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Clinical Study

Airplane stroke syndrome

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ABSTRACT

Only 37 cases of stroke during or soon after long-haul flights have been published to our knowledge. In this retrospective observational study, we searched the Royal Melbourne Hospital prospective stroke database and all discharge summaries from 1 September 2003 to 30 September 2014 for flight-related strokes, defined as patients presenting with stroke within 14 days of air travel. We hypothesised that a patent foramen ovale (PFO) is an important, but not the only mechanism, of flight-related stroke. We describe the patient, stroke, and flight characteristics. Over the study period, 131 million passengers arrived at Melbourne airport. Our centre admitted 5727 stroke patients, of whom 42 (0.73%) had flight-related strokes. Flight-related stroke patients were younger (median age 65 *versus* 73, $p < 0.001$), had similar stroke severity, and received intravenous thrombolysis more often than non-flight-related stroke patients. Seven patients had flight-related intracerebral haemorrhage. The aetiology of the ischaemic strokes was cardioembolic in 14/35 (40%), including seven patients with confirmed PFO, one with atrial septal defect, four with atrial fibrillation, one with endocarditis, and one with aortic arch atheroma. Paradoxical embolism was confirmed in six patients. Stroke related to air travel is a rare occurrence, less than one in a million. Although 20% of patients had a PFO, distribution of stroke aetiologies was diverse and was not limited to PFO and paradoxical embolism.

1. Introduction

Almost 2 billion people travel by air every year. The age of travellers is increasing and long-haul aircraft such as the Airbus A380 and Boeing 777 are now capable of extending flight times to 18–20 hours [1]. As such, an appreciation of the associations between air travel and illness is important.

There is no standard definition of a long-haul flight. However, flight durations longer than 8 hours or distance greater than 5000 km have been shown to significantly increase the risk of deep venous thrombosis (DVT) and pulmonary embolism (PE) [1], and this association could be driven by various factors including comorbidities and dehydration.

The association between air travel and DVT, with or without PE, was labeled "economy class syndrome" by Symington et al. in 1977, based on the theory that highly congested seating arrangements put passengers at risk [2]. Although this term has been used subsequently, the exact mechanism of the association remains unclear. The first description of stroke as a complication of long-haul air travel was in 1968 by Beighton and Richards who described a 48-year-old woman who developed a lower limb DVT during a long-haul flight and had a fatal stroke soon after landing [2]. Although this condition was called "economy class stroke syndrome", it seems to affect business class travellers equally [2]. It may, therefore, be more accurate to call it "airplane stroke syndrome". Although airplane stroke syndrome has been recognised for a long time, only a few cases have been described in the literature as single case reports or small case series (Table 1).

One of the potential explanations for an association between air travel and stroke is paradoxical embolism through a patent foramen ovale (PFO), which is proposed as the aetiology in 17 of 29 published ischaemic strokes (Table 1). However, the relevance of PFO in the pathogenesis of ischaemic stroke is somewhat unclear. It has been estimated that the prevalence of PFO in the general population is 25%. In ischaemic stroke patients with no other identifiable cause the prevalence is 40%, and many of these are likely to be incidental [3].

To further understand airplane stroke syndrome, we describe all identified patients, flights, and stroke characteristics in patients with flight-related stroke at the Royal Melbourne Hospital, Australia. We also report the underlying aetiology of stroke and the presence of a PFO. We hypothesised that PFO is an important, but not the sole, underlying aetiology of flight-related strokes.

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Table 1
Flight related strokes reported in the literature

Study	n	Age in years, sex	Definition	Time of stroke	Aetiology
Beighton et al. [2]	1	48 F	Long-haul	Just after landing	PFO
Masson et al. [2]	1	62 F	10 h	Just after landing	PFO
Isayev et al. [2]	3	46 M	12 h	4 h into flight	PFO
		46 M	14 h	End of flight	PFO
		41 F	2 × 1.5 h	12 h post-flight	PFO
Foerch et al. [2]	3	21	>9000 km	End of flight	PFO
		63	>9000 km	End of flight	PFO
		64	>9000 km	End of flight	PFO
Lapostolle et al. [2]	4	53 F	10.5 h	On arrival	PFO
		67 F	11 h	On arrival	PFO/PE
		51 F	11.2 h	On arrival	PFO/PE
		56 M	8 h	5 h into flight	PFO/PE
Alonso-Canovas et al. [6]	16		Within 6 h of landing		8 ischaemic strokes (1 PFO) 8 ICH
Scacciatella et al. [7]	1	47 M	12 h flight	During landing	PFO/DVT
Pavesi et al. [8]	1	65 F	Long flight		PFO/PE
Belvis et al. [9]	1	36 F	11.35 h	After landing	PFO/PE
Lewis et al. [10]	1	56 M	7.5 h	After landing	Vertebral dissection
Heckmann et al. [11]	1	59 F	9.45 h	4 d post-flight	PFO
Civardi et al. [12]	1	39 M	12 h	During flight	Vertebral dissection
Quinn et al. [13]	1	39 F	2 h	1 d post-flight	Carotid dissection
Parees et al. [14]	1	44 F	8961 km	5 d post-flight	Pulmonary AVM
Edwardson et al. [15]	1	68 M	–	–	Cerebral air embolism/Pulmonary bronchogenic cyst

AVM = arteriovenous malformation, d = days, DVT = deep venous thrombosis, F = female, h = hours, ICH = intracerebral haemorrhage, M = male, PE = pulmonary embolism, PFO = patent foramen ovale.

