. The reference[8] is a 1963 Morbidity and Mortality Weekly Report from the U.S. Centers for Disease Control and Prevention that includes information received from a non-U.S. public health authority. The report states, concerning the individual with smallpox, "He *apparently* [emphasis added] acquired his disease as a result of in-transit exposure either at a terminal or on the plane."[8] This is not evidence of transmission on the plane. It is only a possibility.

Another paper cited frequently as confirmation of transmission of a disease on aircraft is Olsen et al., "Transmission of the severe acute respiratory syndrome on aircraft."[48] This concerns the development of the Severe Acute Respiratory Syndrome (SARS), after arrival, of 18 passengers who had shared a flight from Hong Kong to Beijing with a passenger symptomatic from SARS. The authors indicate that the most plausible explanation for the development of SARS in the passengers involved is that they were infected while on board the aircraft.

However, Olsen et al. also state that "it is possible that the passengers in whom SARS developed were infected before or after the flight."[48] Despite this caveat, the paper has subsequently been used as de facto proof that SARS was transmitted during the flight described. In a typical example, Hertzberg et al. state "In March 2003, a 72-year-old passenger with SARS *infected* [emphasis added] 18 passengers and two flight attendants on a three-hour flight from Hong Kong to Beijing."[24]

Cabin Altitude

For the great majority of commercial aircraft, as they ascend, cabin pressure falls, but at a lower rate than the ambient pressure (the pressure immediately outside the aircraft). At a typical cruising altitude of 37,000 ft the cabin altitude is maintained at about 8000 ft, lower on the more modern aircraft.

Shesser[66] created a table with data from two references[1,42] with the intention of comparing the cabin environments of three different types of aircraft flying at their "cruising altitude." However, the cruising altitudes of the different aircraft are not provided and no mention is made of the potential effect of this on cabin pressure: Shesser seems to believe that the altitude of an aircraft in cruise does not affect its cabin altitude, whereas a higher cruising altitude typically results in a higher cabin altitude. Shesser also introduced the term "effective cabin altitude,"[66] which is not a term recognized by aeromedical specialists or used in airline operations. Had Shesser sought input from an aeromedical specialist, these confusions could have been quickly addressed and the paper would have likely been clearer and of more value.

Jagoda et al., when describing medical emergencies in commercial air travel, state that "Cabin pressurization minimized gas expansion, though there will be an approximate 10% increase in gas volume".[33] While the cabin pressurization system does reduce the change in pressure with increasing altitude, in the cruise at a (typical) maximum cabin altitude of 8000 ft, the increase in gas volume is in the order of 30%, not 10%, when compared to sea level.[70]

Jassar et al.[34] did a study to challenge the theory that flying after recent myringoplasty may have an adverse effect on graft take rates owing to variation in air pressure. It was undertaken with one carrier and one aircraft type (British Aerospace ATP, a propeller aircraft) flying at a cruising altitude of 13,000 ft with cabin altitude maintained at 3000 ft, well below the cabin altitude of most jet airliners during cruise. However, they extrapolated their findings to flights between 7000 and 8000 ft cabin altitude (typical of a jet airliner) stating, "Although these flight parameters are greater, they are unlikely to affect graft take rates."[34] This statement was not based on any data. Furthermore, the authors did not take into account the typically longer lengths of flight in jet aircraft than in the study aircraft (which was 45 – 60 min) and, because in a jet aircraft the descent is typically from a higher cabin altitude than in a propeller aircraft, the need to perform more Valsalva maneuvers (or similar actions) to equilibrate middle ear pressure. The latter may need to be undertaken with a suboptimal Eustachian tube function, as recognized by the authors. Our view is that the authors should have limited their recommendations to the parameters of the study, i.e., 3000 ft cabin altitude and relatively short duration flights. They may not have realized the potential differences in cabin pressure, and rates of change of cabin pressure, between propeller and jet aircraft.

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Pressure/Volume Relationship

One of the fundamental tenets of aviation physiology is that with increasing altitude, atmospheric pressure decreases and gas volumes in body cavities increase.[70] With decreasing altitude, the opposite occurs. This is not always appreciated. Bui et al. state, "We therefore speculate that both headaches are triggered by increasing atmospheric pressure during the descending phase, which will result in expanding the air in the cavities and thereby inducing the headache in the aforementioned phase."[7] This is physiologically incorrect; when atmospheric pressure increases during descent, volume of air in cavities decreases. Furthermore, it was noted that the authors did not specify the "cavities" to which they were referring. A letter to the editor about this was not followed by a correction.

Naouri et al. state, when referring to gas expansion with decreasing cabin pressure during climb, "To prevent this event, current guidelines recommend avoiding the consumption of soft drinks and foods at risk during and prior to the flight."[46] It is wise to avoid the consumption of carbonated drinks prior to flight because the gas retained in the gut will increase in volume during the climb and may cause symptoms; however, consumption during the cruise should not be an issue as the gas volume produced by a carbonated drink that is opened and consumed in the cruise will not change since there will usually be no further significant increase in altitude (and associated decrease in cabin pressure/increase in gas volume) once cruise altitude is reached.[70]

Other Technical Aspects of Commercial Aircraft Operations

There are other aspects of commercial aircraft operations of which nonspecialist authors may not be aware, which can result in errors.

