Incidence and MRI patterns of acute ischemic stroke at a quaternary care hospital in Mexico City

Mariana López-Mejía,* Pedro Yeverino-Suárez,** Ernesto Roldán-Valadez*

ABSTRACT

Introduction. Stroke is a rapidly neurological deficit with a high mortality rate and can induce long-term disability. MRI is a fundamental image tool for ischemic stroke diagnosis. There is still scarce information about the stroke incidence and its MRI patterns in specialized centers in Latin America. Material and methods. Retrospective study of patients with clinical diagnosis of stroke on admission at the Emergency Room with brain MRI confirmation. Patients were recruited from January 2011 to December 2012. Results. 238 patients were admitted with symptoms of stroke, 124 underwent brain MRI with 76 confirmations. The age distribution was 42 men (65.38 ± 15.85 years; range 33-91 years) and 34 women (69.47 ± 12.08 years, range 31-89 years). We found a crude annual incidence rate of 119.84 per 100,000 cases of acute ischemic stroke with a male to female ratio of 1.2:1, with 64% of patients included in the 65-74 and 75-84 age groups. We confirmed previously reported MRI patterns: middle cerebral artery was the most commonly affected one with 69.74% (χ² = 104.216, p < 0.001); decreased flow was more common than vessel occlusion (47.37% vs. 30.26%); 71.62% of cases had < 1/3 involvement of the red arterial territory (χ² = 73.324, p < 0.001). Small infarcts (< 70 cm³) accounted for 71.23% of cases (χ² = 13.164, p < 0.001). Conclusion. The incidence rate in our center is lower than some developed countries, higher rates can reflect an improvement in awareness of people about stroke; information about MRI patterns in specialized facilities could help in tailoring thrombolytic strategies for selected patients.

Key words. Ischemic stroke. Incidence. MRI. Perfusion. Diffusion.

Correspondence:
Ernesto Roldán-Valadez, M.D., M.Sc.
Magnetic Resonance Unit, Medica Sur Clinic & Foundation
Puente de Piedra, No. 150, Col. Tlalpan, C.P. 14050. México, D.F.
Tel.: (52-55) 5666-1765. Fax: (52-55) 5424-4429
E-mail: ernest.roldan@usa.net

*Magnetic Resonance Unit, **Emergency Department. Medica Sur Clinic & Foundation. Mexico City. Mexico.
INTRODUCTION

Comparing stroke rates and patterns in different parts of the world and at different points in time may increase our understanding of this disease. Stroke is defined as a rapidly developed global or focal neurological deficit lasting more than 24 h or leading to death with no apparent cause other than vascular origin. Stroke will be a public health problem in Latin America during the next decades because of an increase in life expectancy, changes in the lifestyle of the population and the increase in incidence of diseases such as metabolic syndrome, diabetes and hypertension in most of the countries in this geographical area. Because epidemiological and clinical characteristics of stroke vary according to environmental, racial, and sociocultural factors, we need to be aware of the peculiarities of stroke on this continent to reduce the impact burden of this epidemic.

For health policy planning, it is imperative to understand projected future prevalence and cost of stroke in each country and to identify potential actions that might reduce this burden. Currently, stroke is the fourth leading cause of death in the United States and a leading cause of disability. The cost of treating stroke victims is expected to soar in the next two decades, according to a study by the American Heart Association and the American Stroke Association with real total direct annual stroke-related medical costs expected to increase from $72 billion to $183 billion (2010 dollars) between 2012 and 2030.

The burden of prolonged hospitalization on the family of stroke patients, the aftermath of disability from the disease, and the economic implication on survival of stroke patients, as well as the overstretching of health facilities have been previously explored. However, some basic demographics features and magnetic resonance imaging (MRI) patterns in patients undergoing acute ischemic stroke (AIS) are missing in the current literature, specifically data from facilities considered to be quaternary care hospitals. This concept refers to hospitals with advanced levels of medicine, which are highly specialized and not widely accessed. Experimental medicine and some types of uncommon diagnostic (diffusion-perfusion analysis of MRI images for our study) or surgical procedures are considered quaternary care; a quaternary care hospital may have virtually any procedure available, whereas a tertiary care facility may not offer a sub-specialist with that training. These services are usually only offered in a limited number of regional or national health care centers.

