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The Safety of Airplane Travel in Patients with Symptomatic Carotid Occlusion

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Abstract

Objective—Patients with carotid stenosis or occlusion may be at increased risk for stroke during air travel. Records from the Carotid Occlusion Surgery Study (COSS), a randomized trial of surgical revascularization for complete carotid artery occlusion and hemodynamic ischemia, were examined for evidence of stroke related to air travel.

Methods—COSS subjects who travelled by airplane to a regional Positron Emission Tomography (PET) center for a screening cerebrovascular hemodynamic evaluation were identified. Maximum altitude and total flight time were estimated based on the distance between origin and destination. Ischemic events were determined by a structured telephone interview within 24 hours of travel. Patient demographics, co-morbidities, OEF data and 24-hour interview responses were recorded.

Results—Seventy-seven patients with symptomatic carotid occlusion travelled by airplane to a single PET center (174 flights). Fifty two (67.5%) were male and 25 (32.5%) were females. The average age was 58.7 ± 1.4 years. Twenty-seven patients (35.1%) demonstrated evidence of ipsilateral hemodynamic cerebral ischemia as measured by PET OEF, while 50 (64.9%) had normal OEF. Patients flew an average distance of 418.9 ± 25.9 miles for 107.1 ± 4.7 minutes per trip. No patient reported symptoms of a transient ischemic attack or stroke during or within 24 hours after airplane travel (95% CI 0 – 2.0%).

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Competing Interests
The authors report no competing interests.

Conclusions—The risk of stroke as a consequence of air travel is low, even in a cohort of patients at high risk for future stroke owing to hemodynamic impairment. These patients with should not be discouraged from air travel.

Keywords

PET; Stroke; Cerebrovascular Disease

Introduction

Patients with symptomatic high-grade carotid stenosis or occlusion are at high risk for ipsilateral ischemic events.(1) It is also known that a large percentage of in-flight medical emergencies are caused from neurological symptoms (20–34%), including cerebrovascular ischemic events.(2, 3) Some authors have speculated that the relatively hypobaric and hypoxic in-flight environment can precipitate ischemic symptoms. (4–7) Owing to this rationale, some authors have advocated counseling patients with atherosclerotic cerebrovascular disease to avoid commercial airplane travel.(5)

The Carotid Occlusion Surgery Study (COSS) was a randomized trial of surgical bypass for patients with symptomatic atherosclerotic carotid occlusion and increased oxygen extraction fraction (OEF). When a cerebral artery is occluded and collateral flow is insufficient to maintain cerebral blood flow, the brain compensates by increasing the amount of oxygen removed from the blood (OEF). This serves to maintain normal oxygen metabolism and brain function. Increased OEF is a powerful predictor of stroke risk in patients with recently symptomatic carotid artery occlusion.(1)

COSS required PET measurements of OEF after enrollment and prior to randomization, and many clinically-eligible subjects were flown to a regional PET centers for this purpose. In the present study, we identified subjects that travelled via commercial airplane to a PET center to determine the incidence of air travel-related stroke.

Methods

COSS was a prospective, randomized, blinded-adjudication treatment trial designed to determine whether superficial temporal artery-middle cerebral artery bypass, in addition to best medical therapy, reduced the risk of ipsilateral ischemic stroke in patients with carotid occlusion and hemodynamic cerebral ischemia.(1)

Patients with either a cerebral TIA or ischemic stroke in the territory of an occluded carotid artery were eligible for enrollment in COSS. Cerebral hemodynamic assessment by PET was required prior to randomization. Many subjects travelled by airplane to a regional PET center for testing, owing to lack of locally available O-15 PET capability. COSS was performed under a Food and Drug Administration (FDA) Investigational New Drug (IND) exemption for O-15 labeled water and oxygen, the PET radiopharmaceuticals used for OEF measurement.

The protocol required telephone follow-up for all subjects after PET scanning, including a structured questionnaire to identify possible adverse events, including ischemic symptoms. Telephone interviews were conducted 24 hours after each patient had completed their return flight home. We identified all patient travelers and collected information regarding demographics, clinical history, diagnostic imaging, and flight information. Arrival and departure cities were recorded for all subjects. Distances between airports were obtained from airline websites. Altitude, cabin pressure, and alveolar PO2 were estimates based on standard commercial airlines flying at standard operational altitudes (35,000 feet).(6) Statistical analysis was limited to descriptive statistics and a calculation of the 95% confidence interval for stroke incidence.(8)

Patients provided written informed consent according to local Institutional Review Board and Human Research Protection Office (HRPO) regulations (Washington University in St. Louis HRPO #01-370 and University of North Carolina IRB approval #307-1020).

Results

Seventy-seven COSS subjects traveled via airplane to a PET facility. Demographics, comorbidities and concurrent treatment are shown in Table 1. All subjects travelled by commercial airline, mostly between cities located in the midwestern United States (total of 174 domestic flights). The time between qualifying events and PET hemodynamic testing was 69.0 ± 4.1 days (Table 2). Average OEF ratio for all travellers was measured to be 1.044 ± 0.006 (range = 0.926–1.182). Twenty-seven patients (35.1%) had an OEF that was elevated (1.104 ± 0.006; normal ≤ 1.065), (9) consistent with ipsilateral hemodynamic cerebral ischemia.

Seventy seven patients flew a total of 174 flights as part of the COSS study. Patients flew an average time of 107.1 ± 4.7 minutes per flight and an average distance of 418.9 ± 25.9 miles per flight (Table 2). Table 2 shows the estimated cabin pressure at 12 psi (assuming an atmospheric pressure of 3.4 psi at 35,000 feet and a differential cabin pressure of 8.6 psi), and a change in alveolar PO_2 from 107 mm Hg (sea level) to 76 mm Hg (5,000 foot level simulated by pressurized aircraft flying at 35,000 feet).