Rodenberg states, "All commercial airliners have on board extra bottles of 'medical' (humidified) oxygen exclusively for passenger use."[58] However, humidified oxygen was not automatically available on board commercial airliners at that time (1987), which continues (Thibeault C, Evans AD. 2020. Personal commnication). Two other papers reproduced the same error.[33,59]

Concerning oxygen flow rates, Rodenberg states, "….and a flow rate of 4 to 6 $L \cdot min^{-1}$."[58] However, emergency oxygen bottles on board have two ports: 2 or 4 $L \cdot min^{-1}$. A 6 $L \cdot min^{-1}$ rate is not available. Drummond and Drummond, without reference, perpetuate the same misinformation by stating "All commercial airlines carry humidified oxygen that is capable of providing 4 to 6 $L \cdot min^{-1}$ of 100% oxygen".[17]

Some medical conditions can benefit from a decrease in cabin altitude with its associated increase in oxygen concentration, but this is rarely something that can be easily achieved. For example, Jagoda states, "If symptomatic relief is not achieved with these measures, request that the captain establish a sea level cabin altitude."[33] He mentions this procedure several times, which is advocated by several other authors. Unfortunately, while this approach may be desirable for certain medical conditions and is theoretically possible, it is in practice very seldom an option in typical civil aircraft jet operations since it is not usually feasible to reduce cabin altitude to sea level without descending. High ground or conflicting traffic may prevent descent, and at lower altitudes fuel consumption is greatly increased, which could prevent the flight from reaching its destination. If, for clinical reasons a ground level cabin altitude is advisable, the usual solution is an early descent and landing, with a diversion. (In military operations, other options may be available.)

Ruskin et al. write "The Boeing 787 Dreamliner (Boeing Company, Chicago, IL) uses a novel design to compress and heat cabin air, enabling it to maintain a relative humidity of 30%."[60] Although the 787 does use a novel approach to providing cabin air, compression and heating does not materially affect its relative humidity. In order to increase the relative humidity of cabin air, water has to be added, which is a separate process. Ruskin et al. also write, "Fresh air entering the cabin is first passed through a catalytic converter to remove ozone and then through a charcoal filter that removes volatile organic compounds such as fuel vapors."[60] At the time of writing (2008) catalytic converters and charcoal filters were not fitted to all aircraft, although they were available as an option (Thibeault C, Evans AD. 2020. Personal communication).

In their 2010 paper, Lapostolle et al. state that, "La pressurisation de la cabine implique une recirculation de 50% de l'air environ. Cela peut constituer un risque de transmission d'infection" ("The cabin pressurization implies a recirculation of approximately 50% of the air. It could constitute a risk of disease transmission").[40] This is incorrect; cabin pressurization does not necessarily imply air recirculation. Cabin pressurization began in the late 1930s, as aircraft began cruising at increasingly high altitudes, while cabin air recirculation was introduced much later.[28] Furthermore, air recirculation constitutes a virtually zero risk of disease transmission if the most efficient High Efficiency Particulate (HEPA) filters are used (which they are on most modern airliners). Such HEPA filters remove 99.97% (at least) of particulates (including bacteria and viruses).[28]

Donner states, "Newer aircraft use high-efficiency particulate filters to remove gaseous contaminants, including some volatile organic compounds that may act as mild respiratory irritants."[16] However, typical HEPA filters do not remove gaseous contaminants, only particulates, as implied in the name.[28]

Regulations

There is much misunderstanding concerning the (somewhat complex) regulation of first aid and medical kits on board aircraft. Minimum requirements for international airline operations, including on board medical supplies, are determined by the International Civil Aviation Organization (ICAO, a United Nations Specialized Agency) and can be found in ICAO Annex 6, Aircraft Operations.[30] ICAO develops "Standards" in consultation with States (national governments) that are mandatory and must be implemented by all signatory governments (currently numbering 193) to the "Convention on International Civil Aviation."[31] Although Standards are developed by ICAO, they are implemented by national regulatory authorities, e.g., a Civil

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Aviation Authority or a Directorate of Civil Aviation, through a national legal framework.

ICAO also develops Recommended Practices, which are "desirable" for implementation (but not mandatory), and finally, guidance material is produced by ICAO to support the implementation of the "Standards and Recommended Practices" (SARPS). The national regulatory authority of the state of registration of an airline may add its own requirements, over and above those required by ICAO Standards, because of national influences or needs.

Jagoda and Pietrzak, when describing the regulatory framework for civil aircraft operations, write, "The first aid kits are not regulated…….".[33] As mentioned, this is incorrect. At the international level, "adequate medical supplies" are required to be carried on board according to ICAO Standards but their *contents* are determined by each individual State, e.g., USA, China, France, etc. Contents can, therefore, differ between airlines regulated by different States.

Lateef et al. write, "Further there are no 'Good Samaritan' laws protecting a doctor-passenger who provides medical assistance on board an aircraft."[41] Many States, including the USA, had a Good Samaritan law in force when this paper was written (2003).[74] The authors contradict themselves later on, recognizing the U.S. Aviation Medical Assistance Act. However, they quote the wrong date: the Act was written in 1998, not 1988.

Sand et al. state, "However, in Europe, the regulations regarding equipment and medication are loosely formulated….."[61] This is incorrect and seems to have occurred because the authors used as their reference an undated generic reference of the Joint Aviation Requirements – Operations, Part 1 (JAR-OPS1). Had the authors referenced the specific Acceptable Means of Compliance (AMC) for the relevant parts of the JAR-OPS (1.745 and 1.755) applicable at the time, they would have found a list of medications and equipment for both first aid and medical kits that were mandatory for airlines; they could add medications and equipment but could not remove any (unless first agreed by the Joint Aviation Authorities).

In a later paper, Sand et al. write, referring to emergency medical kits on board aircraft, "Unfortunately, the data for all airlines in the present study showed that ICAO Standards were not fulfilled."[62] Here the authors confuse ICAO *Standards* with ICAO *Recommended Practices*. It is not a Standard to carry a medical kit, but a Recommended Practice.[30] As described above, Recommended Practices are not mandatory – they are "desirable," unlike Standards. The relevant ICAO *Standard* is "An aeroplane shall be equipped with: accessible and adequate medical supplies."[30] ICAO *recommends* what should comprise the on board medical supplies, but such recommendations are not mandatory. National regulatory authorities, not ICAO, have the legal authority to specify the *contents* of on board medical supplies.

