

Frequency, Mechanisms, Outcome and Review of the Literature

Stroke Following Attempted Suicide

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Abstract

Background: Only a few patients with strokes following a suicide attempt (SFSA) are described in the literature. The best-known mechanism is the dissection of cervical arteries. We aimed to determine the frequency, clinical presentation, mechanisms, and outcomes of SFSA patients in one academic institution and in all patients reported in the literature.

Method: We retrospectively identified all SFSA in the Acute Stroke Registry and Analysis of Lausanne (ASTRAL) from 2003 to 2021. A thorough workup was performed to establish the stroke mechanism. We also searched for all published SFSA cases in the worldwide literature for further analysis of demographics, comorbidities, and medium-term outcome.

Results: In our center, SFSA frequency was six out of 6,767 patients (0.0009%), with 83% being male. Comparing all reported 22 patients (own and published) to non-SFSA patients in ASTRAL, SFSA patients were younger (median 51 vs 75 years), had higher National Institutes of Health Stroke Scale scores on admission (median 13 vs 6) and higher three-months mortality (36 vs 15%). The most frequent mechanism was carotid dissection from hanging (41%), however, multiple other stroke mechanisms have been found or suspected.

Conclusions: SFSA are rare and seem to affect younger patients presenting with more severe strokes and higher medium-term mortality. While carotid dissection emerged as the predominant cause, several other stroke mechanisms have been identified.

Keywords: Carotid dissection; disorders of adult personality and behaviour; stroke; suicide attempt; vascular disorders

Introduction

Ischemic stroke is one of the leading causes of death and disability-adjusted life years (DALYs) [1]. It is caused by multiple mechanisms including cardiac diseases, atherosclerosis, cervical artery dissection and microangiopathy. On the other hand, suicide too is a major public health issue, being the 15th leading cause of death worldwide [2] and self-harm accounting for a significant number of DALYs. Suicide attempts are approximately 20 times more frequent than completed suicides [2] and

are the most important risk factor for subsequent suicides [3–6]. Although there is a debate about the exact proportion [7], most suicides are related to mental disorders [8], with mood disorders including bipolar disorders, substance use related disorders, schizophrenia and personality disorders being the most common diagnoses. Methods of suicide vary with time and between countries [2]. In 2021 in Switzerland, men attempted suicide by hanging (35%), firearm (20%), jumping from height (12%) or the tracks (11%), while women used

hanging (23%), drug poisoning (22%), jumping from height (18%) or the tracks (14%) [9].

Whereas suicide, suicide attempts and depression are well studied following a stroke, strokes following a suicide attempt (SFSA) are rarely reported. In total, we identified 16 cases in the worldwide literature [10–25].

Given the limited information available, more data is needed to assess the quality of the current evaluation and management of SFSA at our institution and elsewhere. We report a consecutive series of SFSA over 18 years in a single University hospital adding the published cases from the literature to assess the clinical presentation, mechanisms, quality of management, and outcome of patients with SFSA in ours and other institutions.

Methods

We retrospectively reviewed the discharge diagnoses of all hospitalized patients between 2003 and 2021 using the Acute Stroke Registry and Analysis of Lausanne (ASTRAL), the associated ASTRAL-E (includes transient ischemic attacks [TIAs], subacute strokes, intracerebral hemorrhage) and the electronic hospital archives. ASTRAL is a prospective cohort of all acute ischemic stroke patients admitted to the stroke unit and/or intensive care unit of the Centre Hospitalier Universitaire Vaudois (CHUV) within 24 hours of the last known well [26]. Stroke was defined according to the WHO definition as “a new syndrome of rapidly developing clinical symptoms and/or signs of focal disturbance of cerebral function lasting longer than 24 hours with no apparent

cause other than vascular origin, regardless of whether infarction was evident on cerebral radio imaging” [27]. We defined SFSA as strokes within seven days following a suicide attempt and compared them to all other consecutive patients from ASTRAL. To ascertain that no SFSA were missed, we searched our electronic medical records combining the terms “stroke” or “TIA” with “suicide attempt” or “suicide”.

Demographics, vascular risk factors, and acute clinical and radiological findings were collected, including the type of suicide attempt, mechanism of stroke, initial clinical deficit and findings on neurovascular imaging. Psychiatric comorbidities were considered present if an ICD-10 diagnosis used in the Elixhauser Comorbidity Index “depression” or “psychosis” was documented in the medical records. Clinical outcome measured by the modified Rankin Scale (mRS) was determined at seven days and three months after stroke onset.

