# Differences in Ischemic Anterior and Posterior Circulation Strokes: A Clinico-Radiological and Outcome Analysis

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*Background:* There are limited data comparing posterior (PC) and anterior (AC) circulation acute ischemic strokes (AIS). We aimed to identify specific features of PC and AC strokes regarding clinical, etiological, radiological, and outcome factors. *Methods:* Patients from the Acute STroke Registry and Analysis of Lausanne, a prospective cohort of consecutive AIS, from years 2003 to 2008 were included. The stroke territory was determined by a combination of neuroimaging and clinical symptoms. Patients with uncertain localization or with simultaneous AC and PC strokes were excluded. Multivariate associations between territory and multiple variables were investigated. *Results:* A total of 1449 patients were included, 466 (32.2%) had a PC territory stroke and 983 (67.8%) an AC. On multivariate analysis, those with PC AIS had lower National Institutes of Health Stroke Scale at admission, more often showed decreased consciousness, visual field defects, and vestibulo-cerebellar signs, but less hemisyndromes, dysarthria, and cognitive symptoms compared to AC AIS patients. Male sex, arterial dissection, lacunar mechanisms, and endovascular recanalization were more frequent in PC strokes, whereas cardioembolic strokes and IV-thrombolysis rates were lower. Less early ischemic signs on admission CT, overall arterial pathology, and 24-hour recanalization were present in PC strokes but intracranial arterial pathology was more prevalent than in AC. The adjusted clinical outcome at 3 months was similar in both groups. *Conclusions:* In this large retrospective consecutive AIS series, there were specific differences in clinical presentation, etiology, and arterial pathology between PC and AC strokes which did not influence clinical outcome. These findings could lead to a tailored diagnostic work-up, acute treatment strategies, and secondary prevention.

**Key Words:** Clinical neurology—outcome—anterior circulation—posterior circulation



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Received May 17, 2018; revision received October 30, 2018; accepted November 8, 2018.

Dr. Michel reports grants from Swiss Heart Foundation, during the conduct of the study; grants and personal fees from Boehringer-Ingelheim, grants and personal fees from BMS, personal fees from Bayer, personal fees from Daiichi-Sankyo, personal fees from Medtronic, personal fees from Amgen, personal fees from Pfizer, personal fees from Astra-Zeneca, outside the submitted work. All personal fees are used for education and research.

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1052-3057/$ - see front matter



https://doi.org/10.1016/j.jstrokecerebrovasdis.2018.11.016

## Introduction

About 20% of the cerebral blood flow is directed to the posterior circulation (PC), explaining the approximate 20% rate of PC strokes observed in several case series.[1-5] Current data comparing PC and AC strokes with regards to clinical, etiological, radiological, and outcome factors are scarce and multivariate analyses were not applied[6,7-9] or are limited to large PC-only case series.[2,10,11] The arterial anatomy and the site of obstruction in PC and AC strokes show notable differences.[10,12] There are conflicting data about stroke mechanism in PC as compared to AC strokes. Some publications show more frequent embolism in the former,[3,13] and others more lacunas.[9] Initial stroke severity has received little attention in PC and AC stroke comparisons; however National Institutes of Health

Stroke Scale (NIHSS) seems to be less reliable for PC than AC strokes.[14,15]

It is therefore important to distinguish AC and PC strokes for stroke etiology and treatment may differ in the acute and chronic phases. Furthermore, PC strokes may simulate AC strokes clinically in a significant proportion of patients,[16-19] although clinical identification of circulation in candidates for acute thrombectomy seems straightforward.[20] Initial stroke severity, age, level of consciousness, hyperglycemia, and stroke mechanism[21-24] are associated with outcome after acute ischemic stroke (AIS) and may vary between AC and PC strokes. Only DiCarlo et al.[7] performed an adjusted outcome analysis and found higher disability and mortality rates in PC stroke at 3 months.

