Is there a Neurologist on this Flight?

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Abstract

Objective: To analyze the frequency of neurologic events during commercial airline flights and to assess whether on-board emergency medical kits are adequate for in-flight neurologic emergencies.

Methods: Mayo Clinic's Departments of Emergency Medicine, Medical Transportation Service and Division of Aerospace Medicine collaborate to provide real time in-flight consultation to a major US airline that flies approximately 10% of all US passengers. We analyzed a database that catalogs the air-to-ground medical consultations, for all medical events reported from 1995-2000. All cases with potential neurologic symptoms were reviewed and classified into various neurologic symptom categories. The cost of diversion for each neurologic symptom was calculated and then extrapolated to assess the cost of neurologic symptoms to the US airline industry.

Results: 2042 medical incidents led to 312 diversions. Neurologic symptoms were the single largest category of medical incidents, prompting 626 calls (31%). They caused 34% of all diversions. Dizziness/vertigo was the most common neurologic symptom followed by seizures, headaches and cerebrovascular symptoms. Whereas seizures and dizziness/vertigo were the most common reasons for diversion, loss of consciousness/syncope was the complaint most likely to lead to a diversion. The estimated annual cost of diversions due to neurologic events is almost $9,000,000.

Conclusions: Neurologic symptoms are the most common medical complaint requiring air-to-ground medical support and are second only to cardiovascular problems for emergency diversions and their resultant costs to the U.S. airline industry. Adding antiepileptic drugs (AEDs) to the onboard medical kit, and greater emergency medical training for inflight personnel could potentially reduce the number of diversions for inflight neurologic incidents.

The commercial airline industry transported approximately 600 million US passengers in the year 2000. As the number of air travelers has steadily risen over the past 5 years[1] and as the population rapidly ages, it follows that the number of older passengers as well as passengers with chronic or serious medical problems will also increase. Heightened attention to in-flight medical problems recently resulted in the introduction of automated external defibrillators on US commercial jets[2-5], underscored concerns of pulmonary embolism from prolonged flights, [5-10] and highlighted an increased occurrence of behavioral outbursts, or "air rage". To date, the incidence of various in-flight neurologic symptoms has not been systematically assessed, as US airlines do not uniformly report medical emergencies or emergency medical landings[2, 11-13].

When a medical emergency occurs on an aircraft, the pilot in command has the final authority of how to best deal with the emergency, taking into the account not only the medical problem of the passenger, but also the safety and well-being of all the passengers and flight crew in their charge. In such situations, the flight crew typically asks passengers with medical training to volunteer aide in patient care. . Every aircraft has a medical kit for use by physicians, with minimum contents mandated by the Federal Aviation Administration (FAA) [2]. Most US carriers have arranged for consultation from ground-based medical providers with in-flight medical experience to assist and supervise the flight crew, passenger volunteers, and nonphysicians in using the emergency medical kit. The medical support occurs verbally by radio or air phone. The medical provider may speak to the pilot, cabin crew, medical volunteers or stricken passengers to suggest

and guide use of the on board medical kit or to help decide if a plane needs to make an unscheduled emergency landing (i.e. diversion). Such medical ground consultations are initiated at the discretion of the pilot in command.

The Departments of Emergency Medicine, Medical Transportation Service and Division of Aerospace Medicine at Mayo Clinic collaborate to provide real time in-flight consultations to a major US airline. The clientele of this airline is representative of the US flying public, constituting almost 10 % of all US passengers. In this study, we reviewed the Mayo-airline collaborative experience so as to assess the adequacy of care for in-flight neurologic incidents. We sought to determine whether current emergency medical equipment and medications aboard commercial airliners are appropriate for neurologic incidents, and in particular, whether an antiepileptic drug should be added to onboard emergency medical kits. To this end, we examined the frequency of, reasons for, and cost of urgent unscheduled landings for neurologic symptoms. Frequency of emergency diversions is an important outcome measure because they are the direct result of either a serious medical problem requiring immediate hospitalization or an inability to properly assess or effectively treat an on-board patient.