In addition, we performed a literature search on Medline from 1964 onwards using the terms “suicide attempt”, “stroke”, “hanging”, “near-drowning”, “hara-kiri”, “toxic ingestion”, “carotid dissection”, “vene/venous section” in English, as well as screening the references of identified articles for further reports in any language. Native-speaking physicians extracted data from articles published in languages other than English. National Institutes of Health Stroke Scale (NIHSS) and mRS were reconstructed from the clinical descriptions in the identified cases.

We calculated the SFSA frequency among all acute ischemic stroke patients during the observation period in ASTRAL and in all suicide attempts visiting our emergency department. Then we combined available data from our SFSA patients with those published and compared them with all non-SFSA patients from ASTRAL analyzing the baselines characteristics of both groups. Continuous variables were described as median \pm interquartile range and categorical variables were expressed as percentages. Given the small number of patients in the SFSA group, only descriptive comparisons were reported.

The study was performed according to the guidelines of the cantonal ethics commission for research on humans of the Canton of Vaud. Although patients received a written information from the hospital that their routinely collected clinical data may be used for quality and scientific purposes, a patient’s decision to opt out from data analysis did not need to be considered because this was a quality assurance project of the diagnostic/treatment practice in our institutions. Such analyses aiming at the evaluation of treatment efficiency and safety for quality purposes fall outside the Swiss Human Research Act of 2011.

Results

During the observational period, six out of 6,767 acute ischemic strokes (0.0009%), and six out of 14,587 suicide attempts (0.0004%) were identified as SFSA in our center. We excluded a 7th patient with a suicide attempt with a benzodiazepine overdose for not fulfilling our definition of SFSA.

Among the six patients included, five were male, with a median age of 47 years. The initial NIHSS score was four (median, range 0–7). The patients had few stroke risk factors and all of them had a history of psychiatric disorders (table 1).

The mechanisms leading to stroke varied and were linked to the type of suicide attempt. Two suicide attempts were by hanging, three by hemorrhage (two venesection and one arterial section – Hara-kiri), and one by drowning in a lake. The drowning patient (patient #1) had an embolus from insufficiently anticoagulated atrial fibrillation (AF) as the presumed stroke mechanism occurring simultaneously with the suicide attempt. In the hanging attempts (patients #2 and #5), the stroke mechanism was carotid dissection, whereas in the patients with extensive hemorrhage (patients #3, #4 and #6), several stroke mechanisms could be suspected: A) hypotension due to hypovolemia with border-zone infarction, B) activation of the coagulation cascade (e.g., factor VII expression) due to acute bleeding with systemic hypercoagulability, and/or C) hypothetical cardiac arrhythmia related to the activation of the coagulation cascade due to acute blood loss leading to thromboembolic stroke.

Below there is a summary of the circumstances of each SFSA patient (for further details see table 2).

Patient #1: Attempted drowning in a lake. The patient was found comatose, hypothermic (26.8 °C) and with a Glasgow Coma Scale of 8, leading to intubation. A moderate left hemisphere was not registered. After extubation on the next day, the diagnosis of a right deep middle cerebral artery (MCA) embolic stroke was made using computed tomography. The suicide attempt followed the diagnosis of a TIA due to a new onset AF five days earlier. A vitamin K antagonist had been started (international normalized ratio [INR] = 1.1 on admission). The likely stroke mechanism was AF related to insufficient anticoagulation. There was no psychiatric diagnosis except for an adjustment disorder following the TIA diagnosis.

Patient #2: Found hanging on a rope from a tree, probably after a few minutes. Right embolic MCA stroke from right internal carotid artery dissection. Diagnosed with recurrent major depressive disorder (MDD).

Patient #3: Venesection in the neck, both wrists and legs with a kitchen knife. The patient called the daughter afterwards. Suffered multilevel posterior circulation strokes with a fall of hemoglobin from 155 to 109. As indicated before, in patients with extensive hemorrhage (patients #3 and #4), several stroke mechanisms can be suspected. Figure 1 shows the neuroimaging for patient #3. The patient was diagnosed with recurrent MDD with psychotic features and a not otherwise specified personality disorder.