Little is known about the differential effects of acute recanalization treatment by thrombolysis in PC and AC, given that acute thrombolysis and thrombectomy treatment trials often include AC strokes only.[25-28] A retrospective case series of thrombolysed patients showed similar outcomes in PC and AC with lower intracerebral hemorrhage risk in PC patients.[24] A small randomized study of acute basilar occlusion found a potential benefit for intra-arterial thrombolysis.[29] Some advocate for longer recanalization windows in PC stroke,[2,30] but no solid evidence exists to support this hypothesis. The efficacy and risks from heparinoids do not seem to differ between AC and PC strokes.[6,31]

## Methods

All consecutive patients, included in the Acute STroke Registry and Analysis of Lausanne (ASTRAL) from January 2003 to July 2008, were selected, including lacunar strokes or strokes with minor deficit. ASTRAL is a prospective cohort of all AIS patients admitted to the stroke unit and/or intensive care unit of the Centre Hospitalier Universitaire Vaudois within 24 hours after last-well time, as published previously.[32] Patients with minor strokes also are admitted to the stroke unit with an initial continuous surveillance period of at least 24 hours. Patients with AIS whose last proof of good health was more than 24 hours before hospital arrival, patients with hemorrhagic strokes (intracerebral hemorrhage and subarachnoid hemorrhage), and patients with transient ischemic attacks as defined by complete disappearance of symptoms and signs within 24 hours were excluded from ASTRAL. Also, patients with uncertain localization on clinical and/or radiological grounds (n = 136) and patients with simultaneous strokes in the AC and PC (n = 43) were excluded.

Briefly, a large range of parameters were collected and recorded from ASTRAL in a prespecified manner and then analyzed retrospectively including: demographics, medical history, and cardiovascular risk factors (preexisting or newly diagnosed), current medications, clinical symptoms and signs, and vascular stroke territory.

The NIHSS is performed or supervised by NIHSS-certified personnel on admission. Stroke mechanism was classified according to TOAST[33] with dissections and multiple causes recorded as additional mechanisms.

Acute brain imaging on admission (mostly on CT scans, 64 detectors since 2005) was assessed for early ischemic lesions and silent strokes. At least one arterial study of cervical and cerebral arteries was obtained, mainly CT-angiography with multidetector-array technology in helicoidal mode in the acute phase of stroke, alternatively MR angiography and/or Doppler including transcranial Doppler in the acute or subacute phase of stroke. On the first good quality arterial study obtained within 24 hours of stroke onset, arterial abnormalities (i.e., stenosis $\geq$ 50% or occlusions) in the ischemic territory were recorded for all arterial segments as published in detail elsewhere.[20] Perfusion-CT (4 axial perfusion slices with 20 mm coverage before November 2005, 16 slices with 80 mm thereafter) was performed in most patients arriving less than or equal to 24 hours with a suspicion of supratentorial stroke and assessed for acute focal hypoperfusion to help determine the stroke territory.

Repeat brain CT or MRI was usually performed at 24 hours after stroke onset in patients receiving acute recanalization treatment. Imaging was also repeated during the hospital stay in any nonpalliative patients when clinically indicated, such as worsening in cases of greater than or equal to 2 NIHSS points. Imaging was assessed for ischemic and hemorrhagic changes; the latter were classified into radiological and clinically symptomatic groups according to ECASS-II.[25]

In patients with initial arterial occlusion, recanalization was reassessed at 24 hours (permitted range 12-48 hours) using angio-CT, angio-MRI, or Doppler imaging. Recanalization of initially occluded intracranial arteries was classified as absent, partial, or complete as published in detail elsewhere[20]; for this analysis, partial recanalization was grouped with no recanalization. The proportion of patients with radiological brain edema was calculated for the admission imaging performed less than or equal to 24 hours of stroke onset, and again in the subacute phase (i.e., >24 hours after stroke onset) for patient who had subacute imaging. Radiological edema was defined as brain swelling with at least 5 mm midline displacement supratentorially, or at least 2 mm infratentorially.