Silverman and Gendreau write, "Ground radiation exposure should be restricted to 1 mSv per year in the population, but air-travel-related cosmic-radiation exposure does not have a specific limit,"[67] citing the International Commission on Radiological Protection (ICRP) 2007.[32] The ICRP states, on page 83, "Public exposure encompasses all exposures of the public other than occupational exposures and medical exposures of patients,"[32] indicating that air travel related exposure is indeed included when assessing radiation exposure to the public. On page 98, ICRP (2007) states, "For public exposure in planned exposure situations, the Commission continues to recommend that the limit should be expressed as an effective dose of 1 mSv in a year."[32] Flying is clearly a "planned exposure."

Touze et al. state, "…défibrillateurs externes semi-automatiques qui sont depuis 2002 obligatoires sur tous les vols de la compagnie Air France" ("…semi-automatic external defibrillators that are now mandatory since 2002 on all Air France flights").[72] While Air France elected to carry automatic external defibrillators (AEDs) on its aircraft in 2002, there was no national legal requirement mandating this at that time and AEDs are still not mandated in Europe.[19]

Kesapli et al. state, "The administration manual in case of an urgent medical situation during flights and the content of medical kits and first aid kits are currently determined by the International Air Transport Association and Space Medicine Association,"[36] citing the International Air Transport Association (IATA) Medical Manual[29] and the Journal of the Aerospace Medical Association (AsMA).[2] This is incorrect in several ways. Firstly, the content of medical kits and first aid kits are not determined by IATA or AsMA. Those two associations only make recommendations; the content is formally recommended to States by ICAO but is legally determined and regulated by national authorities. In addition, AsMA is the "Aerospace Medical Association" and not the "Space Medicine Association", which is a different entity and has no involvement in determining medical supplies to be carried on board commercial aircraft. In addition, Kesapli cites an out-of-date edition of the IATA Medical Manual.

Hinkelbein et al. state, "Furthermore, the Federal Aviation Administration require all airlines flying into the United States to carry Automated External Defibrillators,"[26] quoting Mahony et al.[44] However, Mahony had misinterpreted the reference as this regulation, included in Title 14 of the Code of Federal Regulations,[75] only applies to U.S. registered aircraft and not all airlines flying into the United States. Making a similar error, Wong[77] states, "Moreover, all European airplanes flying to the US are legally obliged to carry AEDs," citing the Aviation Medical Assistance Act.[74] Again, the correct reference is the Code of Federal Regulations[75] which applies only to U.S. registered aircraft.

Hammadah et al. state "Since 2004, all passenger-carrying aircraft of $>$7500 pounds maximum payload capacity have been mandated to have $\geq$1 flight attendant trained in advanced cardiac life support…..according to Federal Aviation Administration (FAA) regulations".[23] This is incorrect; to our knowledge no country, including the United States, mandates training in advanced cardiac life support for cabin crew (flight attendants). Instead of referencing the FAA regulations, which would have likely avoided this mistake, the authors cited Gendreau et al.[21] and Rodenberg.[58] Neither paper mentions such a mandate. Furthermore, the Rodenberg paper was written in 1987, a long

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time before the mentioned 2004 FAA regulations were published so it is difficult to understand why Rodenberg's paper would be included by Hammadah et al. (in 2017) as a reference to the 2004 FAA regulations.

Medical Events

When comparing data from different sources, it is particularly important to base the comparisons on the same type of data, to ensure a valid comparison. This is not always found to be the case.

One example concerns the difference between "medical events" and "medical emergencies." The meaning of these two items is clearly different, yet they are often used interchangeably. The term "medical events" can cover all events from mild headache to death. The term "medical emergencies" is more specific but is not used consistently and, unfortunately, there is no internationally agreed definition. Accurate international comparisons are, therefore, challenging and are one reason why sometimes medical emergencies are reported as "frequent" and sometimes as "rare."

Rodenberg states, "It is estimated that 5% of all airline passengers have a chronic illness…,"[58] quoting Beighton and Richards who actually write "In fact, as many as 5 per cent of passengers on routine scheduled services are suffering from some form of disability…,"[5] without offering any reference. It is not known how this figure was derived. Furthermore, Rodenberg[58] refers to a different concept, i.e., chronic illness, as opposed to disability. Then Rosenberg[59] cites Rodenberg[58] for the same problematic statistic, another example of the use of an unsubstantiated figure being perpetuated.

Drummond and Drummond, in "On a wing and a prayer: medical emergencies on board commercial aircraft," state "However, 75% of 'flight-associated' medical emergencies occur while travelers are on the ground, in the hours immediately before or after travel,"[17] citing Cummins and Schubach.[12] However, Cummins and Schubach do not use the term "flight-associated" medical emergencies and Drummond and Drummond provide no explanation.

Gendreau et al. state, "A 1997 study by the Air Transport Association found that ground-based medical assistance resulted in a 70 percent decrease in medical diversions."[21] The data of the reference cited[3] do not support this statement. The lead author of this review was involved in that 1997 study and a realistic comparison of any change in diversion rate after ground-based medical support was introduced was not possible, since the prior diversion rate for the same group was not known.