Methods

All emergency calls from one carrier were logged into the Mayo in-flight Advisory Report (MIFAR) database which records in-flight symptoms, age of the patient, flight number, aircraft position, recommendation regarding use of the medical kit and

whether or not an emergency landing was needed. All reports are then categorized into one of several symptom groups defined by the MIFAR authors **(Table 1)**. No uniformly defined categories are used by all airlines**.** The MIFAR database contains a record of all in-flight events from 1995-2000.

All potential neurologic events were culled from all reports independently and subcategorized by 2 neurologists (JS, DW) into various neurologic symptoms **(Table 2).**

Annual incidence rates per year for neurologic symptoms as a group were calculated and neurologic symptoms were separately tabulated based on the average yearly number of flights and US passengers flown by that carrier over the 6 year time period.

The incidence of diversion and likelihood of an emergency landing was documented for each symptom. The likelihood of diversion was defined as the number of diversions of each respective symptom divided by the frequency of the symptom. The estimated cost of a diversion may range from $15,000 to as high as $893, 000[14] on some international routes depending on length of delay, the airport that the plane is diverted to, and whether or not fuel has to be dumped in order to maintain a safe landing weight. As the airline industry does not publish estimates regarding the average cost of a single diversion, relevant calculations were made based upon a conservative estimate of minimum $50,000 per diversion. This estimate was consensually determined by the medical directors of this US carrier (DZ) and those of 5 international airlines for the purpose of establishing the magnitude of aggregated costs. For purposes of this analysis, it was also assumed that the cost of a diversion did not vary between medical conditions. Based on this figure, the minimum expense of neurologic symptoms to the carrier was

calculated and the economic data was extrapolated to estimate costs the US airline industry as a whole. This airline carried 9.74% of all US passengers and flew 12.05% of total miles flown by US airlines from 1995-2000, as determined by the Air Transport Association.[1] Total cost to the US airline industry was determined by extrapolating from these data which represented 10% of US flights and airline passengers.

Results

Of a total of 4,003,809 flights (571,972 flights per year) flown by the carrier from 1995- 2000, there were a total of 2042 separate in-flight incidents requiring medical consultations. **Table 1** shows the breakdown of all medical incidents. Neurologic symptoms comprised the single largest symptom category followed by unknown/undefinable, cardiovascular, gastrointestinal and respiratory incidents. The balance of the calls was from other categories including deaths **(Table 1)**. None of the deaths were neurologic in origin, but rather terminal cancer patients being flown home where they were expected to die.

Of the 2042 medical incidents, 312 (15.2%) resulted in unscheduled emergency landings or diversions. Although neurologic symptoms prompted the most emergency calls, cardiovascular symptoms comprised the single largest category of emergency landings followed by neurologic, respiratory and other medical symptom groups **(Table 1)**.

Overall, neurologic symptoms were the fourth most likely to cause a diversion following cardiovascular, obstetrical, and respiratory.

Table 2 summarizes the data regarding neurologic symptoms. Dizziness and vertigo accounted for the highest number of neurologic complaints followed by seizures, headache, and cerebrovascular symptoms. Seizures and dizziness/vertigo were the most common symptoms resulting in diversion. However, the likelihood of diversion was highest for loss of consciousness/syncope (71%), non-alcohol induced confusion (66%), cerebrovascular symptoms (23.8%) and seizures (23.6%).

Rationale for Diversion

Of the 31 diverted patients for seizures, the following factors contributed to this decision: status epilepticus (5), repetitive seizures with intermittently preserved consciousness (5), prolonged postictal states (7), lacerations/injury (3), febrile convulsions in infants (2) and diversion in-progress at the time of the call despite a single seizure with recovery (9). The only difference between the seizure cases, which were diverted, and those that were not was the absence of repetitive seizures and injury in the nondiverted flights**.**

All diversions for loss of consciousness/syncope were secondary to the crews' concern that a serious medical emergency needed immediate attention. Similarly, all 36 diversions for patients with dizziness/ vertigo were due to a worry that loss of consciousness was imminent. Of the 5 diverted patients with cerebrovascular symptoms, all had progressive worsening of symptoms that led to the decision. Of the 4 passengers diverted for mental status changes, 2 patients had adverse cognitive effects from anti-parkinsonian medications. The distinguishing feature of the sole headache patient that diverted was the complaint of additional neurologic symptoms.