Table 1: Characteristics of all reported strokes following a suicide attempt (SFSA) and comparison with a consecutive sample of 6,767 acute ischemic strokes from the Acute Stroke Registry and Analysis of Lausanne (ASTRAL).

| | SFSA patients in our center | All SFSA patients reported | Control group (ASTRAL) |
|---|-----------------------------|----------------------------|------------------------|
| N | 6 | 22 | 6767 |
| Female, n (%) | 1 (17%) | 6 (27%) | 2996 (44%) |
| Age (years), median (IQR) | 47 (38–56) | 51 (36–59) | 75 (63–83) |
| Admission NIHSS, median (IQR) ¹ | 4 (0–7) | 13 (5–27) | 6 (3–14) |
| mRS (7 days), median (IQR) | 3 (0–4) | 4 (2–6) | 2 (1–4) |
| mRS (3 months), median (IQR) | 1 (0–2) | 3 (1–6) | 2 (1–4) |
| Mortality (7 days), n (%) | 1 (17%) | 7 (32%) | 352 (5%) |
| Mortality (3 months), n (%) | 1 (17%) | 8 (36%) | 944 (15%) |
| Psychiatric comorbidity, n (%) ² | 6 (100%) | NA | 879 (13%) |

IQR: Interquartile range; mRS: Modified Rankin Scale; NIHSS: National Institutes of Health Stroke Scale; NA = Not available.

¹ For the patients identified in the literature, the admission NIHSS and long-term outcomes were estimated from the descriptions.

² Only data from patients of our center was used because of missing data in the published cases.

Table 2: Description of the six SFSA patients in our center

| | Age (years), sex | Type of suicide attempt | Stroke diagnosis and presumed mechanism | Initial neurological deficits | Psychiatric diagnosis Cerebrovascular risk factors Comorbidities | Imaging findings | Complementary exams | NIHSS on admission, NIHSS on admission, 7 days, 3 months | Clinical outcome* (mRS at 7 days, 3 and 12 months) |
|----|------------------|--|---|--|--|---|--|--|--|
| #1 | 80, f | Self-drowning in a lake. Found comatose and hypothermic (26.8 °C). | Right deep MCA embolic stroke. Earlier diagnosis of intermittent AF 5 days before. AF episode on admission. | Left hemiparesis. | Left MCA-TIA 5 days earlier with new onset intermittent AF. Acute adjustment disorder probable with anxiety and depression. Hypertension, type 2 diabetes. | CT (day 1): frontal right subcortical stroke. MRI (day 6): unchanged. | ECG monitoring: intermittent AF. Cardiac US: bi-atrial dilatation, PFO not searched. | 3, 1, 0 | 0, 0, 0 |
| #2 | 52, m | Found hanging from a tree after a few minutes. | Right embolic MCA stroke from occlusive right ICA dissection. | Left-sided sensorimotor hemisyndrome and multimodal hemineglect. Left lateral homonymous hemianopia and astereognosis. | MDD. Acute fracture of the thyroid cartilage. | CT (acute): right MCA cortical swelling. CT (day 1): right MCA cortico-subcortical effacement. CTA (day 1): occlusion probable dissection of the right ICA. CT (3 months): chronic strokes of the right MCA. | None | 7, 7, 0 | 1, 0, 0 |
| #3 | 58, m | Venesection in the neck, both wrists and legs with a kitchen knife. Called for help. | Multilevel posterior circulation strokes. Potential mechanisms: A) hypotension due to hypovolemia; B) systemic hypercoagulability from acute bleeding; C) cardiac arrhythmia related to acute blood loss. | Partial Wallenberg's syndrome with cerebellar syndrome, dysarthria, right Horner's syndrome, left corticospinal signs and discrete contralateral sensitive hemisyndrome. | Recurrent MDD with psychotic features, not otherwise specified personality disorder. Suicide attempt with benzodiazepines 1.5 months earlier. Non-specified personality disorder. Type 2 diabetes. Smoking 90 py. Mild hyperhomocysteinemia. | CT, CTP, CTA (acute): mild atherosclerosis. CT (day 1): ischemic lesion of bilateral PICA (right>left), left PCA. Cortical lesions in left occipital, subcortical temporal-occipital and left temporal areas. CT (day 3): mass effect on right PICA lesion. CT (day 20): mild hemorrhagic transformation of the right PICA and left PCA lesions (fig. 1). | ECG monitoring: no arrhythmias. Cardiac US: preserved left ventricular function without segmental dysfunction; negative PFO. | 5, 5, 2 | 4, 2, 1 |
| #4 | 44, m | Hara-kiri-like self-stabbing with a kitchen knife injuring left thoracic cage, pleura, pericardium, diaphragm, stomach walls, transverse colon, liver and a section of the gastropiploic artery. | Right embolic posterior MCA and left posterior junctional stroke. Presumed mechanism: see patient #3. | Anhedonia, amnesia, ideomotor apraxia. | MDD with psychotic features. Traumatic pericardial tamponade. Voluntary hospitalization in a psychiatric hospital 2 months before for insomnia and depression. | CT (day 5), MRI (day 6): right posterior superficial MCA and left posterior border zone lesions. MRA (day 6): normal (fig. 2). | Cardiac US: preserved left ventricular function without segmental dysfunction; negative PFO. | 0, 36, 36 | Suicide by defenestration (day 4) |
| #5 | 26, m | Found hanging from a balcony after 5 minutes. | Occlusive dissection of the left common and internal carotid artery. | Likely epileptic seizure when found. Slight asymmetry of contraction of the left soft palate. | Suspected bipolar disorder. Cervical and supraglottic edema with involvement of the left recurrent laryngeal nerve and paralysis of dilator muscle of the left vocal cord. | CT (acute): normal. CTA: occlusion of the left distal CCA. CTP normal. CT (day 1): normal. CTA: partial recanalization, stenosing thrombi at origin of the left internal and external carotid. MRI (day 6): small left deep and superficial posterior border zone lesions. MRA (3 months): irregular bifurcation of the left ICA. | None | 0, 0, 0 | 0, 0, 0 |