Crowe[10] cites Cummins et al.[11] but misunderstood the difference between "km flown" (number of kilometres flown by an aircraft) and "passenger km" (number of km flown by an aircraft multiplied by the number of passengers carried). Cummins et al. correctly wrote, when referring to the number of passenger deaths, "…125 per billion passenger-kilometers, and 25.1 per million departures."[11] Crowe, when referring to this, wrote, incorrectly, "…about 125 deaths per billion *km* [emphasis added] flown, or 25.1 deaths per million flights."[10]

Silverman and Gendreau wrote, "Several studies have provided evidence of dehydration or increased lower-limb oedema in healthy people during long simulated flight,"[67] supported by two references.[39,68] While increased lower-limb edema is a well recognized phenomenon, evidence of flight-induced dehydration is disputed. For example, Landgraf et al. state, "All alterations in plasma viscosity, hematocrit, and albumin in this study are within the range of physiological variation."[39] Simons et al., in his letter to the editor, does mention "Because dehydration is a risk factor in long-haul flight…,"[68] but does not provide any reference. However, a 2008 study in which Simons is an author states, "However, in general there is no evidence for the theory that exposure to a low humidity environment (even in the nude) can lead *per se* to dehydration,"[64] citing Nicholson.[47] Finally, a 1992 report of the Royal Air Force Institute of Aviation Medicine[71] concluded that ill effects from exposure to low humidity for 24 h are unlikely, if overall hydration is maintained.

Concerning medical emergencies, Sand et al. state "The majority of passenger transportation airlines, however, are not documenting medical emergencies on board their aircraft,"[63] citing a previous paper.[61] This conclusion is questionable. At that time, membership of the International Air Transport Association (IATA, the trade association for airlines) was approximately 240 airlines representing around 84% of all traffic: to the author's (CT) personal knowledge, most of those airlines, if not all, were documenting medical emergencies, although documentation was not standardized.

Hinkelbein et al. write, "Cardiac causes are the most frequent problems during airline travel,"[25] quoting Qureshi and Porter[55] and Sand et al.[61] After reviewing both papers we could not find any statement to support that affirmation. This illustrates a challenge of classification, in that if simple syncope is included in a list of "cardiac events" the number of such events is greatly increased. We feel it is advisable to separate incidences of syncope, most of which resolve quickly, without identification of a specific cause, from other cardiac-related diagnoses, which is exactly what Qureshi and Porter, and Sand et al., had done. They did not say that cardiac events were the most frequent problems.

Hinkelbein et al. write, "Concerning cardiac arrest, up to 89% of patients with sudden in-flight cardiac arrest suffer from VF/VT" (ventricular fibrillation/ventricular tachycardia),[25] quoting O'Rourke et al.[49] and Brown et al.[6] Hinkelbein et al. misinterpreted the data in each of these papers. From O'Rourke et al.'s paper, Hinkelbein et al. confused the percentage of VF/VT cardiac arrests reported to have occurred in-flight (22%) and in the terminal building (89%). The data for in-flight VF/VT related cardiac arrest in Brown et al.[6] was 25%.

Dusse et al. state, "MacCallum et al. demonstrated that on flights lasting *less than 4 h*, [our emphasis] the risk of venous thromboembolism (VTE) is approximately two times higher compared to non-traveler subjects…..".[18] In fact, MacCallum wrote "Those who had flown $>$ *4 h* [our emphasis] in a single leg in the previous 4 weeks had twice the risk of VTE (OR 2.20, 95% CI, 1.29–3.73)."[43] So, it is flying more (not less) than 4 h that supports the statistic quoted.

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Hinkelbein et al. state, "….and each year, about 1,000 persons die aboard IATA carriers,"[27] citing Charles[9] and Truhlar et al.[73] Charles does not refer to IATA in his paper. While Truhlar et al. do, citing O'Rourke[49] and Brown,[6] neither provided an IATA reference.

Kodama et al. state, "The most common causes of diversion included syncope/presyncope (25%), cardiac symptoms (19%), seizures (9%), respiratory symptoms (9%), and possible stroke (4%),"[37] citing Peterson et al.[52] Surprisingly, the data retrieved from the Peterson et al. paper show that the most common causes of diversion were in fact very different, i.e., cardiac arrest (57.9%), cardiac symptoms (18.4%), obstetric or gynecological symptoms (18%), possible stroke (16%), and seizures (12%).

In-flight Deaths

Shesser[66] writes that the reported sudden death incidence for Qantas is about 20 times that which would be expected for the general middle-aged population (45 to 54 yr). This might be true but since the age range of Qantas passengers is not provided such a comparison is not useful.

In two different papers,[53,54] in 2004, Possick and Barry, citing DeJohn et al.,[14] state that there were 15 deaths among 1.4 million passengers carried, giving a fatality rate of 10.7 per million passengers, whereas DeJohn states that the fatality rate was 0.107 (although there was a discrepancy in the DeJohn paper in the figures used to calculate this rate). In response to a note to the editor, Possick and Barry responded that they had noticed the discrepancy in the DeJohn paper but did not contact him (DeJohn C. 2020. Personal communication). This is a good example of an author without specialist knowledge publishing a fatality rate, 10.7 per million passengers, that is clearly far greater than that experienced in practice (by a factor of 100). Involvement of an aeromedical practitioner in the writing of the paper or in its peer review would probably have prevented the error getting into print.

Kesapli et al. write, "The most frequent decisions resulting in emergency landing were *death* [our emphasis], epilepsy, and dyspnea, which is in accordance with the literature,"[36] citing Baltsezak.[4] However, death is not mentioned as a cause of diversion by Baltsezak.

Rodenberg states, "During the past 40 years there has been an average of 21 deaths in-flight per year"[58] citing the Federal Aviation Administration (FAA).[76] However, Rodenberg took an FAA estimate and wrote as if it were factual. Delaune et al. state, in reference to the DeJohn et al. report[14] "The DeJohn report indicated 15 fatalities or 0.01 per million passengers."[15] In fact, the DeJohn report states that the ratio was 0.107 fatalities per million enplanements, as mentioned above.