The acute stroke territory was determined by a combination of clinical symptoms and signs as well as neuroimaging, as described above. The following territories were attributed to the AC: anterior choroidal artery, middle cerebral artery, anterior cerebral artery, and posterior cerebral artery if supplied by a dominant posterior communicating artery. The following territories were considered as belonging to the PC: vertebral artery territory, basilar artery, posterior cerebral artery supplied mainly by the basilar artery and stroke with unmistakable brainstem/cerebellar signs despite absence of radiological lesions.

Thalamic strokes were attributed to the PC with the exception of lateral geniculate lesions (vascularized by the anterior choroidal artery). The results of vascular imaging were not used for this categorization.

Whenever possible, intravenous thrombolysis was started within 3 hours. Endovascular treatment (mechanical thrombectomy, intra-arterial thrombolysis, or intravenous thrombolysis followed by mechanical thrombectomy) was performed according to the Swiss guidelines during the study period,[34] that is, NIHSS was greater than or equal to 6 at the time of treatment and treatment could be initiated within 6 hours of symptom onset. The rest of the acute stroke management and secondary prevention of ASTRAL patients followed current European Stroke Organization guidelines.[25]

Rankin score and living situation was assessed by Rankin-certified personnel in an unblinded manner at 3 months in the outpatient clinic or using a structured telephone interview in patients not able to attend the 3 months clinic.

The variables described above were compared in patients with isolated AC and PC strokes and described using odds ratios and its associated $P$ values in order to quantify the strength of the association. Missing data were not imputed. In direct comparisons, we aimed to exclude a type 1 error (alpha error) with 5% likelihood (e.g., $P < .05$); this threshold was then used to fit a multivariate logistic model in order to determine patient- and stroke-related variables independently associated with PC strokes. This multivariate analysis (MVA) did not include stroke symptoms as these may overshadow pathophysiological differences and treatment decisions. We did however perform a separate MVA for symptoms in order to identify a clinical pattern of PC versus AC stroke patients upon hospital arrival; this MVA was adjusted for demographic variables shown to be different between PC and AC strokes in the current analysis, that is, prestroke mRS, age, gender, onset-to-hospital delay, and known versus unknown time of onset.

We compared favorable outcome at 3 months, defined as mRS 0-2 in patients with a prestroke mRS less than or equal to 2, between PC and AC and adjusted this for variables shown to be different between PC and AC strokes in the current analysis, or to influence prognosis of AIS in our previous analysis[35]: prestroke mRS, age, gender, admission NIHSS, onset-to-hospital delay, known versus unknown time of onset, thrombolysis or endovascular treatment within recommended time frames, stroke mechanism (TOAST), decreased level of consciousness, and visual field deficits. We also performed an unadjusted comparison of the mortality at 3 months after stroke, and of different causes of death. The latter were classified as death directly related to stroke (such as cerebral herniation), death from another vascular cause, death from nonvascular cause, and unknown cause of death.

The ethics commission for research on humans of the Canton of Vaud (ECCV), subcommission III, approved the scientific use of anonymized data from ASTRAL according to local legislation which does not require patient consent for routinely collected patient data for retrospective analyses.

## Results

There was little difference in demographics, stroke risk factors, and prestroke treatment between AC and PC patients except for higher rates of male sex in PC strokes (Table 1). In MVA, PC patients were more male sex, arrived later at the hospital, and more often had known time of stroke onset (Table 4). The severity of PC strokes, measured by NIHSS, was less severe on admission. Regarding specific symptoms and signs, PC patients had less paresis, sensory deficits, aphasia and neglect, and more visual field defects, cerebellar or (central) vestibular signs and symptoms, and decreased level of consciousness (Table 5); using stroke symptoms including age, gender, and known time of onset, the area under the receiver-operator curve (ROC-AUC) reached .91 for prediction of PC strokes. The only pathognomonic symptom for PC stroke was oculomotor brainstem signs which were found in 34.7% of PC patients and only 1 out of 983 patients with supratentorial stroke (conjugate horizontal nystagmus beating to the left in a patient with right frontal middle cerebral artery stroke).