Although stroke affects both gender and is increasingly common from the sixth decade, with young patients not being exempted; we have noticed that most centers cover only a limited age range, monitoring stroke up to age 65 years and none routinely collecting data on those older than 75 years, in whom the incidence of stroke might be highest. The areas of the world covered by these studies are still very limited, and reliable information remains sparse for nonwhite populations.

Recent studies comparing the age-adjusted incidence between Hispanic- and white-populations showed significant differences in first ischemic stroke as 140 to 168 per 100,000 vs. 88 to 136 per 100,000. It is accepted than an “ideal” stroke incidence study does not exist, but studies closely approaching it will reveal the most reliable and comparable results. There is a need for further studies to fill the gaps of the worldwide incidence of stroke, particularly for developing countries. For example, information about the incidence rates of AIS in young and older Mexican patients from tertiary or quaternary care hospitals is missing in the medical literature to the best of our knowledge.

The aims of this study were focused in review the incidence rates and MRI patterns of AIS in a quaternary-care hospital in Mexico City and make comparisons with what has been documented on the disease in urban settings from other countries.

MATERIAL AND METHODS

Study design

This was a retrospective study carried out at Medica Sur Clinic & Foundation, in Mexico City. This study belongs to a research line trying to identify MRI predictive biomarkers in the evaluation of AIS, the main protocol for this research received previous approval by the Institutional Review Board (2010-EXT-05). The facility fulfills the requisites to be considered a quaternary-care private hospital in the south of Mexico City. The hospital runs several postgraduate training programs such as internal medicine and a fellowship in whole-body MRI. There are consultant neurologists available at any time, and the hospital has the possibility to perform advance magnetic resonance imaging analyses such as diffusion and perfusion.

Clinical and imaging definitions of stroke

We use the World Health Organization (WHO) definition of stroke, “rapidly developing clinical signs of focal (at times global) disturbance of cerebral function, lasting more than
24 h or leading to death with no apparent cause other than that of vascular origin” as it is and accepted standard.7

In the last decade, an advanced MRI technique known as diffusion-weighted imaging (DWI) added another dimension to diagnostic imaging improving the diagnostic yield while being practical and feasible.11 DWI measures the net movement of water in tissue due to random (Brownian) molecular motion of water and shows hyperintense ischemic tissue changes within minutes to a few hours after arterial occlusion due to a reduction of the apparent diffusion coefficient (ADC).12 The ADC reduction occurs primarily in the intracellular space associated with disruption in membrane ionic homeostasis and cytotoxic edema. A decreased ADC and increased signal on DWI (described in MRI reports as hyperintense focal region) represent irreversible ischemia; the combination of DWI, ADC maps and T2-weighted images allows differentiating acute from subacute or older AIS lesions.13

DWI has emerged as the most sensitive and specific imaging technique for acute infarct, far better than non-enhanced computed tomography or any other MRI sequence (Figure 1A). It has a high sensitivity (88 to 100%) and specificity (95 to 100%) for detecting infarcted regions, even at very early time points,14,15 within minutes of symptoms onset.14,16 Thus, early after ischemia onset, the visible diffusion lesion will include both regions of irreversible infarction with more severe ADC changes and regions of salvageable penumbra with less severe ADC changes (Figure 1B).