Rodenberg[58] uses a reference of an M.D. thesis without a title,[56] a reference which is very difficult to find. It is not known if the thesis was accepted by the supervising university. It is surprising that a peer reviewed journal accepted such a reference. Rodenberg cites another reference,[45] and states "Interestingly, of the 90 deaths reported by BOAC, only 11 (12%) were considered to be beyond prevention while aloft".[58] The reference[45] was misread by Rodenberg, who did not go to the source reference,[13] which states that the number 11 actually applies to the series of 25 deaths reported by Qantas (not BOAC) and the ratio of deaths beyond prevention is stated as 44% (not 12%). The Flight Safety Foundation[20] repeats the same mistake as Rodenberg.

Rosenberg suggested that, "Expanding the definition of 'in-flight death' to include those that occur in the terminal, en route to the hospital, and during the hospital stay may be a more adequate representation of the in-flight mortality rate."[59] That would be inappropriate unless one postulates that all those deaths are due to the flight, a highly questionable assumption for deaths that occur in the terminal before a flight.

Automated External Defibrillators

As mentioned above, the regulations concerning whether AEDs are required to be carried are complex and may not be well understood. In addition, reported efficacy when used in flight is not always accurate. Some misunderstandings in the literature are highlighted below.

Kesapli et al. citing Brown et al.[6] state, "…adding an AED to the medical kit might be turned into a necessity rather than a proposal for the aircraft as 89% of sudden death in aircraft, estimated to be about 84% in our study, has been noted to be due to VF/VT…".[36] In fact, Brown et al. report a figure of 25% VF/VT as the presenting rhythms among their cardiac arrest population. The Kesapli et al. statement that VF/VT is estimated to occur in about 84% of cases of on-board cardiac arrest in their study is not supported by the data presented as an AED was used only five times, with 13 deaths. The AED is the only equipment carried on board capable of indicating the heart's electrical rhythm, so a maximum of 38% (5/13) of the cases may have been shown to be in VF/VT. However, it is not reported in the paper how many cases of VT/VF were found, or in the five cases where an AED was used, if a shock was given. According to the authors, a possible reason for such little use of AEDs in the case of sudden death may be the intervention of medical professionals for these critically ill patients and their lack of awareness of the presence of an AED on the aircraft. However, it is difficult to understand why an airline would carry AEDs on their aircraft and not offer it to health professionals who volunteer to help.

Groeneveld et al.[22] discuss the cost-effectiveness of AEDs on large capacity passenger aircraft, but base their conclusions on just one study, in American Airlines, by Page et al. in 2000.[51] Page et al. state that four patients who received shocks were in the terminal and 11 were on the aircraft. However, what is not mentioned is that for 10 of those 11 patients the aircraft was on the ground, at the gate (Personal communication with the airline's medical director and coauthor on Page et al.[51]).

Page et al. also state, "The experience of American Airlines refutes a possible conclusion from the data on Qantas that cardiac arrest aboard aircraft, as compared with that occurring on the ground, is more likely to be due to bradycardia."[51] The Qantas study referred to[49] reported use of defibrillators in 46 cardiac arrests, 27 of which were on the aircraft in-flight. Of the 27, 21 presented with asystole or pulseless idioventricular rhythm. Since the American Airlines study included only one death

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when the aircraft was actually in flight it cannot be used to refute a possible conclusion from the data of Qantas because there is insufficient in-flight data in the former.

Groeneveld et al.[22] compared the data from Page et al. (which involved outcomes primarily, 14 out of 15, from events that occurred on the ground) with that of O'Rourke et al.[49] (which involved outcomes of more than half, 27 out of 46, from on board events) and not surprisingly found a difference: survival to hospital discharge is much improved when the event occurs on the ground when compared to an in-flight event. This is a good example of data from very different situations (on the ground vs. inflight) being compared as if the environments were similar. These two papers (Page et al.[51] and Groeneveld et al.[22]) have been referenced in good faith by many authors.

Finally, Drummond and Drummond, citing Smith et al.,[69] state, "Lufthansa started its AED program only after being found liable for not providing adequate care for a passenger who had a cardiac arrest."[17] However, what Smith stated (without a reference) is, "In addition, a federal judge found Lufthansa Airlines negligent for failing to provide timely treatment for a patient suffering a cardiac arrest."[69] We believe Smith was referring to Krys v. Lufthansa German Airlines,[38] which was not related to use of an AED after a cardiac arrest but rather to failure to divert the aircraft.

DISCUSSION AND RECOMMENDATIONS

The incorrect use, misinterpretation, and misquote of references prompted the writing of this paper. As the literature review progressed, it became clear that many such misinterpretations and misquotes resulted from authors being unfamiliar with the subject of aviation medicine and/or the commercial aviation environment. This is perhaps not surprising since aviation medicine remains a specialization rarely covered during medical school or mainstream medical and surgical postgraduate specialty training. To address this, letters have been sent from the Aerospace Medical Association (AsMA) to a number of medical colleges encouraging the inclusion of basic aviation medicine training in medical curricula, but with little apparent effect. We are convinced that the inclusion of, for example, principles of cabin pressurization, oxygen and humidity levels, and recirculation and filtration, would help reduce the number of errors made by some authors in these topics. Such knowledge would also assist practitioners when making "fit to fly" recommendations to their patients. The President of the Aerospace Medical Association wrote (April 2020) "Most clinicians remain woefully underprepared to advise or even discuss these potential impacts with their traveling patients."[50]

If a practitioner from another field is interested in publishing on the subject, we recommend he seek an associate trained in aviation medicine and knowledgeable of the commercial aviation environment. The following are examples of sources that may be contacted for assistance: AsMA, the International Academy of Aviation and Space Medicine, national civil aviation authorities, or national associations of civil aviation medical examiners. Alternatively, these resources may be able to suggest a suitable peer reviewer who can help provide insight to the authors during the peer review process.