2. Methods

In this retrospective, observational, single centre study, we manually searched our local prospective stroke database and all discharge summaries from the Royal Melbourne Hospital Stroke Unit from 1 September 2003 to 30 September 2014 for flight-related stroke admissions. We employed a standardised search methodology using a keyword search for the following terms: "stroke", "plane", "airplane", "travel", "flight", "trip", "holiday", "PFO", and "airport". We subsequently manually reviewed the electronic discharge summary as well as the patient record in order to determine eligibility for inclusion in the study.

Patients were included in the analysis if they had a stroke during the flight or within 2 weeks of landing. The presence of DVT was diagnosed by Doppler ultrasound, and the presence of a PFO was diagnosed by transaesophageal echocardiography with or without bubble test. Stroke aetiology was determined using the Trial of Org 10172 in Acute Stroke Treatment (TOAST) criteria [4] and stroke severity using the National Institutes of Health Stroke Scale (NIHSS). The diagnosis of paradoxical embolism as stroke aetiology was based on the overall clinical impression of the treating physician, supported by all available investigations. Three of the study authors (H.H., N.Y., A.M.) subsequently reviewed the discharge summaries and available investigations in order to reach consensus and agree on the diagnosis of paradoxical embolism. The study was approved by The Melbourne Health Human Research Ethics Committee.

Melbourne's main domestic and only international airport is located about 20 km from the Royal Melbourne Hospital. The airport is within the catchment area of the hospital, such that acute medical emergencies requiring ambulance transport to hospital which occur at the airport are transported to the Royal Melbourne Hospital by default. During the study period, 28 million international and 103 million domestic passengers arrived at Melbourne airport [5].

Data are presented as median (interquartile range) or number (%). We compared flight-related and non-flight-related stroke patients using the chi-squared or the Mann–Whitney tests. We additionally compared within the flight-related stroke group the patients with stroke during the flight, within 2 days of the flight, and within 3–14 days of the flight with the chi-squared or the Kruskal–Wallis tests as appropriate. Statistical analysis was performed in the Statistical Package for the Social Sciences version 22 (IBM, Armonk, NY, USA).

3. Results

Over the study period we had 5727 stroke admissions. Of those, a total of 42 patients (0.73%) had flight-related strokes. Table 2 shows the baseline clinical characteristics, stroke characteristics, and outcomes in patients with and without flight-related stroke. Median patient age in the flight-related stroke group was 65 years

Table 2
Baseline characteristics, stroke characteristics, and outcomes in patients with and without flight-related stroke

	Flight-related strokes, n = 42	Non-flight related strokes, n = 5685	p-value
Age, years	65 (55–70)	73 (62–82)	<0.001
Male	22/42 (52.4%)	3181/5685 (55.0%)	0.642
Hypertension	18/42 (42.9%)	2391/5604 (42.7%)	0.980
Diabetes mellitus	6/42 (14.3%)	1424/5545 (25.7%)	0.092
Atrial fibrillation	3/42 (7.1%)	1281/5534 (23.1%)	0.014
High cholesterol	11/42 (26.2%)	1260/3327 (37.9%)	0.730
Smoking	9/42 (21.4%)	935/5551 (16.8%)	0.429
Baseline mRS	0 (0–0)	0 (0–2)	0.010
Discharge mRS	4 (2–5)	4 (2–5)	0.023
Baseline NIHSS	9 (3–16)	9 (4–18)	0.477
ICH	7/42 (16.7%)	1228/5536 (22.2%)	0.391
IV tPA	11/35 (26.2%)	562/5685 (9.9%)	0.003
Length of stay, days	9 (1–50)	6 (3–12)	0.011
Discharge destination			<0.001
Home	20/42 (47.6%)	1932/5549 (34.8%)	
Interstate/ overseas	15/42 (35.7%)	5/5549 (0.1%)	
Local institutes/ Hospitals	7/42 (16.7%)	2891/5549 (52.1%)	
In-hospital deaths	0	721/5549 (12.9%)	

Data are presented as median (interquartile range) or n (%).
ICH = intracerebral haemorrhage, IV tPA = intravenous tissue plasminogen activator, mRS = modified Rankin Scale, NIHSS = National Institute of Health Stroke Scale.