# Endovascular Treatment of a Severe Stroke Occurring in a Commercial Airplane Over the Sahara

Christian Foerch; Christoph A. Mayer; Joachim Berkefeld; Se-Jong You

**BACKGROUND:** The occurrence of an acute stroke syndrome during a long-distance flight demands critical decisions from the crew and attendant physicians. One in particular is whether the flight should be continued or be detoured to a nearby airport.

**CASE REPORT:** We describe a 42-yr-old woman who suffered from a severe stroke in a commercial airplane over the Sahara. The captain, together with a physician aboard and the next of kin, decided not to detour to north African or south European airports, but to continue flying to Frankfurt, Germany (final destination; remaining flight time 4 h), where an efficient transfer infrastructure and an advanced medical standard were presumed. At the hospital, the patient was successfully treated by means of catheter-based mechanical thrombus extraction. The patient was free of neurological deficits at discharge.

**DISCUSSION:** The geographically unbalanced availability of complex but highly effective therapies such as mechanical recanalization in acute stroke challenges decision making in aviation medicine. In selected cases it might be beneficial to continue flying to cities with advanced medical standards instead of deviating to nearby airports.

**KEYWORDS:** stroke, endovascular treatment, thrombectomy, aviation medicine, airplane, flight, doctor's kit.

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Suspected acute stroke is a critical aviation emergency that demands immediate action. This includes providing medical first aid to the patient and arranging the quickest possible admission to a sufficiently equipped hospital.[9,10] Strokes account for approximately 2% of in-flight medical emergencies.

Unfortunately, specific treatment of ischemic stroke by thrombolysis is not possible in an airplane, as intracerebral hemorrhage cannot be ruled out based on clinical parameters alone.[7] However, depending on whether qualified personnel and equipment are available, supportive measures can be applied to in-flight stroke patients.[5,9,10] Positioning the patient in upper body elevation may be indicated for lowering of potentially raised intracranial pressure, easier management of vomiting, and improved oxygen supply. Frequent blood pressure measurements and adjustment of low (<120 mmHg) and very high (>220 mmHg) systolic blood pressure values are recommended. If available, monitoring of heart rate and oxygenation using an automated external defibrillator and a pulse-oximeter, respectively, would be desirable. Certain subtypes of stroke, such as large intracerebral hemorrhage or basilar artery thrombosis may cause a sudden loss of consciousness.[2,12] Intubation and ventilation may then be necessary.

In parallel to providing first aid to the patient, the option to divert the flight to nearby airports has to be evaluated.[6,9,10] In view of the narrow time window of thrombolysis, this seems to be of high relevance, particularly in suspected stroke patients. Typically, the flight captain reaches the decision based on geographical factors and the remaining flight time to the destination airport, as well as considering the recommendations of available physicians aboard and the airline's ground medical emergency team.

Highly effective but technically advanced treatment options have recently been implemented in stroke medicine, such as mechanical thrombectomy with catheter-based extraction systems.[13] In view of the geographically unbalanced availability of these therapies, the already complex interplay between stabilizing the patient and evaluating deviation strategies in aviation

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emergency medicine is increasingly challenged with the decision of whether the flight should be continued to cities with advanced medical standards or deviate to the closest airport. We present an impressive case illustrating this dilemma.

## CASE REPORT

The patient, a 42-yr-old woman of German nationality, boarded a direct flight from Windhoek, Namibia, to Frankfurt, Germany, after a 3-wk holiday, which was uneventful in terms of medical issues. However, a few hours prior to departure, she noticed mild nausea and loss of appetite. Following the suggestion of her primary care physician, the patient injected low molecular weight heparin (Mono-Embolex 3000 IE) subcutaneously for prevention of deep vein thrombosis due to immobility. The patient sat in an economy class seat and fell asleep after takeoff. Approximately 6 h into the flight—the aircraft was 300 km north of the border between Niger and Algeria in the middle of the Sahara—she woke up allegedly due to an inconvenient sleeping position and adjusted her posture. Shortly thereafter she recognized pain and cramps in her left leg. She stood up and intended to walk down the isle, but suddenly lost stability due to a left-sided hemiparesis. A flight attendant noticed her condition and informed the pilot and a cardiologist who coincidentally was on the same flight. The patient was examined and diagnosed with a severe stroke syndrome. She was placed in a blanket and carried into the business class in order to create better conditions for medical care. A doctor's kit was offered, but not obtained. The neurological status of the patient remained fairly stable, with a slightly drowsy level of consciousness, a gaze deviation to the right side, and a severe left sided hemiparesis. She received a few drops of water with the help of a straw. Still, no specific medication was applied. Attempts to use the restroom remained unsuccessful.