Overall, medical complaints resulted in an aggregated cost of $26 million/ per year to US airlines based on unscheduled emergency landings alone, excluding costs of ground ambulance and hospital care. The overall cost of neurologic symptoms amounted to almost nine million dollars per year.

Discussion

The high incidence of neurologic symptoms found in this review is in agreement with a previous analysis by the FAA's Civil Aeromedical Institute (CAMI)'s report which also found that neurologic emergencies were the most common in-flight medical problem, second only to cardiac events with regards to diversions[11]. This data was based on information from two airlines and two in-flight medical care delivery categories from 1990-1993[11]. Related studies of in-flight medical conditions based on data from medical delivery groups have shown that neurologic emergencies consistently rank in the top 3 most common medical categories for both incidence and rate of unscheduled medical emergencies[11-12]. However, differences in data collection methods and classification schemes make meaningful comparisons between studies difficult.

In 1986, the Federal Aviation Administration (FAA) established the " Emergency Medical Equipment Requirements Rule" requiring large, passenger aircraft to carry emergency medical kits[2, 5,11,12,15-18]. At that time, the FAA set a minimum standard for medical kit contents. This rule was updated in 1994 to include protective gloves[2, 5,11,12], revised again in 1995 to extend requirements to commuter planes[2, 5,11,12], and was most recently amended in 1998 to include automated external defibrillators[2, 5,11,12].

Table 3 summarizes current requirements of the FAA [2,5,11,12], European Aviation Authority guidelines[15, 18] and examples of 3 large international carrier's medical kits[15, 18]. Based on the results of this study, consideration of to including antiepileptic drugs (AED) is warranted. As depicted in Table 3, the European aviation authority adopted an AED requirement as a standard medical supply with the presence of diazepam. The Australian-based Qantas Airways stocks phenytoin tablets along with diazepam onboard its jets[15, 18]. However, there are challenges in the U.S. associated with selecting the appropriate seizure medication, particularly regarding DEA-scheduled drugs such as benzodiazepines. At the time of the last FAA rule update in 1998, the agency disagreed with a proposal to include an AED because no data was provided to confirm the necessity of this addition[2].

In-flight personnel in the US are trained in emergency medical procedures, operation of medical equipment, use of the emergency medical kit, and use of automated external defibrillators[2]. They are certified in standard cardiopulmonary resuscitation and first aid, as well as each airline's own first aid protocol for various emergencies of which seizures and stroke are included[2], but are not required to meet proficiency standards established for emergency medical personnel. The Association of Flight Attendants reported that members receive first aid instruction that ranges from a minimum of 30 minutes to a few hours[19]. The high percentage of diversions, which carries a high economic impact, mandates that decision-making pertaining to the medical necessity of diversion and adequacy of in-flight treatment should be evaluated given implications of such information as both an important public health issue and as a matter of economic justification.

An obvious question arising from these data is why are neurologic complaints more common than other in-flight complaints? The answer may relate to the unusual nature of the cabin environment, specifically with pressurization, turbulence and hypoxemia. As an example, alveolar oxygen in a plane that is pressurized to a differential of 8.6-11.77 psi (a common pressurization range of commercial jets) flying at 35,000 feet may vary from 59- 76.8 mm Hg[20]. The pressure differential varies slightly between aircraft models, but typically is equivalent to 6-8000 feet above sea level. Thus, it may not be surprising to see a high incidence of dizziness/vertigo, headaches and seizures in this setting[21]. In addition, seizures and other symptoms likely occur from dehydration, sleep deprivation, stress, and heightened effects of alcohol or medications, all of which are commonly associated with air travel[20-21].

The high incidence of diversions due to seizures was not unexpected as their dramatic presentation likely led to an immediate call for attention from passengers and flight crews. Similarly, dizziness and vertigo are also likely to lead to increased attention from airline personnel. The relatively low rate of diversion for cerebrovascular symptoms may indicate a greater need for both flight crews and the public to be made more aware of stroke symptoms and treatment. Because early intervention for cerebrovascular disease may be crucial, the problem of brief, resolved transient ischemic attacks (TIAs) in the airline environment presents a unique challenge in deciding whether to divert. This issue needs to be explored in further detail.