Regarding the stroke mechanism, dissections, lacunar, and unknown mechanisms were more often found in PC and cardiac causes less often (Tables 1 and 4).

The MVA showed less early ischemic signs on acute imaging in PC strokes. Arterial abnormalities in the ischemic territory were about 2 times more frequent in AC patients, both for intra- and extracranial vessels (Table 3), but this difference did not remain significant in the MVA. Occluded arteries recanalized more frequently in AC in unadjusted comparisons, both intra- and extracranially (Table 3); this difference did not remain significant after adjusted analysis.

AC patients were more often thrombolysed and PC patients more frequently received acute endovascular revascularization procedures (Tables 2 and 4).

Symptomatic hemorrhagic transformation (independently or not of thrombolysis) was somewhat more frequent in AC patients in univariate analysis (Table 3). When checked, the frequency of radiological brain edema in the subacute phase was 1.9% in PC patients, which was significantly lower than the 6.6% in AC stroke (Table 3).

Whereas favorable outcome at 3 months was twice as frequent in PC in unadjusted analysis, this outcome was not significantly different (odds ratio 1.19, 95% confidence intervals .80-1.78) after adjustment for multiple variables.

There was no significant difference between PC and AC stroke in the unadjusted comparison of causes of death

**Table 1.** *Univariate comparisons of demographics, stroke risk factors, and treatment before stroke onset*

| Variable | Overall | PC | AC | Odds ratio with 95% confidence intervals | *P* value |
|---|---|---|---|---|---|
| Number of patients | 1449 | 466 (32.2%) | 983 (67.8%) | - | - |
| Age (years ± SD) | 68.74 | 66.8 (±16.3) | 69.7 (±15.6) | .99 | .002 |
| Male sex | 811 | 286 (61.4%) | 525 (53.5%) | 1.38 (1.10-1.74) | .005 |
| Private insurance status | 275 | 92 (19.7%) | 183 (18.6%) | 1.07 (.81-1.42) | .610 |
| Risk factors | | | | | |
| Previous TIA or stroke | 390 | 132 (28.4%) | 258 (26.3%) | 1.11 (.87-1.42) | .403 |
| Hypertension | 932 | 295 (64.1%) | 637 (66.3%) | .91 (.72-1.15) | .424 |
| Diabetes mellitus | 203 | 56 (12.3%) | 147 (15.3%) | .77 (.56-1.07) | .124 |
| Hypercholesterolemia | 883 | 305 (66.6%) | 578 (60.6%) | 1.30 (1.03-1.63) | .029 |
| Smoking | 312 | 92 (20.1%) | 220 (22.9%) | .85 (.64-1.11) | .237 |
| Atrial fibrillation | 375 | 75 (16.4%) | 300 (31.2%) | .43 (.33-.57) | <.0001 |
| Coronary artery disease | 201 | 54 (11.8%) | 147 (15.3%) | .74 (.53-1.03) | .073 |
| Prosthetic valve | 42 | 14 (3.1%) | 28 (2.9%) | 1.05 (.55-2.02) | .862 |
| Ejection fraction ≤35% | 71 | 15 (3.3%) | 56 (5.9%) | .55 (.31-.98) | .041 |
| Prestroke medications | | | | | |
| Antiplatelets | 501 | 157 (34.1%) | 344 (35.5%) | .94 (.74-1.18) | .590 |
| Anticoagulation | 159 | 45 (9.8%) | 114 (11.9%) | .81 (.56-1.16) | .247 |
| Antihypertensive | 777 | 233 (50.7%) | 544 (56.4%) | .79 (.64-.99) | .043 |
| Anticholesterol | 216 | 105 (22.8%) | 211 (21.9%) | 1.05 (.81-1.38) | .699 |
| Any of these preventive treatments | 937 | 284 (61.6%) | 653 (67.4%) | .78 (.62-.98) | .031 |
| Mechanism of stroke | | | | | |
| Atherosclerosis | 187 | 45 (9.8%) | 142 (14.8%) | 1.09 (.73-1.61) | .673 |
| Cardiac | 510 | 115 (25.1%) | 395 (41.3%) | .61 (.38-.62) | <.0001 |
| Lacunar | 141 | 98 (21.4%) | 43 (4.5%) | 7.80 (5.17-11.85) | <.0001 |
| Dissection | 76 | 28 (6.1%) | 48 (5.0%) | 2.00 (1.20-3.34) | .008 |
| Rare or multiple causes | 127 | 32 (7%) | 95 (9.9%) | 1.20 (.74-1.82) | .527 |
| Unknown | 375 | 141 (30.7%) | 234 (24.5%) | 2.07 (1.54-2.78) | <.0001 |