Table 2: Description of the six SFSA patients in our center (continuation)

| | Age (years), sex | Type of suicide attempt | Stroke diagnosis and presumed mechanism | Initial neurological deficits | Psychiatric diagnosis Cerebrovascular risk factors Comorbidities | Imaging findings | Complementary exams | NIHSS on admission, NIHSS on admission, 7 days, 3 months | Clinical outcome* (mRS at 7 days, 3 and 12 months) |
|----|------------------|--|---|--|--|--|---------------------|--|--|
| #6 | 36, m | Self-inflicted stab with cervicotomy and phlebotomy of the palmar side of the left wrist. Cardiac arrest with low flow of 5 min. | Multiple ischemic lesions of the bilateral parieto-occipital territories and bilateral frontal of the junctional territories. | Paresis of the right-sided cranial nerve XII, initial plegia of the right lower limb. Impairment of verbal memory and executive functions. | Acute and transient psychotic disorder, unspecified cannabis and cocaine dependence. | CT, CTA (day 2): multiple ischemic lesions of the bilateral parieto-occipital territories and bilateral frontal of the junctional territories without arterial dissection. | None | 12, 1, 0 | 4, 1, 1 |

AF: Atrial fibrillation; CCA: Common carotid artery; CT: Computed tomography; CTA: Computed tomography angiography; CTP: Computed tomography perfusion; ECG: Electrocardiogram; f: Female; ICA: Internal carotid artery; m: Male; MCA: Middle cerebral artery; MDD: Major depressive disorder; MRA: Magnetic resonance angiography; MRI: Magnetic resonance imaging; mRS: Modified Rankin Scale; NIHSS: National Institutes of Health Stroke Scale; PCA: Posterior cerebral artery; PFO: Patent foramen ovale; PICCA: Posterior inferior cerebellar artery; py: Pack year; SFSA: Stroke following a suicide attempt; TIA: Transitory ischemic attack; US: Ultrasound. * No patient was thrombolized. All patients received acetylsalicylic acid 100 mg after stroke confirmation. Patient #1 and #5 received long-term and transitory oral anticoagulation, respectively.

Patient #4: Hara-kiri-like self-stabbing with a kitchen knife resulting in multiple thoracic and abdominal injuries requiring several blood transfusions. Potential stroke mechanisms after extensive hemorrhage apply. Acute neuroimaging showed bihemispheric strokes (fig. 2). The patient was diagnosed with MDD with psychotic features. The patient committed in-hospital suicide by defenestration after having been transferred from the intensive care unit to the visceral surgery division four days after the initial suicide attempt.

Patient #5: Found hanging from a balcony after five minutes. Suffered from occlusive dissection of the left common and internal carotid artery. Patient was suspected to have a bipolar disorder.

Patient #6: Self-inflicted stab resulting in a cervicotomy and phlebotomy of the palmar side of the left wrist. Cardiac arrest with low-flow duration of five minutes. Suffered from multiple bilateral ischemic lesions in the parieto-occipital territories and the junctional regions. The patient was diagnosed with an acute and transient psychotic disorder combined with cannabis and cocaine dependence.

One patient exhibited clinical signs of post-anoxic encephalopathy, which was confirmed by a subacute magnetic resonance imaging. None of the patients underwent thrombolysis. All patients received 100 mg of acetylsalicylic acid following confirmation of the stroke. Patient #1 (confirmed AF) received long-term and patient #5 transitory oral anticoagulation, respectively.

