

## Aerospace Medicine Clinic

This article was prepared by Isaac Yourison, M.D.

You're the senior flight surgeon on call in the Medical Group when your nurse runs into your office and proceeds to rapidly tell you about a patient who just called the advice line. He is a 45-yr-old, right-handed, male squadron commander in the Air Traffic Control Wing. His wife woke him around 3:30 this morning to see why the dog was barking. He went downstairs and found the dog barking at something outside. He flipped on the flood light and pushed the curtain to the side, which is when he realized he couldn't feel the curtain with his right hand. This did not strike him as odd, since he thought his arm may have just fallen asleep. Of note, he and his daughter had a conversation about the dog barking and she didn't mention that he had slurred or confused speech. He went back to bed and noticed that he moved his phone on the nightstand by brushing the charging cable and became concerned as his sensation had not returned. He went to his wife's powder mirror and didn't notice any facial droop, but did feel his upper lip was numb on the left more so than the right. He went back to bed but was unable to get to sleep because he was feeling anxious.

Waking up later around 5 a.m., he got out of bed and performed his morning routine, which included brushing his teeth and shaving with his right hand. He noticed that he had to be very intentional about how much pressure he was applying to the toothbrush and razor as well as his teeth and face. He felt he had to consciously tell himself to push harder or lighter with his right hand. He drove to work, which is about an hour away, and began climbing the stairs to his floor. A woman walking up behind noted that he looked pale, which he told her was due to him feeling a bit worn down. He sent some emails stating that he wouldn't be in afternoon meetings, then called a nurse advice line and was routed to you as the flight surgeon on duty. After reviewing the case, you are concerned that he is having an acute ischemic stroke and recommend he go to the nearest emergency room.

1. Which of the following, if present, would exclude him from receiving intravenous tissue plasminogen activator (tPA)?
  - A. Onset of symptoms for <4.5 h.
  - B. Stroke associated with aortic arch dissection.

- C. Persistent blood pressure (BP) elevation of 175/105 mmHg.
- D. Platelet count 120,000/mm<sup>3</sup>.

### ANSWER/DISCUSSION

**1. B.** Stroke associated with aortic dissection is a contraindication to receiving tPA due to the increased risk of brain ischemia from hypotension and direct compromise of cerebral circulation. Onset of symptoms for <4.5 h is an inclusion criterion to administer tPA. Other inclusion criteria include age >18 yr and clinical diagnosis of ischemic stroke causing neurological deficit. BP elevation is not a contraindication unless BP is sustained >185/110 mmHg. Thrombocytopenia is not a contraindication until platelets are <100,000/mm<sup>3</sup>.<sup>11</sup>

The patient drove an hour back to his hometown and was evaluated in a local emergency room. Based on his history and exam findings, the physician was also concerned that he was having an ischemic stroke. Vital signs were within normal limits, with the exception of mild hypertension (HTN), BP 148/92 mmHg. Neurological exam demonstrated normal cranial nerves II–XII, with the exception of left lower facial nerve sensory loss in the V2 distribution, normal strength in upper and lower extremities, decreased sensation to light touch on the lateral aspect of his right hand and wrist, normal deep tendon reflexes, normal gait, negative Romberg, no pronator drift, no dysdiadochokinesis, and negative Babinski and Hoffman testing. No aphasia, visual cuts, or gaze preferences were noted on exam. Other medical, surgical, social, and family histories and review of systems were negative and noncontributory. Lab results with complete blood count, basic metabolic panel, and coagulation studies were within normal limits. Coronary lipid panel, thyroid studies, and glycosylated hemoglobin were drawn, but did not return for several days. Initial imaging studies were unremarkable and included noncontrast computed

Reprint and copyright © by the Aerospace Medical Association, Alexandria, VA.  
DOI: <https://doi.org/10.3357/AMHP.6257.2023>

tomography of the head, computed tomography angiography of the head and neck, and lower extremity venous duplex. However, magnetic resonance imaging of the brain revealed an acute ischemic stroke in the posterior left middle cerebral artery (MCA) distribution. He was determined not to be a candidate for tPA, since it was >4.5 h after the event. He was transferred to a larger local hospital for acute stroke management. A follow-up echocardiogram with bubble study showed an intracardiac shunt consistent with a patent foramen ovale (PFO).