Patients, inclusion and exclusion criteria

We retrieved and reviewed the medical case records of all patients who had a clinical diagnosis of stroke (or similar diagnosis as: probable stroke, ischemic stroke, lacunar stroke, hemorrhagic stroke, basilar stroke) whom arrived to the ER from January 2011 to December 2012. The inclusion criterion was First-Ever-in-a-Lifetime stroke, because it most closely reflects important determinants of disease etiology. Patients with TIA (i.e. a neurological deficit lasting < 24 h with no stroke found on brain imaging) or prior stroke were excluded.17

Only those cases that had complete information, met the WHO clinical criteria for diagnosis and had an MRI study for confirmation of diagnosis were considered. The digital MRI records of patients with inclusion criteria were reviewed to acquire necessary data for the image pattern analysis.

Standard data presentation and risk measures

We collected data over complete years to avoid confounding from the possible effect of seasonal variations in incidence, which was documented in several community-based studies.9,18 Considering previous stroke epidemiologic studies used mid-decade 10-year age bands we retain this convention in our study.7

Dividing the number of cases of first-ever stroke by the number of screened individuals older than 18 years during the observed time period, allowed us to calculate the crude stroke annual incidence rate per 100,000 population, this measure of risk has been previously reported.2

We additionally calculated an age-adjusted incidence rate using mid-decade 10-year age bands (25 to 34, 35 to 44, 45 to 54, 55 to 64, 65 to 74, 75 to 84 and 85 to 94 years).19

Statistical analysis

Descriptive and frequency statistics were obtained for the variables of interest. Chi square was used to test for statistical significance between categorical variables, t-test was used in continuous variables. A P value < 0.05 was considered statistically significant. All analyses were carried out using the IBM® SPSS® Statistics software (version 22.0.0.0 IBM Corporation; Armonk, New York, USA). General presentation of the manuscript followed the guidelines set by the International Committee of Medical Journal Editors.20
RESULTS

Demographic data

During a two-years period (2011-2012), 31,708 individuals underwent admission in the ER, 238 subjects were clinically diagnosed to have stroke, 124 patients undergone brain MRI with 76 MRI diagnoses of AIS. This number accounted for 0.75% of total medical admissions to the ER over the same period. This gave a crude annual incidence rate of 119.84 cases of AIS per 100,000.

We found a gender and age distribution of 42 men (65.38 ± 15.85 M, SD; range 33-91 years) and 34 women (69.47 ± 12.08 years, range 31-89), giving a ratio of male to female 1.2:1; that is, we observed a strong preponderance of male stroke patients which was not statistically significant χ² = 0.842, p = 0.359. The age distribution spread over a 7 mid-decades, with 64% of patients in the 65-74 and 75-84 age groups, this represent a significant difference χ² = 70.145, p < 0.001. Table 1 depicts the incidence rate by age groups and figure 2 shows the age distribution using mid-decade 10 year-age bands. Table 2 shows the annual incidence rate grouped by age group and gender with 95% CI.

Table 1. Crude annual incidence rate of acute ischemic stroke grouped by age.

<table>
<thead>
<tr>
<th>Age-group</th>
<th>Population, n (%)</th>
<th>Age-adjusted incidence by age-group (cases per 100,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-34</td>
<td>3 (4)</td>
<td>4.73</td>
</tr>
<tr>
<td>35-44</td>
<td>5 (7)</td>
<td>7.88</td>
</tr>
<tr>
<td>45-54</td>
<td>9 (12)</td>
<td>14.19</td>
</tr>
<tr>
<td>55-64</td>
<td>8 (11)</td>
<td>12.62</td>
</tr>
<tr>
<td>65-74</td>
<td>24 (32)</td>
<td>37.85</td>
</tr>
<tr>
<td>75-84</td>
<td>24 (32)</td>
<td>37.85</td>
</tr>
<tr>
<td>85-94</td>
<td>3 (4)</td>
<td>4.73</td>
</tr>
<tr>
<td>Total</td>
<td>76 (100)</td>
<td>119.84</td>
</tr>
</tbody>
</table>

Table 2. Annual incidence rate of acute ischemic stroke grouped by age and gender with 95% CI.