The overall clinical outcome was positive, with a mRS of 0 at three months in four patients. Patient #4, who committed in-hospital suicide had had no major neurologic deficit at

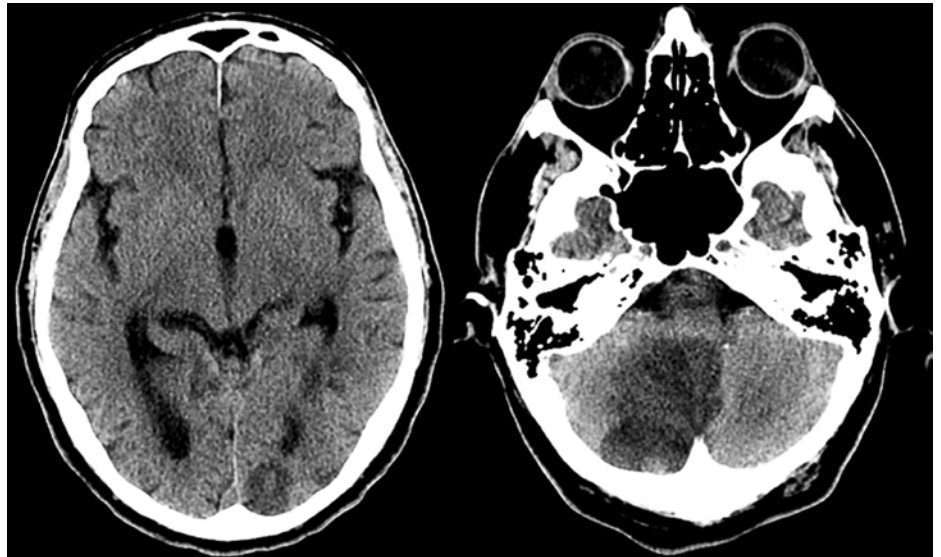


Figure 1: Acute (24 hours) non-contrast computed tomography from patient #3 with multilevel posterior circulation strokes.

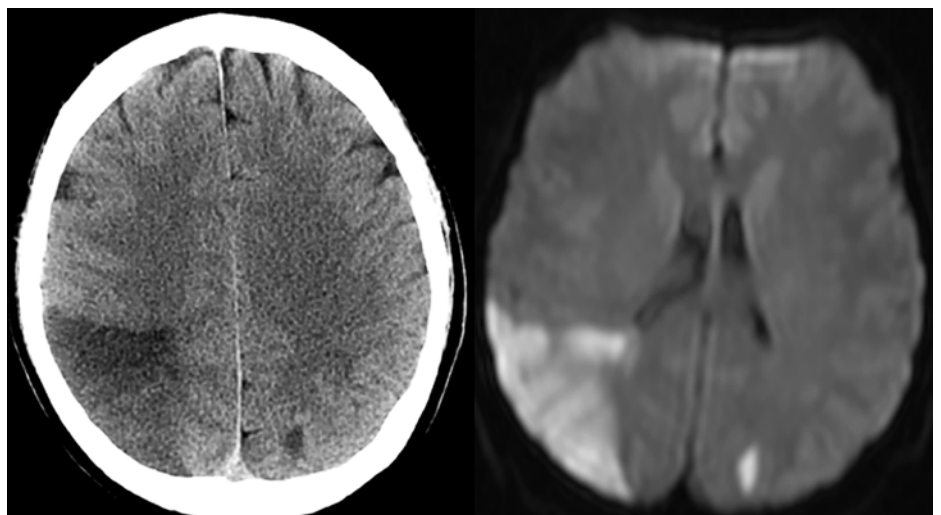


Figure 2: Subacute non-contrast computed tomography (left) and diffusion-weighted magnetic resonance imaging (right) from patient #4 with bihemispheric strokes.