Values are expressed as means and standard deviation (SD) for continuous variables, or absolute counts, and percentage for categorical variables.

**Table 2.** *Stroke onset, severity, acute treatment, symptomatic hemorrhagic transformation, and clinical outcome with univariate comparisons*

| Variable | Overall | PC | AC | Odds ratio with 95% confidence intervals | *P* value |
|---|---|---|---|---|---|
| Number of patients | 1449 | 466 (32.2%) | 983 (67.8%) | - | - |
| Mean interval from last well time to CHUV (min. ± standard deviation)* | 400.5 (±386.9) | 439.7 (±379.6) | 382.2 (±389.13) | 1.01 | <.0001 |
| Known time of stroke onset | 975 (67.3%) | 337 (74.1%) | 638 (67.6%) | 1.41 (1.11-1.80) | .005 |
| NIHSS on admission (mean ± standard deviation) | 9.1 | 5.9 (±7.4) | 10.6 (±7.4) | .90 | <.0001 |
| Any acute revascularization treatment | 239 (16.5%) | 28 (6.0%) | 211 (21.5%) | - | - |
| IV thrombolysis only | 222 (15.3%) | 20 (4.3%) | 202 (20.5%) | .11 (.04-.32) | <.0001 |
| Endovascular treatment and combined treatment | 17 (1.2%) | 8 (1.7%) | 9 (.9%) | 9.0 (3.12-25.85) | <.0001 |
| Unfavorable outcome at 7 days (Rankin > 2) | 614 (42.4%) | 136 (30.0%) | 478 (50.9 %) | .44 (.34-.55) | <.0001 |
| Unfavorable outcome at 3 months (Rankin > 2) | 423 (29.2%) | 100 (26.8%) | 323 (42.1%) | .56 (.43-.72) | <.0001 |
| Death 7 days | 60 (4.1%) | 17 (3.6%) | 43 (4.4%) | .81 (.46-1.44) | .475 |
| Death 3 months | 170 (11.7%) | 39 (10.5%) | 131 (17.1%) | .57 (.39-.83) | .004 |
| Death directly related to stroke | 56 (32.9%) | 13 (33.3%) | 43 (32.8%) | 1.02 (.48-2.19) | .549 |
| Death from another vascular cause | 9 (5.3%) | 2 (5.1%) | 7 (5.3%) | .96 (.19-4.80) | .660 |
| Death from nonvascular cause | 8 (4.7%) | 2 (5.1%) | 6 (4.6%) | 1.13 (.22-5.82) | .584 |
| Unknown cause of death | 97 (57.1%) | 22 (56.4%) | 75 (57.3%) | .97 (.47-1.99) | .534 |

*This OR was calculated for 30 min strata.

over the first 3 months. Half of the deaths in both groups were of unknown cause and about a third was directly related to stroke (Table 2).

## Discussion

In a comprehensive multivariate comparison of consecutive PC and AC stroke patients we found PC strokes to be associated with lower NIHSS scores, different clinical presentations, stroke mechanisms, imaging and arterial pathology, and recanalization modalities, but a similar adjusted 3 months clinical outcome to AC stroke.