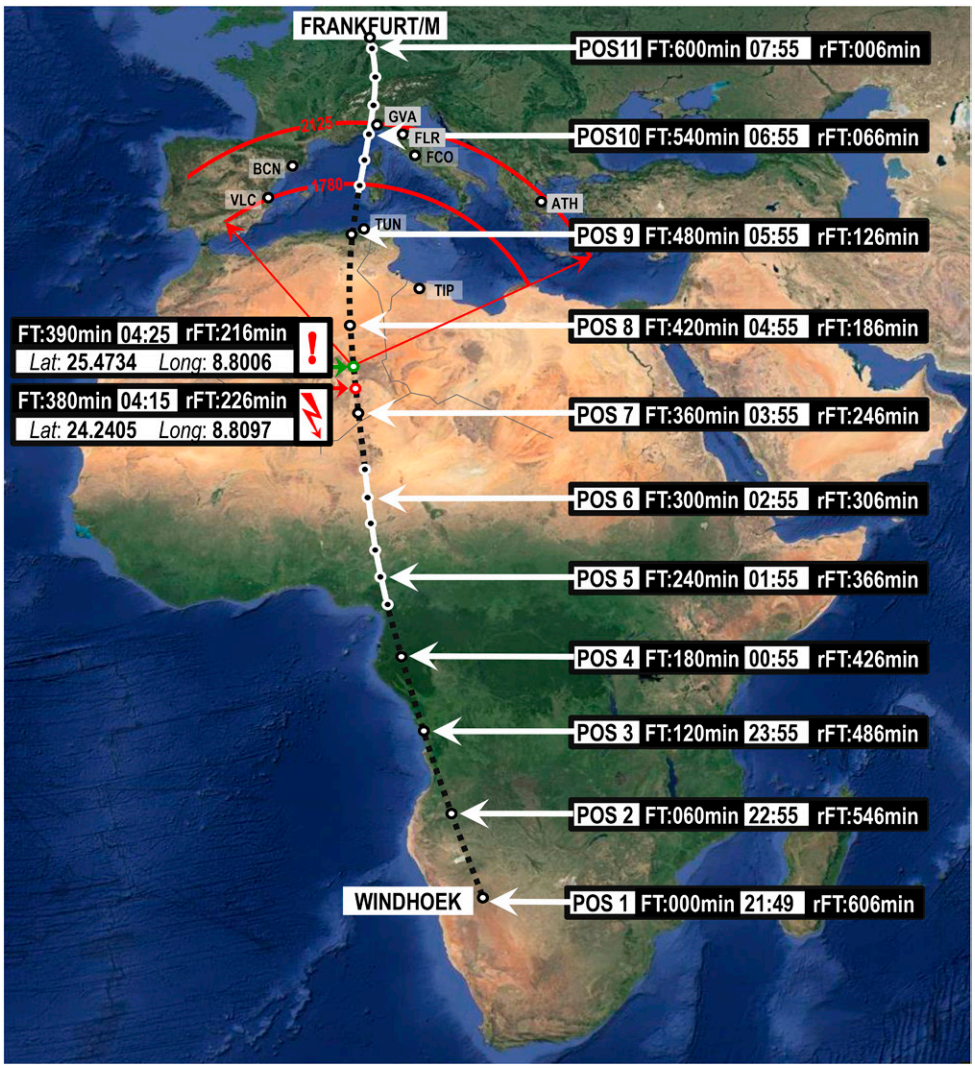


**Fig. 1.** Route of flight NMB285 (according to flightaware.com; black dots with white circles). Parts of the route were reconstructed based on averaged estimated routes of three NMB285 flights of similar duration (white dots with black circles). FT indicates flight-time, rFT indicates remaining flight-time. Reference time zone is CEST. The red circle indicates the position of the aircraft at the time of the stroke incident. The position at the time of assumed decision-making regarding flight deviation is marked with a green circle. Deviation airports at reasonable distances are shown using IATA-codes. A radius of the first accessible European deviation airport (VLC) is drawn at approx. 1800 km. A second radius (through GVA and ATH) is drawn at approx. 2100 km.

Right after the stroke syndrome had been diagnosed, no deviation airport was readily available (see **Fig. 1**). Thus, at that time, there was no alternative to continuing the flight. Later on, the flight captain made the decision to continue the flight to Frankfurt (remaining flight time 216 min) instead of deviating to closer airports such as Tripolis (Libya, 65 min), Tunis (Tunisia, 85 min) or Rome (Italy, 180 min). This decision was based on the relatively stable status of the patient (no further deterioration of the level of consciousness) attested by the physician and the preference given by the next of kin to fly the patient into the "home country," where a rapid transfer to the hospital and a high medical standard were presumed. From all that was known, the narrow therapeutic time window in stroke was not considered as a critical aspect at that time.