<table>
<thead>
<tr>
<th>Age-group</th>
<th>Incidence rate</th>
<th>95% CI Lower bound</th>
<th>95% CI Upper bound</th>
<th>Incidence rate</th>
<th>95% CI Lower bound</th>
<th>95% CI Upper bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-34</td>
<td>4.8</td>
<td>4.308</td>
<td>5.291</td>
<td>1.0</td>
<td>0.508</td>
<td>1.4916</td>
</tr>
<tr>
<td>35-44</td>
<td>11.9</td>
<td>11.408</td>
<td>12.391</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>45-54</td>
<td>11.9</td>
<td>11.408</td>
<td>12.391</td>
<td>4.0</td>
<td>3.508</td>
<td>4.491</td>
</tr>
<tr>
<td>55-64</td>
<td>14.3</td>
<td>13.808</td>
<td>14.791</td>
<td>2.0</td>
<td>1.508</td>
<td>2.491</td>
</tr>
<tr>
<td>65-74</td>
<td>21.4</td>
<td>20.908</td>
<td>21.891</td>
<td>15.0</td>
<td>14.508</td>
<td>15.491</td>
</tr>
<tr>
<td>75-84</td>
<td>33.3</td>
<td>32.808</td>
<td>33.791</td>
<td>10.0</td>
<td>9.508</td>
<td>10.491</td>
</tr>
<tr>
<td>85-94</td>
<td>2.4</td>
<td>1.908</td>
<td>2.891</td>
<td>2.0</td>
<td>1.508</td>
<td>2.491</td>
</tr>
</tbody>
</table>

MRI patterns in AIS

We found a non-significant trend regarding the affected side of cerebral hemispheres in both genders with the left hemisphere being more frequently affected then the right one χ² = 0.111, p = 0.139, for males; and χ² = 0.947, p = 0.330 for females; figure 3 shows the hemisphere distribution for each gender.

The more frequently affected artery was the middle cerebral artery (MCA) 69.74%, followed by the posterior cerebral artery (PCA) 11.84%, and the basilar artery 10.53%. Less than 8% of cases were distributed among the rest of arteries of the Willis polygon. These differences were significant χ² = 104.216, p ≤ 0.001; figure 4A presents the affected arteries.

There was an unequal distribution in the decrement of arterial blood flow observed for all patients, 35 (47.37%) had decreased flow, 26 (30.26%) occluded and 13 (22.37%) had normal arterial flow evaluated in the 3D time-of-flight MR angiography; this findings had statistical significance, χ² = 9.919, p = 0.007. Figure 4B shows the decrement in arterial blood flow.

Considering the infarct extension, 71.62% of patients showed less than 1/3 involvement of affected territory; 24.32% showed 2/3 of the arterial affected territory, and only 4% presented a full affection of the arterial territory.
involved. This finding had a significant difference $\chi^2 = 73.324$, $p \leq 0.001$; figure 4C depicts the percentages of infarct extension.

Our last variable in the MRI pattern analysis involved the calculation of the infarct size by measuring the cm$^3$ of each infarct in the DWI sequence. We found 71.23% of cases corresponding to infarcts with small volume ($< 70 \text{ cm}^3$) and 28.77% of infarct with a large volume ($< 70 \text{ cm}^3$). These values represent a significant difference, $\chi^2 = 13.164$, $p \leq 0.001$; figure 4D shows the percentages of volume distribution.

DISCUSSION

The incidence and imaging patterns of AIS in Mexico have not been widely studied to the best of our knowledge, the reports about the incidence of AIS for Hispanics is limited as well, this scarce evidence compelled us to report the findings from a quaternary care hospital focusing only on the AIS incidence of patients that arrived to the ER.