The higher rate of male sex in PC strokes has been described before.[3,6,6] Interestingly, all other demographic variables and risk factors were very similarly distributed in our AC and PC stroke patients in multivariate analysis. Subramanian et al.[36] showed higher age and less diabetes in PC strokes whereas Kim et al.[37] found less diabetes and more hypertension.

Despite better known onset times of symptoms, delay to the hospital was longer in PC strokes, independently of their lower NIHSS. These differences were minor in absolute terms however.

Similar to others we found that admission NIHSS is lower in PC strokes.[6,9] This is likely due to insufficient weighting of PC symptoms, which may explain why the adjusted 3 months outcome is similar in PC strokes in our study despite a lower initial NIHSS.[14,15] NIHSS may be less useful for assessment of PC strokes including for thrombolysis decision.[14,15] In order to better assess the severity of PC AIS, a new scale might be useful, also to better assess the need for thrombolysis. With the results of this study, we observe that the most common signs and symptoms of acute PC strokes are visual field defects, cerebellar or (central) vestibular signs and symptoms, and decreased level of consciousness. This could serve as a basis for the creation of a new scale where existing NIHSS items are weighted differently (e.g., 4 points for tetra-ataxia), and other items (such as oculomotor brainstem findings, including nystagmus) may be added.

Although Tao et al. did not perform a multivariate analysis of specific clinical signs and symptoms present on the NIHSS, they also found hemiparesis to be less and vestibulo-cerebellar symptoms to be more frequent in PC strokes.[18] Similarly, dizziness was also the most prevalent symptom in the New England Medical Center Posterior Circulation Stroke Registry.[1] In contrast, a decreased level of consciousness and visual field deficits were more prevalent in our patients, in keeping with the function of the territories predominantly irrigated by the PC.

Surprisingly, dysarthria was less frequent in PC strokes in the univariate (but not multivariate) analysis. One reason could be that paresis and corticospinal signs are more frequent in AC strokes which will also lead to more corticobulbar signs and therefore dysarthria. On the other hand, PC strokes more often present with noncorticospinal

**Table 3.** *Acute imaging based on CT and/or MR if performed within 24 hours of stroke onset, and recanalization rates at 24 hours with univariate comparisons*

| Variable | Overall | PC strokes | AC strokes | Odds ratio with 95% confidence intervals | *P* value |
|---|---|---|---|---|---|
| Number of patients who had acute CT or MRI < 24 h of stroke onset | 1403 (96.8%) | 443 (31.6%) | 960 (68.4%) | - | - |
| Acute CT | 1357 (96.7%) | 422 (95.3%) | 935 (97.4%) | .54 (.30-.97) | .054 |
| Acute MRI | 24 (1.7%) | 12 (2.7%) | 12 (1.3%) | 2.20 (.98-4.94) | .082 |
| Both | 22 (1.6%) | 9 (2.0%) | 13 (1.4%) | 1.51 (.64-3.56) | .471 |
| Early ischemic changes | 487 (34.7%) | 95 (21.4%) | 392 (42.2%) | .40 (.30-.51) | <.0001 |
| Any silent strokes on imaging | 295 (21.0%) | 84 (20.0%) | 211 (23.4%) | .83 (.63-1.10) | .198 |
| Acute CTA or MRA findings | | | | | |
| Number of patients with acute CTA/MRA | 1155 (79.7%) | 367 (82.8%) | 788 (82.1%) | - | - |
| Occlusion or stenosis related to stroke | 606 (43.2%) | 125 (28.2%) | 481 (50.1%) | .33 (.25-.43) | <.0001 |
| Intracranial arterial abnormality | 507 (36.1%) | 110 (24.8%) | 397 (41.4%) | .42 (.32-.55) | <.0001 |
| Extracranial arterial abnormality | 268 (19.1%) | 52 (11.7%) | 216 (22.5%) | .44 (.31-.61) | <.0001 |
| Simultaneous intra- and extracranial abnormalities ("tandem lesions") | 182 (13.0%) | 41 (9.3%) | 141 (14.7%) | .58 (.40-.84) | .004 |
| Recanalization at 24 h with CTA/MRA | | | | | |
| Number of patients available with initial occlusion and assessment of recanalization | 348 (24.8%) | 76 (17.1%) | 272 (28.3%) | - | - |
| Intracranial recanalization | 121 (8.6%) | 11 (2.5%) | 111 (11.6%) | .25 (.12-.49) | <.0001 |
| Extracranial recanalization | 16 (1.1%) | 1 (.2%) | 15 (1.6%) | .23 (.03-1.76) | .101 |
| Overall recanalization* | 108 (7.7%) | 10 (2.3%) | 98 (22.1%) | .27 (1.13-.55) | <.0001 |
| Symptomatic intracranial hemorrhage < 7 d | 55 (3.8%) | 11 (2.4%) | 44 (4.6%) | .52 (.26-1.01) | .049 |
| Edema on acute admission CT/MRI | 6 (.4%) | 1 (.002%) | 5 (.5%) | .42 (.05-3.61) | - |
| Edema on subacute CT/MRI > 24 h (if checked) | 74 (5.1%) | 9 (1.9%) | 65 (6.6%) | .28 (.14-.56) | .000 |