Prior to arrival at the destination airport, the emergency services were notified so that the patient was already expected and

immediately disembarked at the gate. She was then checked into the Frankfurt medical emergency distribution system and rapidly delivered to the tertiary care University hospital. When the patient reached the clinic, conservative and interventional stroke treatment options were already prepared and ready for application.

The clinical examination at admission (approx. 5 h after symptom onset) revealed a hemispheric stroke syndrome including dysarthria, gaze deviation to the right side, neglect for the left side, and a severe left-sided hemiparesis with a National Institute of Health Stroke Scale score of 15. A CT scan, including a CT angiography, was immediately performed and showed an occlusion of the distal carotid artery (carotid T including the middle cerebral artery) and early infarct signs in the basal ganglia and the right insular cortex (the Alberta stroke program early CT score[11] was 6) (**Fig. 2** and **Fig. 3**).

Due to the already extended time window, IV thrombolysis was not performed. Instead, the patient was transferred to the catheter lab for mechanical thrombectomy. Angiography confirmed an occlusion of the right carotid artery (from the carotid bulb to the carotid T) and indicated collateral flow from the posterior cerebral artery territory and from lepto-meningeal arteries into the right middle cerebral artery territory. By means of a solitaire stent retriever, large amounts of thrombus material were extracted. The vessel was reopened after the first maneuver.

After the intervention, the patient was transferred to the intensive care unit. She rapidly recovered from anesthesia, allowing for swift extubation. A few hours later, she was fully alert, had no further gaze abnormalities, and started moving the formerly plegic left-sided extremities. She was asked in detail about her medical history, which was uneventful. Apart from a birth control pill, she did not take any medication. Follow-up CT 6 d after stroke onset revealed infarctions in the basal ganglia and the insular cortex on the right side (**Fig. 4**).

We conducted a broad diagnostic work-up in order to identify stroke etiology, including sonography of the brain-supplying vessels, transesophageal echocardiography, Holter ECG monitoring, CSF analysis, and laboratory tests for vasculitis, thrombophilia, and vascular risk factors. Apart from a mild right ventricular hypertrophy and a small persistent foramen ovale with a minor right to left shunt, no abnormalities were found. Furthermore, there was no clinical or sonographic evidence for the presence of a deep vein thrombosis. Thus, the exact etiology of the stroke could not be determined. Despite its manifestation during a long-haul flight in the economy class[3] and the "cramp-like pain" the patient experienced in her left leg prior to the incident, we were reserved diagnosing a paradox-embolic stroke. The patient was discharged home free of neurological deficits with the recommendation to take aspirin and atorvastatin, and to further evaluate the right ventricular hypertrophy.

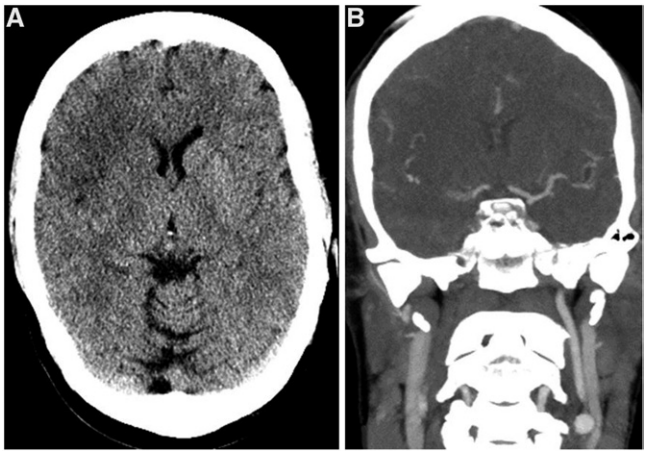


**Fig. 2.** A) Initial preinterventional CT scan shows circumscribed early signs of infarction in the basal ganglia, insular cortex, and frontal operculum of the right hemisphere (ASPECTS score 6) due to B) occlusion of the right internal carotid artery and M1 segment of the middle cerebral artery in CTA.