This review revealed that authors may cite secondary references rather than the original source (sometimes when the original paper was readily available). In such cases, the citation often omitted to indicate that a secondary source was being cited. The practice of secondary referencing is not specific to aviation medicine; however, if authors are not familiar with the subject matter (often the case, as already mentioned) the risk of misinterpretation or misquote is increased. Even when the original source is used, it could be incorrectly quoted or interpreted in a paper and the nonoriginal (including incorrect information) paper may then be repeatedly referenced in subsequent papers. Where possible, the original source should be reviewed and referenced to reduce the likelihood of the repetition of such errors. When the original source cannot be accessed, it should be indicated in the citation that the reference is not the primary source. This would facilitate the peer review process.

However, sometimes obtaining original references can be challenging, which may explain why questionable assumptions have been made, based on secondary references. Difficulties in obtaining original references is often greater for authors lacking experience in aviation medicine, e.g., documents published by governments or international organizations may not be revealed by a standard literature search, and contacting one of the abovementioned resources may help avoid such problems.

The consistent use of terminology across different countries and medical disciplines is an ongoing challenge. However, without such consistency, it is difficult to make valid comparisons between studies and it increases the risk of confusion. We would like to highlight one such inconsistency, use of the terms "medical events" and "medical emergencies" which have clearly different meanings, but which have been used interchangeably. This is one reason why some papers will state that the rate of medical emergencies is increasing whereas others state it is not. Our recommendation is that if an author wishes to address medical emergencies in particular, the reason why the incidents under study are categorized as "emergencies" should be clearly described.

Other terms that are frequently used inconsistently concern descriptors for personnel working in the aircraft. We suggest the following terms: "cabin crew" for personnel working in the cabin, "flight crew" for personnel working in the cockpit, and "aircrew" when referring to a combination of flight crew and cabin crew, can be used. These terms are based on International Civil Aviation Organization definitions and if other terminology is felt to be necessary, it should be described sufficiently so that the meaning is clear.

Finally, the peer review process should verify that information published as factual is indeed regarded as the mainstream view and can be supported by appropriate references. This review revealed in several papers that arguments or ideas presented as possibilities in one paper were presented as factual in a subsequent paper and then formed the basis of questionable conclusions, an outcome that was evidently not identified as a flaw by the peer review process.