2. Given the findings presented above, what is the most likely etiology of his stroke?
  - A. Large intracranial vessel thrombotic occlusion.
  - B. Systemic hypoperfusion.
  - C. Cardioembolic.
  - D. Blood and hypercoagulable disorder.

### ANSWER/DISCUSSION

**2. C.** As the PFO is the likely source of the stroke, the most likely etiology is cardioembolic. At the time of his stroke, his Risk of Paradoxical Embolism (RoPE) score was 8, which suggests an 84% chance that his stroke was due to the PFO and is also associated with a 6% 2-yr risk of recurrent stroke or transient ischemic attack (TIA).<sup>3,8</sup> In the setting of embolic infarct with no other evidence for a source, it is reasonable to conclude that the PFO was the likely mechanism. The RoPE calculator assigns points for HTN, diabetes mellitus, prior stroke, infarct on imaging, smoking, and age. He only received points for cortical infarct on imaging. His condition stabilized in the hospital, and he was started on a statin and dual-antiplatelet therapy and instructed to follow up with Cardiology and Neurology. His lip symptoms resolved within 2 d and his hand symptoms within 1 wk. At his outpatient Cardiology follow-up appointment, the results of his workup, including complete blood count, basic metabolic panel, glycosylated hemoglobin, thyroid-stimulating hormone, and a thorough hypercoagulable panel, were noted to be within normal limits. His lipid panel revealed a low-density lipoprotein level of 135. A follow-up lipid panel 2 mo later showed an appropriate decrease in low-density lipoprotein to 64. He underwent a 48-h Holter study and results were read as normal. He was determined to be a good candidate for PFO device closure and underwent successful closure of the PFO with a St. Jude Amplatzer™ device (Abbott Laboratories, Chicago, IL) in the following weeks. Aspirin and clopidogrel were continued for 6 mo. Clopidogrel was stopped after 6 mo and he was continued on atorvastatin and baby aspirin. A medical evaluation board was submitted, and he was found suitable for continued military duty.

Today he comes to see you at the flight surgeon's office to discuss a possible aeromedical waiver and return to air traffic control (ATC) duties, as he is approximately 12 mo status post his cerebrovascular accident. Per Air Force regulations, stroke and TIA are disqualifying for all flying classes.<sup>7</sup> Congenital cardiac anomalies are also disqualifying, specifically PFO

associated with embolic phenomena. Waivers are generally not considered unless a correctable cause is discovered and treated. Since in this case a correctable cause (PFO) was successfully treated, ATC waiver is possible. He is very motivated to return and wants your opinion on future risks.

3. In addition to recurrent stroke, what are the other related events of aeromedical concern if he returns to duty?
  - A. Myocardial infarction.
  - B. Seizure.
  - C. Aphasia.
  - D. Fall risk.

### ANSWER/DISCUSSION

**3. B.** Aeromedical concerns after stroke are future risk of seizure, risk of stroke recurrence, and residual neurological or cognitive deficits. Regarding seizure, which could lead to sudden incapacitation, the risk is more elevated within the first year after stroke. Based on his SeLECT score of 3, his risk of seizure within the first year was 4%.<sup>6,9</sup> The SeLECT calculator assigns points for severity of stroke, large-artery atherosclerotic etiology, early seizures, cortical involvement, and territory of MCA involvement. He received points for cortical and territory of MCA involvement. There is also an additional 2% risk over the following 4 yr, so his annualized risk of seizure is 0.5%. Regarding recurrent stroke, which could cause either immediate incapacitation or decrements, his Essen stroke risk score (based on prior stroke, age, history of diabetes mellitus, HTN, myocardial infarction, smoking, or atherosclerotic cardiovascular disease) estimates his 1-yr risk of stroke at 1.8%.<sup>13</sup> However, this does not account for his PFO or subsequent closure, so the exact risk is more difficult to determine. Regarding residual neurological deficits, the risk is not easily quantified. The potential for recrudescence exists after infarction of brain or spinal cord tissue and would likely present in a similar fashion to his original cerebrovascular event but would not be expected to be incapacitating.