Table 3: Characteristics of all SFSA case reports in the literature

| | Age (years), sex | Type of suicide attempt | Stroke localization | Stroke diagnosis and presumed mechanism | Neurological deficits | Imaging findings | Early outcome |
|--------------------------------------|------------------|--|--|--|--|--|--|
| Samniah et al. (1988) [17] | 38, f | Ingestion of high doses of verapamil (2280 mg). | Right MCA. | Focal lesion probably secondary to severe hypotension. | Stupor, peripheral pulses not palpable, blood pressure undetectable. Patient developed left hemiparesis 48 h later. | CT (48 h): right temporo-parietal infarction. Patient refused CTA. | Persistent left hemiparesis (no further details). Estimated mRS: 3. |
| Onishi et al. (1989) [10] | 84, m | Hanging with a rope. | Anterior and left middle cerebral arteries. | Bilateral ICA dissection with embolic strokes. | Semicoma, right hemiparesis. Estimated NIHSS = 36. | CT: massive cerebral infarction in the territory of the anterior and left middle cerebral arteries. CTA: linear shadow defect of the left extracranial ICA corresponding with the ligature site. | Conservative treatment and transference to another institution after one month. Total aphasia and the right hemiparesis remained. Estimated mRS (day 7): 5. |
| K. Noguchi et al. (1992) [11] | 50, f | Hanging with a rope. | Right CCA. | Dissection of the right CCA. | Loss of consciousness, strangulation marks on the neck, facial edema, multiple conjunctiva petechiae. Estimated NIHSS = 36. | CT (2 years): atrophic changes. Angiography (2 years): approximately 80% stenosis of the right CCA. | Gradual recovery except for left upper limb weakness (left brachial plexus injury). Estimated mRS (day 7): 3. |
| Ikenga et al. (1996) [13] | 63, m | Hanging with a rope. | Left ICA. | Dissection of the left CCA. | Total aphasia, right hemiparesis, left ptosis. Estimated NIHSS = 30. | CT: no abnormal findings. MRI (day 2): multiple infarctions in the left fronto-temporo-parietal and basal ganglia. MRA (day 2): severe stenosis of the cervical ICA portion, occlusion of the left MCA. | Treatment with thiamylal infusion. Gradual recovery of the aphasia and hemiparesis. Estimated mRS (day 7): 5. |
| Hausmann et al. (1997) [12] | 58, m | Hanging (rope torn after jumping resulting in a 3-meter fall). | Massive bilateral carotid territory strokes (autopsy). | Bilateral CCA occlusion from carotid trauma (probably dissection). | Initially no neurologic deficit. Fractures of the calcaneus bones on both sides. Acute hemiplegia (day 4). Estimated initial NIHSS = 36. Died a few hours later of central regulation failure. | No cerebral imaging. | Autopsy revealed submucosal hemorrhages of the epiglottis. Incomplete rupture of both CCAs. Mixed post-traumatic thrombosis. Diffuse encephalomalacia, hemorrhagic alveolar and interstitial lung edema. mRS (day 7): 6. |
| Blanco et al. (2002) [18] | 33, m | Hanging attempt and drug overdose. | Left ICA, extending to the MCA. | Dissection of the left CCA and occlusion from ICA. | Right hemiplegia. | CT: extensive cerebral infarction (no further details). | Subsequent progressive decline of condition, necessitating the initiation of mechanical ventilation. Died four days later. mRS (day 7): 6. |
| Takeuchi et al. (2009) [19] | 29, m | Hanging. | PCA bilateral (RPLS) | Transient hypertension during hanging might have caused RPLS. Alternatively, hypoperfusion due to hanging might have led to breakage of the blood-brain barrier. | Moderate disturbance of consciousness (GCS 11). No motor weakness or sensory disturbance. Binocular inferior quadrant hemianopsia (day 7). | CT (admission): normal. CT (day 9): bilateral occipital lobes with low density areas in the white matter, partial hemorrhagic change. MRI: bilateral occipital lobes with hyperintensity in the white matter on T2-weighted images. MRA: normal. | Follow-up MRI (day 25): remarkable resolution of the abnormal signals except for the hemorrhagic lesion. mRS (day 7): 2. |
| Garaci et al. (2009) [14] | 37, f | Hanging. | Right thalamus and left cerebellum. | Ischemic arterial event. | Disturbed eye movement, delirium with impairment of memory and executive functions. Estimated NIHSS = 5. | CT (ER): no acute lesion. CT (day 8): low density area in the right thalamus. MRI (day 8): hyperintense area on the right thalamus and left cerebellum on both T2-weighted and FLAIR images. DWI: no area of diffusivity restriction. No cervical arterial dissection. | Slight anterograde memory deficits still present after one month. Estimated mRS (day 7): 2. |
| Kadic et al. (2010) [20] | 59, m | Hanging. | Left ICA. | Dissection of the left CCA and occlusion from ICA. | Initially aphasia and peripheral right facial nerve paralysis. Loss of consciousness and admission to the ICU in the following hours. | CT: total occlusion of the left ICA at the bifurcation. Large left cerebral infarction with diffuse cerebral swelling and midline shift. | Loss of consciousness and admission to the ICU. Died the following day. mRS (day 7): 6. |
| Šupe et al. (2013) [15] | 59, m | Hanging (found 2 min after). | Right MCA territory. | Atherosclerotic (subocclusive stenosis of the right and 70% stenosis of the left ICA). | On arrival: deeply somnolent, without any focal neurological deficits. After 25 min: left-sided hemiplegia. NIHSS = 14. | CT (ER): no acute lesion. CT (25 min): no acute lesion. CT (24 hours after thrombolytic treatment): acute ischemic right MCA territory. | Thrombolysis. Improvement after thereafter. NIHSS = 5. Estimated mRS (day 7): 2. 4 weeks: NIHSS = 3 (mRS 1). Rehospitalization for endovascular treatment six weeks after stroke. |