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REFERENCES

1. Aerospace Medical Association. Medical criteria for the flying passenger. Aerosp Med. 1961; 32:124–137.
2. Aerospace Medical Association Medical Guidelines Task Force. Medical guidelines for airline travel, 2nd edition. Aviat Space Environ Med. 2003; 74(5, Suppl.):A1–A19.
3. Air Transport Association medical kit survey. Washington (D.C.): Air Transport Association; 1997.
4. Baltsezak S. Clinic in the air? A retrospective study of medical emergency calls from a major international airline. J Travel Med. 2008; 15(6):391–394.
5. Beighton PH, Richards PR. Cardiovascular disease in air travellers. Br Heart J. 1968; 30(3):367–372.
6. Brown AM, Rittenberger JC, Ammon CM, Harrington S, Guyette FX. In-flight automated external defibrillator use and consultation patterns. Prehosp Emerg Care. 2010; 14(2):235–239.
7. Bui SBD, Petersen T, Poulsen JN, Gazerani P. Headaches attributed to airplane travel: a Danish survey. J Headache Pain. 2016; 17(1):33.
8. Centers for Disease Control and Prevention. International notes-smallpox-Stockholm.MMWR Morb Mortal Wkly Rep 1963; 12:20. [Accessed Aug. 2020]. Available from https://www.cdc.gov/mmwr/preview/mmwrhtml/lmrk033.htm.
9. Charles RA. Cardiac arrest in the skies. Singapore Med J. 2011; 52(8):582–585.
10. Crowe AR. Case report: stroke following an airline flight. Can Fam Physician. 2004; 50:76–77.
11. Cummins RO, Chapman PJC, Chamberlain DA, Schubach JA, Lirwin PE. In-flight deaths during commercial air travel. JAMA. 1988; 259(13):1983–1988.
12. Cummins RO, Schubach JA. Frequency and types of medical emergencies among commercial air travelers. JAMA. 1989; 261(9):1295–1299.
13. Davies GRW, Degotardi PR. Inflight medical facilities. Aviat Space Environ Med. 1982; 53(7):694–700.
14. DeJohn CA, Véronneau SJH, Wolbrink AM, Larcher JG. The evaluation of in-flight medical care aboard selected U.S. air carriers: 1996 to 1997. Washington (DC): U.S. Department of Transportation, Federal Aviation Administration, Office of Aviation Medicine; May 2000. Technical report no. DOT/FAA/AM-0013.
15. Delaune EF, Lucas RH, Illig P. In-flight medical events and aircraft diversions: one airline's experience. Aviat Space Environ Med. 2003; 74:62–68.
16. Donner HJ. Is there a doctor on board? Medical emergencies at 40,000 feet. Emerg Med Clin North Am. 2017; 35(2):443–463.
17. Drummond R, Drummond AJ. On a wing and a prayer: medical emergencies on board commercial aircraft. CJEM. 2002; 4(04):276–280.
18. Dusse LMS, Silva MVF, Freitas L, Marcolino MS, Carvalho MdG. Economy class syndrome: what is it and who are the individuals at risk? Rev Bras Hematol Hemoter. 2017; 39(4):349–353.
19. European Aviation Safety Agency (EASA) Safety Information Bulletin EASA SIB No. 2018-03. Carriage and use of Automatic External Defibrillators. [Accessed July 2020.] Available from: https://ad.easa.europa.eu/ad/2018-03.
20. Flight Safety Foundation. In-flight death of a passenger requires a thoughtful response from flight attendants. Cabin Crew Safety. 1999; Vol.33, No.4.
21. Gendreau MA, DeJohn C. Responding to medical events during commercial airline flights. N Engl J Med. 2002; 346(14):1067–1073.
22. Groeneveld PW, Kwong J, Liu Y, Rodriguez AJ, Jones MP, et al. Cost-effectiveness of automated external defibrillators on airplanes. JAMA. 2001; 286(12):1482–1489.
23. Hammadah M, Kindya BR, Allard-Ratick MP, Jazbeh S, Eapen D, Wilson Tang WH, Sperling L. Navigating air travel and cardiovascular concerns: is the sky the limit. Clin Cardiol. 2017; 40(9):660–666.
24. Hertzberg VS, Weiss H. On the 2-row rule for infectious disease transmission on aircraft. Ann Glob Health. 2016; 82(5):819–823.
25. Hinkelbein J, Spelten O, Wetsch WA, Schier R, Neuhaus C. Emergencies in the sky: In-flight medical emergencies during commercial air transport. Trends in Anaesthesia and Critical Care. 2013; 3(4):179–182.
26. Hinkelbein J, Böhm L, Braunecker S, Genwurker HV, Kalina S, et al. In-flight cardiopulmonary resuscitation during commercial air transport: consensus statement and supplementary guideline from the German Society of Aerospace Medicine (DGLRM). 182/001 – S2e-Leitlinie. Aktueller Stand: 08/2016. [Accessed 22 Jan. 2021]. Available from: https://www.awmf.org/uploads/tx_szleitlinien/182-001l_S2e_In-flight-cardiopulmonary-resuscitation_2016-08.pdf.
27. Hinkelbein J, Böhm L, Braunecker S, Genwurker HV, Kalina S, et al. In-flight cardiac arrest and in-flight cardiopulmonary resuscitation during commercial air travel: consensus statement and supplementary treatment guideline from the German Society of Aerospace Medicine (DGLRM). Intern Emerg Med. 2018; 13(8):1305–1322.
28. Hunt EH, Reid DH, Space DR, Tilton FE. Commercial airliner environmental control system engineering aspects of cabin air quality. [Abstract.] Presented at the Aerospace Medical Association 66th Annual Scientific Meeting, Anaheim, CA, May 7–11, 1995. [Accessed Aug. 2020]. Available from http://www.smartcockpit.com/docs/Engineering_Aspects_of_Cabin_Air_Quality.pdf.
29. International Air Transport Association. International Air Transport Association Medical Manual, 1st ed. Montreal (QC): International Air Transport Association; 2004.
30. International Civil Aviation Organization, Annex 6 – Operation of Aircraft – Part I – International Commercial Air Transport - Aeroplanes, 11th ed. Montreal (Canada): ICAO; July 2018.
31. International Civil Aviation Organization. Convention on International Civil Aviation, Doc 7300/9, ninth ed. Montreal (Canada): ICAO; 2006.
32. International Commission on Radiological Protection. The 2007 Recommendations of the International Commission on Radiological Protection. Ann ICRP. 2007; 37:1–332.
33. Jagoda A, Pietrzak M. Medical emergencies in commercial air travel. Emerg Med Clin North Am. 1997; 15(1):251–260.
34. Jassar P, Homer JJ, Ram B, Murray D. Does flying after myringoplasty affect graft take rates? Clin Otolaryngol. 2002; 27(1):48–49.
35. Kenyon TA, Valway SE, Ihle WW, Onorato IM, Castro KG. Transmission of multidrug-resistant Mycobacterium tuberculosis during a long airplane flight. N Engl J Med. 1996; 334(15):933–938.
36. Kesapli M, Akyol C, Gungor F, Akyol AJ, Guven DS, Kaya G. Inflight emergencies during Eurasian flights. J Travel Med. 2015; 22(6):361–367.
37. Kodama D, Yanagawa B, Chung J, Fryatt K, Ackery AD. Is there a doctor on board?: Practical recommendations for managing in-flight medical emergencies. CMAJ. 2018; 190(8):E217–E222.
38. Krys v. Lufthansa German Airlines. [Accessed Aug. 2020]. Available from: https://caselaw.findlaw.com/us-11th-circuit/1005408.html.
39. Landgraf H, Vanselow B, Schulte-Huermann D, Mulmann MV, Bergau L. Economy class syndrome: rheology, fluid balance, and lower leg edema during a simulated 12-hour long distance flight. Aviat Space Environ Med. 1994; 65(10, Pt 1):930–935.
40. Lapostolle F, Corège D, Sordelet D, Grave M, Lapandry C, et al. Y a-t-il un médecin dans l'avion? (Is there a doctor on board?). Presse Med. 2010; 39(6):626–631.
41. Lateef F, Tay CSK, Nimbkar N. Is there a doctor on-board? Medical liability during in-flight emergencies. Hong Kong J Emerg Med. 2003; 10(3):191–196.
42. Love JT, Caruso VG. Civilian air travel and the otolaryngologist. Laryngoscope. 1978; 88(11):1732–1742.