The annual crude incidence we found, 119 per 100,000, can be considered an intermediate value between those reported by some Latin-American countries: one of the first studies designed to assess stroke epidemiology was performed in Cuzco, Peru; it reported a crude annual incidence rate (first-ever stroke) of 183 per 100,000 (1995); another study reported in the city of Sabaneta, Colombia; found and annual incidence rate of stroke of 89 per 100,000 (1993).21

In European countries, the stroke incidence has reported higher rates, with significant differences between gender, among men of all ages stroke ranged from 124 per 100,000 in South London (2003) to 185 per 100,000 in the Scottish Borders region (1998); and among women, incidence ranged from 88 to 146 per 100,000 in the same respective studies. Incidence in studies set in Oxfordshire and East Lancashire were similar, ranging from 135 to 152 per 100,000 among males.19

A lower stroke prevalence in Latin-American countries compared than that from developed countries have previously been reported probably because of some unknown protective ethnic factors or differences in dietary habits or lifestyles.21,22 This hypothesis is supported by the finding that stroke prevalence is even lower in rural than in urban areas. The low incidence rate has also been related to the implementation of campaigns directed at teaching the community about the hazards of stroke risk factors.2

Our finding of a strong preponderance of male stroke patients have been recently reported in German, China and Indian datasets.23 It is both of clinical and sociocultural importance to investigate the causes for gender gap in stroke patients- to guarantee that both female and male patients have equal access to in-hospital medical care and to further enlighten gender-specific differences in stroke. So far, the gender ratio of the general population and gender-specific stroke incidence rates are likely to be the major determinants, but sociocultural peculiarities may also play a crucial role.23

Compared with Asia, our incidence rate was very similar to that one reported in the city of Birjand, Iran of 103.4 cases per 100,000 (2008) this study was performed in a tertiary care hospital.24 We believe that a higher incidence rate can reflect an improvement in awareness of people
about stroke and its signs or symptoms as well as more feasible and facile accessibility to healthcare centers, which both can raise the number of referred patients to tertiary care hospitals.

Some limitations in this study need to be addressed: this was an observational study, which limited the inferences that can be made about etiological relationships. Also, poor or incomplete medical record keeping, missing data and lack of essential, specific imaging diagnostic studies were present. Despite these limitations, we have been able to review the incidence and imaging pattern of stroke in selected patients. In addition, although great measures were taken to include all incident stroke cases, in any incidence study, complete capture of all cases cannot be substantiated. The fact that not all subjects underwent a systematic investigation could be a source of information bias. However, our study provides important data for specialized stroke centers.

In conclusion, our findings of incidence and imaging patterns lead us to consider the fact that the knowledge and perception of stroke risk factors and its warning sign can be increased in the hospital patients and health workers, as it has been observed in other centers. Further studies about imaging patterns are necessary in order to correlate these findings in the context of knowledge of race and sex differences in disease biology; these will help
to assess the importance of other putative explanations for race and sex disparity, such as exclusion from care on “socioeconomic rather than clinical grounds”. Also, regional reports of subtype-specific age- and sex-adjusted incidence rates for AIS would permit the development of community-friendly intervention programs aimed at preventing and modifying the risk factors in persons prone to diseases in tertiary and quaternary care hospital. These programs might eventually be incorporated into healthcare system, so that they are recognized early and effectively managed. Lastly, it’s also important to emphasize the need of implementation of the Stroke Guidelines recommended by the American Heart Association/American Stroke Association (AHA/ASA), so that, in the absence of enough formal Stroke Units in Latin America, the ER in as many as possible hospitals would be able to attend patients with AIS or TIA according to international standards.

**ABBREVIATIONS**

- ADC: apparent diffusion coefficient.
- AIS: acute ischemic stroke.
- DWI: diffusion-weighted imaging.
- ER: emergency room.
- MCA: middle cerebral artery.
- MRI: magnetic resonance imaging.
- PCA: posterior cerebral artery.
- WHO: World Health Organization.

**REFERENCES**