Table 3: Characteristics of all SFSA case reports in the literature (continuation)

| | Age (years), sex | Type of suicide attempt | Stroke localization | Stroke diagnosis and presumed mechanism | Neurological deficits | Imaging findings | Early outcome |
|-------------------------------------|------------------|--|---|---|---|---|--|
| Abedini et al. (2014) [21] | 30, m | Ingestion of three rice tablets containing Aluminum phosphide. | Right MCA. | Possible congestion and coagulative necrosis in brain tissue. A similar mechanism appears to induce cerebral vessel injury and activate thrombosis formation cascade, leading to vascular stenosis, ischemic stroke, and in situ thrombosis development in the MCA stem. | Sudden onset of left-sided hemiplegia and dysarthria. NIHSS = 16. | MRI: ischemic lesions in the right MCA territory. | Favorable outcome. Patient was discharged at day 11 with NIHSS = 13 and mRS 3. Re-evaluation after a month showed improvement in left-sided hemiparesis (MRC Scale = 3). |
| Nishiyori et al. (2014) [16] | 64, f | Ingestion of unknown dose of glyphosate surfactant herbicide. | Left hippocampus. | Unclear origin. Hippocampal infarction leading to psychiatric symptoms before drug overdose possible. Or, infarction occurred after the overdose, leading to a 'window period' in which she was able to acknowledge. No other toxic systemic manifestations of the drug were found. | Manifestation of delirium, confusion, and severe anxiety several hours after admission. Prominent short-term memory loss (forgot suicide attempt). Estimated NIHSS = 2. | CT: no acute lesion. Old infarction in the bilateral basal ganglia. MRI (day 9): small high-intensity lesion in the dorsal part of the left hippocampal body on the DWI. Memory tests demonstrated severe short-term recall deficits. | Over the course of a week gradual regression of confusion. Estimated mRS (day 7): 2. Follow-up memory test: partial improvement in some domains, persistent memory impairments. No abnormalities were found on a follow-up brain scan. |
| Garg et al. (2015) [23] | 58, m | Ethylene glycol toxicity after ingestion. | Left MCA, multiple bihemispheric lesions. | Precipitation of oxalate crystals (toxic metabolite of ethylene glycol) in the cerebral blood vessels leading to their obstruction. | Acute left-sided weakness and left visual field defect. | MRI: acute infarctions scattered throughout the brain along with generalized oedema. | Rapid deterioration and loss of consciousness which required intubation after admission. No neurological improvement 3 days later after discontinuing sedation, leading to death on the same day. Estimated mRS (day 7): 6. |
| Prevel et al. (2015) [22] | 49, f | Aceprometazine and lormetazepam poisoning (supposed ingested doses: 12 g and 32 mg, respectively). | Left sylvian and cerebellar infarctions. | Paradoxical embolism. The patient was found to have a PFO with an entrapped thrombus. | Moderate disturbance of consciousness (GCS 11). Anisocoria with non-reactive left mydriasis and body-part pyramidal syndrome. | CT: left sylvian and cerebellar infarctions complicated by perilesional edema causing an under falcorial engagement. Chest CT: massive bilateral proximal pulmonary embolism. | Neurological degradation (not specified). Patient died 2 days later. Estimated mRS (day 7): 6. |
| Wick et al. (2017) [24] | 36, m | CO-Intoxication. | Left cerebellum. | Cerebellar infarction due to CO-Intoxication. | Ataxia, dysarthria, nystagmus. | CT: extensive left-sided cerebellar infarction with hemorrhagic area and significantly enlarged internal cerebrospinal fluid spaces. | Improvement in neurological symptoms after hyperbaric oxygen therapy and surgical intervention to remove the infarcted cerebellar tissue. Estimated mRS (day 7): 2. |
| Kibayashi et al. (2019) [25] | 70, m | Hanging on the first floor with a hard electric cord. | Left CCA. | Traumatic dissection of the carotid artery. | Moderate disturbance of consciousness and right incomplete hemiparesis. | MRI (day 2): infarction of the left parietal region. MRA: complete occlusion of the left CCA. | Development of aspiration pneumonia. Died two and a half months after the suicide attempt. Estimated mRS (day 7): 5. |

CCA: Common carotid artery; CT: Computed tomography; CTA: Computed tomography angiography; DWI: Diffusion-weighted magnetic resonance imaging; ER: Emergency Room; f: Female; FLAIR: Fluid-attenuated inversion recovery; GCS: Glasgow Coma Scale; ICA: Internal carotid artery; ICU: Intensive care unit; m: Male; MCA: Middle cerebral artery; MRA: Magnetic resonance angiography; MRC: Medical Research Council; MRI: Magnetic resonance imaging; mRS Modified Rankin Scale; NIHSS: National Institutes of Health Stroke Scale; PCA: Posterior cerebral artery; PFO: Patent foramen ovale; RPLS: Reversible posterior leukoencephalopathy syndrome; SFSA: Stroke following a suicide attempt.

that time. Patient #6 had a Heidelberg's anti-step splint for walking (mRS of 1).