*The number overall recanalizations may be lower than the sum of intra- and extracranial recanalization combined because the definition of overall recanalization requires that both sites are recanalized in patients with tandem lesions.

**Table 4.** *Significant variables (other than symptoms and signs) associated with PC strokes in the multivariate analysis*

| Variable | Odds ratio with 95% confidence intervals | *P* value |
|---|---|---|
| Female sex | .75 (.56-.99) | .044 |
| Onset to admission delay (by 30 min strata) | 1.01 (.10- 1.03) | .071 |
| Known time of onset | 1.86 (1.28-2.71) | .001 |
| NIHSS on admission | .91 (.89-.93) | <.0001 |
| Mechanism (TOAST) | | |
| Cardiac (reference) | 1.00 | - |
| Atherosclerosis | .91 (.61-1.34) | .623 |
| Lacunar, microangiopathy | 4.69 (2.89-7.60) | <.0001 |
| Dissection | 2.95 (1.56-5.57) | .001 |
| Unknown | 1.72 (1.21-2.45) | .003 |
| Early ischemic signs on acute neuroimaging (mainly CT) | .56 (.40-.78) | .001 |
| IV-thrombolysis | .16 (.83-.32) | <.0001 |
| Endovascular treatment | 6.23 (1.76-22.12) | .005 |

signs (i.e., with oculomotor abnormalities, central vestibular signs, and visual field defects).

Our ROC-AUC of .91 for the symptom combination indicates that symptoms alone are a good but not perfect discriminate of PC from AC. Tao et al. have identified a set of highly specific brainstem symptoms, but their low prevalence limits their applicability in everyday practice.[18] PC strokes simulating AC strokes will therefore remain a clinical problem.[16–19] In patients with large intracranial occlusions and therefore with more severe strokes, we have shown however that a clinical distinction between PC and AC can be made with higher confidence in the first 12 hours where thrombectomy may often be considered.[20]

Regarding these stroke mechanisms, Libman et al.[6] suggested no differences in etiology between AC and PC strokes. We however found PC stroke to be less often cardioembolic and more often due to lacunas and dissections, and found atherosclerotic and cardioembolic strokes in the PC with similar frequency as described in the New England Medical Center Posterior Circulation Stroke Registry.[10] This may have implications for work-up and secondary prevention decisions, in particular when the initial work-up does not show a clear etiology. Subramanian et al.[36] also found atrial fibrillation to be less frequent in PC strokes in multivariate analysis, whereas Hafeez et al.[38] observed a higher frequency of cardioembolic stroke mechanism in PC strokes in a small group of 69 patients in univariate analysis.