No subject reported symptomatic ischemic events during or within 24 hours after airplane travel. The 95% confidence interval for the incidence of stroke per flight was 0 – 2.0% (0/174 flights).(8)

Discussion

These data suggest that patients with carotid artery occlusion are able to tolerate the relatively hypobaric and hypoxemic changes that accompany commercial airplane flight. While this study is uniquely suited to answer this important and clinically-relevant question (prospective assessment of a well-defined, high-risk cohort), it has some limitations. First, the patient cohort size is limited and the risk of stroke associated with air travel may be as high as 2%. However, the 2-year risk of ipsilateral ischemic stroke in patients with carotid occlusion and hemodynamic ischemia ranges from 23 to 40% (1, 9), suggesting that even the upper limit of the estimate is still not a substantial increase in stroke risk. Second, flight

parameters were estimates. While the calculated values of cabin pressure and alveolar PO_2 are estimations, the alveolar PO_2 is necessarily reduced at flying altitudes greater than 22,500 feet (6) which constitutes nearly all commercial flights. In addition, most of the subjects travelled between cities in the midwestern United States. It is possible that longer flights—potentially with higher altitudes and a greater degree and longer period of hypoxemia—may subject patients to an increased risk of ischemic stroke. However, at least one study suggests that short-haul flights (< 2 hours) are no different from long-haul flights (> 2 hours) with respect to the mean decrease in oxygen saturation levels in healthy individuals ascending from ground level to standard cruising altitudes (7). Moreover, given the sigmoidal distribution of the oxygen-hemoglobin dissociation curve and the unique dynamics of cerebrovascular autoregulation, it is unlikely that a modest decrease in oxygen saturation would result in significant cerebral ischemia—even in the setting of known carotid artery disease. Finally, ischemic strokes were assessed by a structured phone interview upon the return flight for all patients. While this method has been validated as an effective tool for stroke detection with high sensitivity and specificity, (10, 11) it may not be as sensitive as a thorough neurological examination.

Alonso-Cánovas et al, examined a cohort of patients with a recent history of airplane travel referred to a local hospital for neurological symptoms (5). Of 77 patients referred, 8 were diagnosed with an ischemic stroke and the majority of these patients (5/8) harbored high-grade carotid stenosis. The authors advised caution in patients with atherosclerotic carotid artery disease given the “potentially increased” risk of stroke with airplane travel. While this study documents stroke as a common neurological cause for hospitalization after air travel, whether a causal relationship with air travel exists is still unclear. First, the overall number of patients is limited. Second, the denominator of all patients flying with atherosclerotic carotid disease is unknown: their stroke risk during or soon after air travel may be no different as during other activities.

In conclusion, the risk of stroke during commercial airplane travel in patients with symptomatic carotid occlusion—including those with hemodynamic cerebral ischemia as measured by PET—appears to be low. There is no direct evidence to discourage these patients from air travel.

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Table 1

Baseline characteristics*

Patient characteristics:	
Males	52 (67.5%)
Females	25 (32.5%)
Age (years)	58.7 ± 1.4
Co-morbidities:	
NIDDM	23 (29.9%)
CAD	10 (13.0%)
PVD	1 (1.3%)
HTN	55 (71.4%)
HL	59 (76.6%)
CKD	1 (1.3%)
Current smoker	22 (28.6%)
Former smoker	32 (41.6%)
5+ drinks/day	4 (5.2%)
Current drug use	0 (0.0%)
Current medications:	
1 antiplatelet	24 (31.2%)
2 antiplatelets	31 (40.3%)
1 antiplatelet/1 anticoagulant	6 (7.8%)
2 antiplatelets/1 anticoagulant	4 (5.2%)
Anticoagulant only	4 (5.2%)
None	5 (6.5%)
Other/unknown	3 (3.9%)
Angiography:**	
Complete L ICA occlusion	32 (41.6%)
Complete R ICA occlusion	45 (58.4%)

* Data are represented either as mean (percentage) or mean ± SEM.

Abbreviations: ASA = Aspirin; CAD = Coronary Artery Disease; CKD = Chronic Kidney Disease; HL = Hyperlipidemia; HTN = Hypertension; ICA = Internal Carotid Artery; NIDDM = Non-Insulin Dependent Diabetes Mellitus; PVD = Peripheral Vascular Disease

** no patients had contralateral carotid stenosis greater than 50% or vertebrobasilar stenosis or occlusion

Table 2

PET and flight data*

PET data:	
Days from symptoms to PET	69.0 ± 4.1
OEF	1.044 ± 0.006
Patients with increased OEF	27 (35.1%)
Patients with normal OEF	50 (64.9%)
Flight data:	
Total Number of flights	174
Time per flight (minutes)	107.1 ± 4.7
Distance per flight (miles)	418.9 ± 25.9
**Cabin pressure (psi, at sea level)*	14.7
†Cabin pressure (psi, at altitude)	12.0
**Alveolar PO2 (mm Hg, at sea level)*	107
†Alveolar PO2 (mm Hg, at altitude)	76
‡Oxygen saturation (SpO2) at sea level	97%
‡Oxygen saturation (SpO2) at altitude	93%

*Data are represented either as mean (percentage) or mean ± SEM.

Abbreviations: OEF = Oxygen Extraction Fraction; PET = Positron Emission Tomography

*Estimated based on standard commercial airplane travel (6)

†Estimated based on a typical operational altitude of 35,000 feet (6)

‡Estimated based on a prior study of 84 healthy individuals (aged 1–78 years) whose oxygen saturations were measured via pulse oximetry at ground level and standard cruising altitudes (7)