Psychiatric comorbidity included acute depressive episodes (n = 2, one after a recent TIA), recurrent depressive disorder (n = 2, one with a previous suicide attempt), and acute and transient psychotic disorder (n =

1). Patient #5 was not formally evaluated by a psychiatrist but had a suspected bipolar disorder.

After reviewing the literature, we found 16 other cases from 1989 to 2023 [10–25]. As in our case series, variable suicide methods led to different types of strokes (table 3).

When comparing all 22 SFSA patients to the non-SFSA patients in the ASTRAL registry, we found the SFSA patients to be significantly younger (median age of 51 vs 75 years), with 83% being male. SFSA patients also had higher admission NIHSS scores (median of 13 vs. 6) and higher mortality rates at three

months (36 vs 15%). The six patients in our center exhibited a higher incidence of psychiatric comorbidities. The most common stroke mechanism was carotid dissection due to hanging (41%), but several other stroke mechanisms have been identified or were suspected.

Discussion

This retrospective review of SFSA in a single institution and in the literature shows that this association is exceedingly rare and that the underlying stroke mechanisms are heterogeneous. Given that this is, in part, a quality assurance project, compared to other stroke patients, patients with SFSA are younger, most of them are male and have a higher incidence of psychiatric comorbidities. The observed three months mortality rate was about two times higher in SFSA patients compared to the older control group.

Various mechanisms of SFSA have been identified, with carotid artery dissection from hanging being the most frequent. Given that hanging is the most common method of suicide reported in Switzerland, it is likely that cervical artery dissection is the most prevalent mechanism of stroke among the studied population. During the observation period, out of the 14,587 suicide attempts documented in our center, only six patients were identified with SFSA. This data underscores the rarity of stroke following a suicide attempt.

Regarding psychiatric comorbidities, we found a significant difference between the observed cases in our center and the ASTRAL database. All six patients suffered from a significant psychiatric illness, compared to only 12.4% in non-SFSA stroke patients. This difference can be explained by the fact that psychiatric disorders are the most common cause for completed and attempted suicide including severe suicide attempts, defined as a suicide attempt that “would have been fatal had it not been for rapid and effective pre-hospital care or other emergency treatment, or in some cases, chance” [28].

The neurological outcome of our six patients was mostly good. However, the overall three months mortality in all 22 reported cases was significantly higher compared to other stroke patients, despite the lower age. One of our patients committed suicide shortly after the suicide attempt, and the seven other patients who died according to the literature, did so from complications following the stroke, that would be massive cerebral infarction of the territory of both anterior and left middle cerebral arteries [10, 18, 20, 22, 23, 25], diffuse encephalomalacia, and hemorrhagic alveolar and interstitial lung edema [12]. This confirms

the potential traumatic severity of suicide attempts.

In conclusion, SFSA is exceedingly rare, but presents a unique clinical challenge due to the complex etiology involving both physical and psychiatric factors. Compared to general stroke patients, those with SFSA seem to be younger, predominantly male, have more severe strokes, and a higher medium-term mortality. The most common cause of SFSA in our study group was carotid artery dissection due to hanging, reflecting the high prevalence of this suicide method in Switzerland. Despite the elevated mortality rate, the possibility of favorable neurological outcomes for SFSA patients exists, indicating that with timely and suitable intervention, recovery may be achievable. Considering the rarity of SFSA relative to the total number of suicide attempts, there is a need for increased awareness among health-care professionals to ensure that these cases are recognized and managed appropriately.

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Ethics Statement

The study was performed according to the guidelines of the cantonal ethics commission for research on humans of the Canton of Vaud.

Conflict of Interest Statement

MS and MN reported no financial support and no other potential conflict of interest.

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Author Contributions

MS: Major contributor to design, acquisition, analysis, interpretation of data, writing, and revising the article.

LM: Significant contributions to design, analysis, interpretation of data, and revising the article.

PC and MN: Substantial contributions to data analysis and interpretation, and article revision.

PM: Substantial contribution to design, analysis, interpretation of data, and writing and revising the article.

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