**Table 5.** *Significant admission symptoms and signs associated with PC strokes in the multivariate analysis*

| Variable | Odds ratio with 95% confidence intervals | p-value |
|---|---|---|
| Paresis | .14 (.095-.23) | <.0001 |
| Sensory | .52 (.38-.85) | .007 |
| Visual fields | 1.84 (1.24-3.41) | .01 |
| Cerebellar/vestibular | 5.10 (3.19-7.30) | <.0001 |
| Oculomotor brainstem signs | Perfect prediction | |
| Aphasia | .08 (.06-.18) | <.0001 |
| Neglect | .10 (.07-.25) | <.0001 |
| Decreased consciousness | 4.79 (1.47-6.84) | .003 |

On acute noncontrast CT scans, the odds of presenting early ischemic signs were significantly associated with AC stroke.[9,20] This may be attributable in part to the lower volume of brain tissue in the PC leading to a well-known lower visibility of posterior fossa lesions on CT as well as the lesser degree of severity of posterior fossa infarcts. It is also less easy to see an early lesion in PC because of artifacts. If stroke needs to be proven early, MRI-based imaging may be better suited to detect PC lesions.

Arterial imaging showed less intra- and extracranial arterial pathology in univariate (but not multivariate) analysis, compatible with the higher frequency of lacunar and unknown stroke mechanisms; the only other comparative study showed similar findings, but multivariate analysis was not performed.[9]

Recanalization rates (spontaneously or with recanalization treatments) in PC strokes were lower in univariate analysis; we have previously shown that the circulation is not independently associated with recanalization, however.[20] Pagola[39] described similar recanalization rates in thrombolysed patients.

The lower IV thrombolysis rate in PC stroke patients cannot be explained by the lower NIHSS or delays, given that the multivariate analysis corrected for NIHSS. Some PC strokes may have been missed because they may present as "stroke chameleons", that is, they present as other conditions[16–19] and lead to a missed opportunity of acute treatment.[2, 40] Therefore, the differences in acute revascularization rates in our comparison groups are not justifiable on pathophysiology and known treatment effects alone,[41,42] and may be better explained by historical assumptions, that is, that endovascular treatment may work particularly well in basilar artery occlusions.

We report that symptomatic hemorrhagic transformations are less often seen in PC stroke. This supports previous literature[39,43] and might be explained by lower volumes of ischemic tissue in PC and less cardioembolic strokes. The significantly lower proportion of cerebral edema on subacute imaging in PC strokes may be related to the smaller volumes of these strokes, where patients mostly present with low volume but disturbing brainstem symptoms. Our findings confirm another study,[44] but are potentially biased because only little over half of our patients underwent subacute imaging. Despite this finding, the proportion of patients with death attributed

directly to the stroke (including herniation from cerebral edema) was statistically not significant between both groups.

Whereas the unadjusted 3 months favorable outcome was better in PC than AC stroke patients, adjustment eliminated this difference, similar to the findings of DiCarlo[7] and in thrombolysed patients by Sarikaya et al.[43] and Libman et al.[6]

The strengths of our study are the large number of patients and variables analyzed, including demographics, risk factors, clinical presentation, and arterial imaging, and the use of multivariate approaches to find independent associations including symptom frequency and clinical outcome.

Limitations of our work are those of a retrospective, observational, nonrandomized single center study which may not have a population representative of other settings for acute stroke care. Not all patients had a stroke confirmed on imaging and MRI was used in only about one-third of patients. The fact that only a few patients had endovascular treatment limited the ability to explore its effects on outcome.

In summary, we found significant differences between PC and AC strokes regarding clinical presentation, stroke mechanism, imaging, and use of recanalization treatment, but a similar 3 months handicap after adjustment for baseline variables.

## Conflicts of Interest

Elodie Zürcher, Benjamin Richoz, and Mohamed Faouzi declare no conflicts of interest related to this article.

## Supplementary Material

Supplementary data to this article can be found online at doi:10.1016/j.jstrokecerebrovasdis.2018.11.016.

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