Despite the low occurrence of non-alcohol related mental status changes, cognitive changes were associated with a high likelihood of diversion. This may also indicate a need for additional education and training of flight crews with regards to

scenarios involving confused passengers, particularly since none of these patients were violent. Moreover, the fact that 2 of the 4 diversions were related to antiparkinsonian medications also suggests that patients should be counseled about flying when medication adjustments are being made or when the severity or unpredictability of on-off symptoms are high

This data is unique and provides the first structured assessment of in-flight neurologic symptoms. However, there are several limitations of this study. The physicians responsible for the MIFAR database categorized problems based on limited clinical information and in the absence of follow-up data. However, a previous study comparing in-flight diagnoses to post flight hospital diagnoses found an agreement of 94% for neurologic symptoms utilizing a similar classification scheme[11-12]. Thus, these categorizations are believed to be good indicators of neurologic symptom profiles. Clearly, more empirical findings are needed to verify these results, including specific followup information regarding diagnosis, treatment and outcome. Such studies will be challenging as airlines are not currently required to log medical complaints and any existing data is not readily available to clinical investigators.

The incidence rates found in this review are conservative and likely underestimate actual incidence rates. Minor in-flight medical incidents that do not require air-to-ground medical support are not routinely reported by the flight crews. This study thus represents only those symptoms that led to alerting the ground medical consultant and excludes events dismissed by flight personnel as requiring medical intervention. The economic impact reflected in these data is conservative; the “true” impact is likely higher. Although the data presented here is limited to the experience of a single US airline, 50 million

passengers fly this airline yearly and the issues and implications of these findings extend to the industry in general. It is recognized that airlines may manage emergency neurologic conditions differently resulting in higher or lower diversion rates. An ideal future study might further examine the impact of diversions on symptom outcome, though the logistics of systematically examining such issues will be challenging.

How should neurologists, emergency medicine, and primary care physicians counsel patients with neurologic illnesses about flying? Several general suggestions can be made. Patients with chronic neurologic conditions should avoid alcoholic beverages. Medication compliance is essential. Individuals with chronic headache and other pain conditions should carry additional analgesics. Those with epilepsy should have extra doses of AEDs, and medication changes should be carefully scrutinized or postponed until travel is completed so as to avoid potential problems.

Although neurologic complaints occurred more often than other medical symptoms, the likelihood of these serious symptoms occurring in-flight is quite low, affecting only 0.01% of all flights. It is, however, valuable for neurologists, as well as other physicians, to be familiar with emergency medical kit contents stored on commercial airlines, as they may be called upon to manage in-flight emergencies and to provide advice regarding the need for diversion (as two of the authors (JS, RC) of this review experienced). Perhaps the neurology community should consider proposing policy changes to the FAA that would require an AED in the onboard medical kit, establish guidelines for in-flight neurologic emergencies, and address minimum training requirements for flight personnel.

Table 1: MIFAR Symptom Classification of Air to Ground Medical Calls

Category	Incidence total N= 6yrs	Incidence (%)	Total Diversions N = 6 yrs	Total Diversions (%)	Likelihood of diversions (%)
Allergies	71	4	4	1	6
Bleeding	42	2	6	2	14
Cardiovascular	274	13	108	35	39
Death	8	0.0	1	0.0	13
Diabetes	72	4	6	2	8
Gastrointestinal	201	9	21	7	10
Infection	165	8	1	0.0	.1
Neurologic	626	31	107	34	17
Obstetrical	46	2	11	4	24
Respiratory	173	9	30	9	17
Psychiatric/ Intoxication	46	2	2	1	4
Unknown	318	16	15	5	5

N= number

Likelihood of diversions= Total diversion by category/ Total incidence of symptom

Table 2: Incidence of Neurologic Symptoms and Diversions

Categories	Incidence Total N= 6yrs	Incidence of symptom: 1 case every X flights/yr	Incidence/ 10mill pass/yr	Diverted (Total N=6yrs)	% of all diversions	Likelihood of diversion	Total US Cost @ $50,000/divert / yr
Seizures	131	26237	4.19	31	29%	24%	2583333
Dizzy/Vertigo	354	9694	11.3	36	34%	10%	3000000
CVA	21	163420	.67	5	4%	24%	416666
Numbness	6	571972	.19	0	0	0	0
Tremor	2	173324	.06	0	0	0	0
Headache	37	92852	1.18	1	1%	3%	83333
Pain NOS	25	137493	.8	5	6%	20%	416666
Trauma	10	344561	.32	1	1%	10%	83333
Confusion	6	571972	.19	4	3%	66%	333333
LOC/syncope	34	102137	1.08	24	22%	71%	2000000
Total Neuro Cost for diversions							$ 8916664