http://prime-pdf-watermark.prime-prod.pubfactory.com/ | 2025-02-10

43. MacCallum PK, Ashby D, Hennessy EM, Letley L, Martin J, et al. Cumulative flying time and risk of venous thromboembolism. Br J Haematol. 2011; 155(5):613–619.
44. Mahony PH, Griffiths R, Larsen P, Powell D. Retention of knowledge and skills in first aid and resuscitation by airline cabin crew. Resuscitation. 2008; 76(3):413–418.
45. Mills FJ, Harding RM. Medical emergencies in the air. I: Incidence and legal aspects. Br Med J (Clin Res Ed). 1983; 286(6371):1131–1132.
46. Naouri D, Lapostolle F, Rondet C, Ganansia O, Pateron D, Yordanov Y. Prevention of medical events during air travel: a narrative review. Am J Med. 2016; 129(9):1000.e1–1000.e6.
47. Nicholson A. Dehydration and long haul flights? Travel Medicine Int. 1998; 16:177–181.
48. Olsen SJ, Chang HL, Cheung TYY, Tang AFY, Fisk TL, et al. Transmission of the severe acute respiratory syndrome on aircraft. N Engl J Med. 2003; 349(25):2416–2422.
49. O'Rourke MF, Donaldson E, Geddes JS. An airline cardiac arrest program. Circulation. 1997; 96(9):2849–2853.
50. Ortega HJ, Jr. Aeromedical Transport – A Niche for Aerospace Medicine. Aerosp Med Hum Perform. 2020; 91(4):311–312.
51. Page RL, Joglar JA, Kowal RC, Zagrodzky JD, Nelson LL, et al. Use of automated external defibrillators by a U.S. airline. N Engl J Med. 2000; 343(17):1210–1216.
52. Peterson DC, Martin-Gill C, Guyette FX, Tobias AZ, McCarthy CE, et al. Outcomes of medical emergencies on commercial airline flights. N Engl J Med. 2013; 368(22):2075–2083.
53. Possick SE, Barry M. Evaluation and management of the cardiovascular patient embarking on air travel. Ann Intern Med. 2004; 141(2):148–154.
54. Possick SE, Barry M. Air travel and cardiovascular disease. J Travel Med. 2004; 11(4):243–248.
55. Qureshi A, Porter KM. Emergencies in the air. Emerg Med J. 2005; 22(9):658–659.
56. Richards PR. M.D. thesis. London (UK): University of London, 1970.
57. Ritzinger FR. Disease transmission by aircraft. Aeromed Rev. 1965; 2(May):1–10; Milit Med. 1965; 130(7):643–647.
58. Rodenberg H. Medical Emergencies Aboard Commercial Aircraft. Ann Emerg Med. 1987; 16(12):1373–1377.
59. Rosenberg CA, Pak F. Emergencies in the air: problems, management, and prevention. J Emerg Med. 1997; 15(2):159–164.
60. Ruskin KJ, Hernandez KA, Barash PG. Management of in-flight medical emergencies. Anesthesiology. 2008; 108(4):749–755.
61. Sand M, Bechara FG, Sand D, Mann B. Surgical and medical emergencies on board European aircraft: a retrospective study of 10189 cases. Crit Care. 2009; 13(1):R3.
62. Sand M, Gambichler T, Sand D, Thrandorf C, Altmeyer P, Bechara FG. Emergency medical kit on board commercial aircraft: a comparative study. Travel Med Infect Dis. 2010; 8(6):388–394.
63. Sand M, Morrosch S, Sand D, Altmeyer P, Bechara FG. Medical emergencies on board commercial airlines: is documentation as expected? Crit Care. 2012; 16(2):R42.
64. Schreijer AJM, Cannegieter SC, Caramella M, Meijers JCM, Krediet RT, Simons RM, Rosendaal FR. Fluid loss does not explain coagulation activation during air travel. Thromb Haemost. 2008; 99(06):1053–1059.
65. Select Committee on Science and Technology. Air travel and health: fifth report. London: United Kingdom House of Lords, November 15, 2000. [Accessed July 2020]. Available from: http://www.publications.parliament.uk/pa/ld199900/ldselect/ldsctech/121/12101.htm.
66. Shesser R. Medical aspects of commercial air travel. Am J Emerg Med. 1989; 7(2):216–226.
67. Silverman D, Gendreau MA. Medical issues associated with commercial flights. Lancet. 2009; 373(9680):2067–2077.
68. Simons R, Krol J. Jet leg, pulmonary embolism, and hypoxia. Lancet. 1996; 348(9024):416.
69. Smith SC, Hamburg RS. Automated external defibrillators: time for federal and state advocacy and broader utilization. Circulation. 1998; 97(13):1321–1324.
70. Stepanek J, Webb JT. Physiology of Decompressive Stress. In: Davis JR, Johnson R, Stepanek J, Fogarty JA, editors. Fundamentals of aerospace medicine, 4th ed. Baltimore (MD): Lippincott, Williams & Wilkins; 2008:46–82.
71. Stroud MA, Belyavin AV, Farmer AW, et al. Physiological and psychological effects of 24-hour exposure to a low humidity environment. Farnborough (UK): Royal Air Force Institute of Aviation Medicine; May 1992. IAM report no 705.
72. Touze JE, Métais P, Zawieja P. Maladie cardiovasculaire et voyage aérien: particularités et enjeux. (Cardiovascular disease and aircraft transportation: specificities and issues). Presse Med. 2012; 41(2):109–115.
73. Truhlar A, Deakin CD, Soar J, et al. European Resuscitation Council Guidelines for Resuscitation 2015: section 4. Cardiac arrest in special circumstances. Resuscitation. 2015; 95:148–201.
74. U.S. Aviation Medical Assistance Act of 1998. [Accessed July 2020]. Available from: https://www.govinfo.gov/content/pkg/PLAW-105publ170/html/PLAW-105publ170.htm.
75. U.S. Code of Federal Regulations. (14 CFR) part 121, subpart X; part 121, appendix A. [Accessed July 2020]. Available from: https://www.govinfo.gov/app/details/CFR-2011-title14-vol3/CFR-2011-title14-vol3-part121-appA.
76. U.S. Department of Transportation, Federal Aviation Administration. Emergency medical equipment requirement. Fed Regist. 1986; 51:1218–1223.
77. Wong M. Doctor in the sky: medico-legal issues during in-flight emergencies. Med Law Int. 2017; 17(1-2):65–98.

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