4. While PFO device closure can reduce stroke risk, it can be prone to adverse events. What is a feared complication from a PFO closure device that could also increase stroke risk?
  - A. Atrial fibrillation (AF).
  - B. Device migration.
  - C. Cardiac erosion.
  - D. Allergic reaction.

### ANSWER/DISCUSSION

**4. A.** AF related to device implantation can increase stroke risk and is more common in PFO patients who had percutaneous closure compared with those who are medically treated. The risk of AF is higher in the first 45 d postclosure, up to a rate of 3.7 patients per 100 patient-years.<sup>2</sup> This can be up to

five times the level of medically managed patients but decreases with time. Cardiac erosion is also a feared complication from PFO closure but is not necessarily linked to increased stroke risk. The best estimate for incidence of erosion with the St. Jude Amplatzer device is 1–3 cases per 1000 implants (0.1%),<sup>1</sup> but this can lead to significant mortality when it occurs. Device migration and allergic reaction are less likely and not known to be related to stroke risk. You discuss with the patient that he should seek immediate medical attention for any palpitations, chest pain, dizziness, or collapse. Regular echocardiographic follow-up to ensure absence of pericardial effusion, alteration in device position, or other abnormalities is recommended.

The patient is doing well and asks what the next step is for aeromedical waiver submission. He undergoes repeat physical exam, with no signs of neurological deficits on routine exam or on neuropsychological testing. There are no indications that he has residual cognitive deficits from his stroke. You discuss that per the U.S. Air Force waiver guide, “supratentorial strokes leave a potential seizure focus. A 2–3-yr seizure-free observation period after stroke and a 1–2-yr observation period after TIA are required prior to any potential waiver consideration.”<sup>7</sup> He has had no seizures or further events and is approaching his 2-yr window, so you draft and submit his waiver.

5. The patient asks you what would have happened if he had been a civilian aviator/controller or had been serving in another branch of the military. You immediately pull up your Federal Aviation Administration (FAA) Guide for Aviation Medical Examiners, which is saved in your browser, and answer that it would most likely have led to:
  - A. Immediate disqualification.
  - B. No change in status.
  - C. Discharge from service.
  - D. Unknown status.

## ANSWER/DISCUSSION

5. **A.** Per the FAA’s Guide for Aviation Medical Examiners, stroke is disqualifying and requires an FAA decision before an individual can be granted a Special Issuance and subsequent medical certificate.<sup>5</sup> The other branches of the military have similar standards. Per Navy guidelines, TIA and/or stroke are permanently disqualifying and waiver approval is deferred to the Naval Authority.<sup>10</sup> Army standards offer similar guidance, since stroke does not meet the standards of medical fitness for flying duty.<sup>12</sup> Your patient is considering working in the civilian sector after his retirement, and since civilian-contracted ATCs must hold a current 2<sup>nd</sup> class FAA medical certificate,<sup>4</sup> he will keep the regulations in mind when transitioning out of military service.

After an evaluation of his records, he was recommended for a flying class III/ground-based operator/ATC waiver, valid for 2 yr. The Aeromedical Consultation Service recommends reevaluation with repeat echocardiograms every 3 yr. He returns

to duty after his waiver approval and continues to follow-up closely with you until you are given orders for permanent change of station.

**Yourison ID.** *Aerospace medicine clinic: stroke.* *Aerosp Med Hum Perform.* 2023; 94(11):864–867.

## ACKNOWLEDGMENTS

The author wishes to thank Dr. Aven Ford, neurology consultant at the Aeromedical Consultation Service, Wright-Patterson AFB, OH, for his kind review and constructive advice in the preparation of this paper. The views expressed are those of the authors and do not reflect the official guidance or position of the U.S. Government, the Department of Defense (DoD), or the U.S. Air Force. The appearance of external hyperlinks does not constitute endorsement by the DoD of the linked websites, or the information, products, or services contained therein. The DoD does not exercise any editorial, security, or other control over the information you may find at these locations.