N= number; CVA= cerebrovascular; LOC= loss of consciousness

Incidence and Diverted total are aggregates over 6 years

Incidence of symptom 1 every X flights: based on 571,972 flights per year

Incidence per 10 million passengers based on an average of 52,022,571 passengers/year from 1995-2000

Total US Cost is an extrapolation of the data assuming that these data represent 10% of the airlines industry/year

Table 3: Comparison of Requirements for Emergency Medical Kit Contents and Sample Airline Kits

FAA Requirements	European Joint Aviation Authority	Air Canada	Japan Airlines	Qantas Airways
Antihistamine tablet 25 mg	Adrenocorticosteroid	Aspirin 350 mg	Aspirin 500 mg	Adrenaline 1:1000
Antihistamine injectable 50 mg	Anti-emetic (metoclopramide)	Ativan 1 mg	Atropine injectable	Anginine 600 ug
Aspirin tablet 325 mg	Antihistamine	Atropine 0.6 mg/1ml	Aminophylline injectable	Aspirin 300 mg
Atropine 0.5 mg, 5cc single ampule	Anti-spasmodic (hyoscine)	Benadryl 50 mg/ml	Berberine 25 mg	Atropine 600ug/ml
Dextrose 50%/50 cc injectable	Aspirin	Bicarbonate 7.5% 50 ml	Chlorpheniramine tablets	Benztropine 2 mg/ml
Epinephrine 1:1000 1 cc injectable	Atropine	Dextrose 5% 250 ml	Chinese herb medicine	Benzylpencillin 3 gm
External Automated Defibrillator	Bronchodilator	Dextrose 50%, 50 ml	Epinephrine	Diazepam 10 mg/2 ml
Epinephrine 1:10,000 2cc injectable	Digoxin	Epinephrine 1 ml 1:1000	Diazepam injectable	Furosemide 50 mg/5 ml
Inhaled bronchodilator	Diuretic (furosemide)	Glucagon 1 mg	Dopamine injectable	Haloperidol 10 mg/ml
Lidocaine 5cc, 20 mg/ml	Epinephrine 1:1000	Gravol 250 mg	Furosemide injectable	Hyoscine 20 mg/ml
Nitroglycerin tablets 0.4 mg	Hypertonic glucose	Haldol 5 mg/1ml	Fradiomycin sulfate gauze	Lignocaine 100 mg/5 ml
Non narcotic analgesic 325 mg	Major Analgesic (nalbuphine)	Inderal 1 mg/ml	Glycerin enema	Loperidol caps
	Nitroglycerin	Instaglucose	Hydrocortisone injectable	Morphine 15 mg/ml
	Sedative/anticonvulsant (diazepam)	Lasix 40 mg/4ml	Isosorbide dinitrate 5 mg	Naloxone 0.4 mg
	Uterine contractant (Ergometrine/oxytocin)	Lidocaine 100 mg/5ml	Lidocaine injectable	Paracetamol supp
		Morphine 15 mg/ml	Methylergometrine injectable	Phenytoin 100 mg
		Nitroglycerin 1/200	Nitroglycerin tablets	Prednisolone 25 mg
		Procainamide 10 ml 100 mg/ml	Nifedipine capsules	Prochlorperazine 12.5 mg/ml
		Solumedrol 125 mg	Pabron Gold	Promethazine 50 mg/2 ml
		Tylenol 2	Ritodrine tablets	Syntocinon 10 IU in 1 ml
		Valium 10 mg/2ml	Scopolamine injectable	Valium 5 mg
		Ventolin	Sodium bicarbonate injectable	Ventolin inhaler
			Sulpyrine injectable	Verapamil 80 mg
			Terbutaline injectable	

Examples of Medication Contents of Emergency Medical Kits. Saline solution was not listed as all kits contained them, Underlined items are pertinent to neurologic symptoms

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