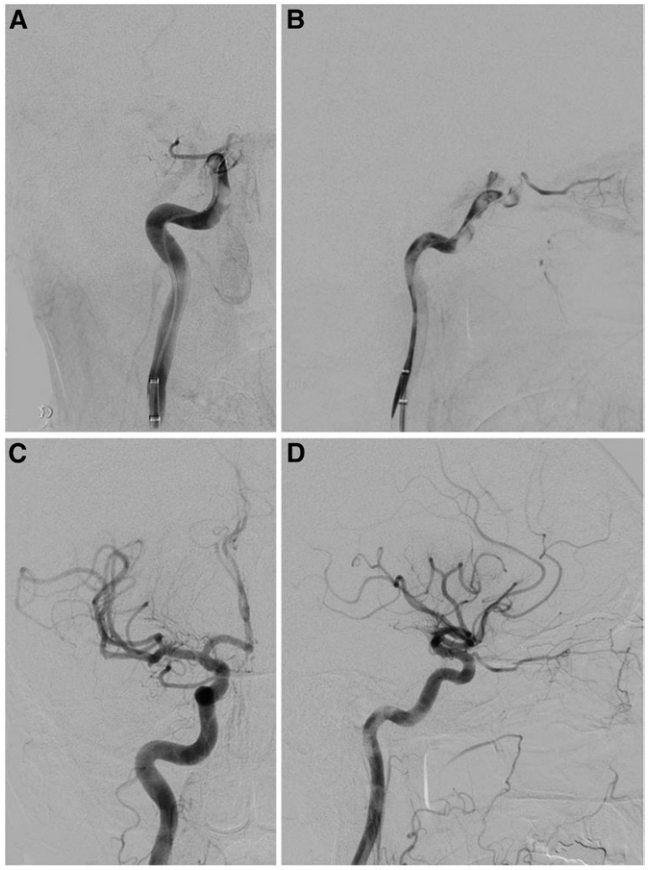


**Fig. 3.** DSA revealed persistent occlusion of the right intradural internal carotid artery and middle cerebral artery. Additionally nonocclusive intraluminal thrombus in the petrous and cavernous segment of the internal carotid artery was detected. A) Right internal carotid artery angiography, posterior-anterior view, and B) lateral view. C & D) Successful recanalization of the right internal carotid artery and middle cerebral artery was achieved using a stent retriever (TICI 3).

## DISCUSSION

We describe a case of successful endovascular treatment of a severe right hemispheric stroke after ultra-long transportation of the patient (distance from symptom onset to hospital

**Fig. 4.** Follow-up CT scan performed the following day shows unchanged extent of infarction compared to pre-interventional CT without hemorrhage.

admission >3000 km). In general, a suspected acute stroke is considered to be a time-critical in-flight emergency that justifies aircraft diversion to the nearest available airport. Large-scale analyses reported that landing at the closest airport is performed in about 15–20% of all in-air stroke cases.[9,10] Severe stroke syndromes (as observed in our patient) may more frequently lead to diversion than mild stroke syndromes.

In our case, vessel occlusion occurred over the Sahara and no nearby airport was readily available. Thus, the flight had to continue at first, and the crew and the onboard physician managed to stabilize the patient. The physician and the next of kin then decided not to favor a detour to Tripolis or Tunis (flight time 90 and 120 min, respectively), as the medical standard was not considered equivalent to that of European cities. Later on, the patient remained stable and the physician, the flight captain, and the next of kin agreed on continuing to fly to Frankfurt, where state-of-the-art treatment and a rapid transfer to the nearby University hospital was expected.

The decision on whether to land or to continue flying after a severe stroke syndrome has occurred is difficult and needs to be made by the crew after weighing all available information.[6] In general, the effectiveness of thrombolysis decreases with increasing time spans elapsed from symptom onset, and any measure should be undertaken to reduce prehospital delays.[1] On the other hand, the given time window of acute ischemic stroke (currently 4.5 h) may well allow continuing the flight for at least 2 h to reach highly equipped medical centers, given that ground transportation and in-hospital procedures are performed as quickly as possible.[8] Thus, as long as the condition of the patient remains stable (according to the judgment of onboard physicians), it appears justified to continue flying to the destination airport if medical standards (e.g., the possibility to perform mechanical thrombus extraction) are higher there than at closer airports. However, it has to be clearly mentioned that this approach could also significantly worsen the patient's prognosis. For example, it cannot be judged without brain imaging whether the stroke symptoms are caused by an ischemic stroke or an intracerebral hemorrhage. In the latter case, it is likely that the patient will deteriorate and may need mechanical ventilation and intensive care treatment.[2,12] Thus, one must also take into account foreseeable dynamics in the patient's condition as well as the options to manage such worsening based on the physician's skills and the available medical equipment.

Recently, randomized clinical trials have been published that proved that thrombectomy is highly effective in stroke patients with large vessel occlusions, nearly doubling the chance for having a good functional outcome as compared to thrombolysis alone.[1] In particular, patients having significant collateral flow as indicated on CT angiography were associated with a favorable outcome.[4] Our patient indeed had a good collateral flow as observed in the angiogram. Otherwise, the prognosis of the patient would have likely been worse.

In summary, as common in cases of medical emergencies onboard airplanes, the occurrence of an acute stroke syndrome challenges the crew and accompanying physicians with a complex evaluation, including the acute medical peril for the patient, the assumable clinical development for the remaining flight duration, and the availability of time critical interventional treatment options. It may in certain cases be justified to continue flying to locations with a high level of medical care. In our case, the patient also benefitted from a precisely timed cascade of medical and rescue service engagement linking the airport to the tertiary care hospital, allowing for very fast implementation of endovascular treatment after arrival.

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