## REFERENCES

1. Amin Z, Hijazi ZM, Bass JL, Cheatham JP, Hellenbrand WE, Kleinman CS. Erosion of Amplatzer septal occluder device after closure of secundum atrial septal defects: review of registry of complications and recommendations to minimize future risk. *Catheter Cardiovasc Interv.* 2004; 63(4):496–502.
2. Chen JZ, Thijs VN. Atrial fibrillation following patent foramen ovale closure: systematic review and meta-analysis of observational studies and clinical trials. *Stroke.* 2021; 52(5):1653–1661.
3. Doufekias E, Segal AZ, Kizer JR. Cardiogenic and aortogenic brain embolism. *J Am Coll Cardiol.* 2008; 51(11):1049–1059.
4. Federal Aviation Administration. 10. Classes of medical certificates. In: *Guide for aviation medical examiners.* Washington (DC): Federal Aviation Administration; 2023:18. [Accessed March 2, 2023]. Available from [https://www.faa.gov/about/office\\_org/headquarters\\_offices/avs/offices/aam/ame/guide/media/AME\\_GUIDE.pdf](https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/aam/ame/guide/media/AME_GUIDE.pdf).
5. Federal Aviation Administration. Decision considerations – aerospace medical dispositions. Item 46. Neurologic – cerebrovascular disease (including the brain stem). Stroke, CVA, TIA. In: *Guide for aviation medical examiners.* Washington (DC): Federal Aviation Administration; 2023. [Accessed February 26, 2023]. Available from [https://www.faa.gov/about/office\\_org/headquarters\\_offices/avs/offices/aam/ame/guide/app\\_process/exam\\_tech/item46/amd/cd/](https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/aam/ame/guide/app_process/exam_tech/item46/amd/cd/).
6. Galovic M, Döhler N, Erdélyi-Canavese B, Felbecker A, Siebel P, et al. Prediction of late seizures after ischaemic stroke with a novel prognostic model (the SeLECT score): a multivariable prediction model development and validation study. *Lancet Neurol.* 2018; 17(2):143–152.
7. Hesselbrock R, Van Syoc D, Gregory D. Transient ischemic attack (TIA) and stroke (Apr 2020). In: *Aerospace medicine waiver guide.* Wright-Patterson AFB (OH): U.S. Air Force School of Aerospace Medicine; 2023. [Accessed February 26, 2023]. Available from <https://www.af.mil/711HPW/USAFSAM/>.
8. Kent DM, Ruthazer R, Weimar C, Mas JL, Serena J, et al. An index to identify stroke-related vs. incidental patent foramen ovale in cryptogenic stroke. *Neurology.* 2013; 81(7):619–625.
9. Labovitz DL, Hauser WA, Sacco RL. Prevalence and predictors of early seizure and status epilepticus after first stroke. *Neurology.* 2001; 57(2):200–206.
10. Naval Aerospace Medical Institute. 10.12. Transient ischemic attack (TIA). In: *U.S. Navy aeromedical reference and waiver guide.* Pensacola (FL): Naval Aerospace Medical Institute; 2023. [Accessed February 26, 2023].

Available from <https://www.med.navy.mil/Navy-Medicine-Operational-Training-Command/Naval-Aerospace-Medical-Institute/Aeromedical-Reference-and-Waiver-Guide/>.

11. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, et al. Guidelines for the early management of patients with acute ischemic stroke: 2019 update to the 2018 guidelines for the early management of acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2019; 50(12):e344–e418.
12. U.S. Army. 4-27. Neurological. In: Standards of medical fitness. Washington (DC): Department of the Army; 2019:40. Army Regulation 40-501. [Accessed February 26, 2023]. Available from [https://armypubs.army.mil/epubs/DR\\_pubs/DR\\_a/ARN37720-AR\\_40-501-002-WEB-4.pdf](https://armypubs.army.mil/epubs/DR_pubs/DR_a/ARN37720-AR_40-501-002-WEB-4.pdf).
13. Weimar C, Diener HC, Alberts MJ, Steg PG, Bhatt DL, et al. The Essen stroke risk score predicts recurrent cardiovascular events: a validation within the Reduction of Atherothrombosis for Continued Health (REACH) registry. *Stroke*. 2009; 40(2):350–354.