A Population-Based Study of the Incidence of Acute Spinal Cord Infarction

Adnan I. Qureshi, MD, Mohammad Rauf Afzal, MD, and M. Fareed K. Suri, MD
Zeenat Qureshi Stroke Institute, St. Cloud MN

Abstract

Background—There is a paucity of reliable data regarding incidence of acute spinal cord infarction in population-based studies.

Objectives—To determine the incidence of acute spinal cord infarction using a population-based design.

Methods—Medical records and neuroimaging data of all patients with acute spinal cord infarction from Stearns and Benton Counties, Minnesota, between January 1, 2010 and May 31, 2014 were reviewed. Patients with a first-time diagnosis of spinal cord infarction were categorized as primary or secondary depending upon underlying etiology identified. We calculated the incidences of primary and secondary spinal cord infarction adjusted for age and sex based on the 2010 US census (189,093 resident populations).

Results—The age- and sex-adjusted incidence of spinal cord infarction was 3.1 [95% confidence interval (CI) 1.6–7.2] per 100,000 person-years. The age- and sex-adjusted incidence of primary and secondary spinal cord infarction was 1.5 [95% CI 0.6–3.6] and 1.6 [95% CI 0.6–3.6] per 100,000 person-years, respectively. The age-adjusted incidences among men and women were 1.5 [95%CI 0.6–3.7] and 4.6 [95% CI 2.2–8.7] per 100,000 person-years, respectively. No case fatality was observed at one month.

Conclusion—We provide incidence rates for acute spinal cord infarction to assist in future studies and resource allocation.

Keywords
Spinal cord infarction; incidence; population-based study; spinal cord ischemia; state-wide survey

1. Introduction

The American Heart Association Stroke Council recommended inclusion of spinal cord infarction in the updated definition of stroke for the 21st Century [1]. Spinal cord infarction was defined by “spinal cord cell death attributable to ischemia, based on pathological, imaging, or other objective evidence of spinal cord focal ischemic injury in a defined vascular distribution; or clinical evidence of spinal cord focal ischemic injury based on symptoms persisting ≥24 h or until death, and other etiologies excluded [1].” The American Heart Association Stroke Council identified paucity of epidemiological data regarding spinal cord infarction. Most studies on spinal cord infarction are derived from single or selected multiple centers, and are not valid for estimation of incidence or prevalence due to biases in variable referral patterns, heterogeneous diagnostic procedures, and lack of data regarding the catchment population [2–4]. To address the gap in our understanding, we performed this study to determine the actual incidence of acute spinal cord infarction in a population-based cohort using a standard definition and associated disability.

2. Methods

The methodology of the population-based studies involving Stearns and Benton Counties situated in central Minnesota has been previously described [5,6]. This study population consists of 189,093 persons according to the US 2010 census residing in a total area of 1751 square miles in both counties. The estimated 1% and 2% population increases between April 1, 2010 and July 1, 2013 in Stearns and Benton counties was very small to affect calculation of incidences using the US 2010 census and case ascertainment in the following four years.
The median age of study population was 33.7 years, and 23.5% were under the age of 18 years, and 12.1% who were ≥65 years of age as previously described [5,6]. This study population consists of 92.3% White, 2.9% African American, 0.3% Native American, 1.8% Asian, 0.03% Pacific Islander, and 2.7% from other categories [7]. St. Cloud Hospital is the only acute care hospital that provides neurosurgical and comprehensive stroke care services within Central Minnesota and all spinal cord infarction patients within the catchment area are expected to be admitted to St. Cloud Hospital through primary emergency department arrival or referral from surrounding clinics and hospitals.

2.1. Case Ascertainment

Patients admitted with acute spinal cord infarction (symptom onset <24 hr of admission) from January 1, 2010 to May 31, 2014 were identified using primary or secondary diagnoses of spinal cord infarction (ICD-9-CM) code 336.1. The medical records of all patients with the above mentioned diagnoses codes were reviewed.

Spinal cord infarction was defined by acute onset clinical syndrome of focal spinal cord deficits consistent with ischemic injury as described in previous reports [4,8] with exclusion of compressive etiologies through magnetic resonance imaging (MRI) or computed tomographic (CT) scan spine imaging [1]. The cases were further classified as probable if MRI spine demonstrated changes suggestive of focal ischemic injury including T2-weighted hyperintensity in a vascular distribution, and decreased diffusion on diffusion weighted imaging (DWI) and apparent diffusion coefficients [9,10]. Cases were classified as possible if clinical syndrome and other medical history (atrial fibrillation with systemic embolization or recent aortic repair procedure) was suggestive of spinal cord infarction but MRI spine was not performed. Patients who had primary residence within the zip codes included in Stearns and Benton Counties were included to calculate the incidences.

2.2. Data Collection

The protocol for data collection was approved by local Institutional Review Board. Patients medical records were reviewed using the EPIC electronic medical record system for information regarding demographic characteristics, etiology, preexisting cardiovascular risk factors, location of spinal cord infarction, modality used for diagnosis (MRI or CT spine, or spinal angiogram) with findings, in hospital complications including deep venous thrombosis, pressure ulcers, and pulmonary embolism, and final outcome at discharge and one month survival. The severity of disability at presentation was graded using the American Spinal Injury Association (ASIA) Impairment Scale, which divides the clinical deficits into five categories [11–13]. The categories range from no motor or sensory function is preserved in the sacral segments S4–S5 to normal motor and sensory functions.

2.3. Sensitivity Analysis

We calculated the state-wide incidence of spinal cord infarction using another methodology. A list of patients admitted with primary or secondary diagnoses of spinal cord infarction (ICD-9-CM) code 336.1 were retrieved from Minnesota Hospital Association data from January 1, 2010 to December 31, 2013. The methodology of data collection by Minnesota Hospital Association has been previously described [14]. There were 28 cases of spinal cord infarction cases based on primary or secondary diagnoses among 5,303,925 resident populations aged 20 years or greater in Minnesota State, providing a crude incidence of 0.1 [95% confidence interval (CI) 0.01–2.4] per 100,000 person-years.

2.4. Statistical Analysis

The specificity and positive predictive value of ICD-9-CM code 336.1 for identification of spinal cord infarction was calculated. Crude and age- and sex-adjusted incidence rates (age-adjusted to the 2010 US Standard Population) for acute spinal cord infarction were calculated as previously described [5,6]. The age- and sex-adjusted rate was calculated by multiplying each crude rate by the appropriate weight and summing the products. The incidence was expressed as events per 100,000 person-years. The age-adjusted incidence rates were calculated for men and women, and primary and secondary spinal cord infarction separately.

3. Results

There were 30 patients admitted with primary and secondary ICD-9-CM code 336.1 in St. Cloud Hospital. Two and five patients had diagnosis of spinal cord trauma or neoplasm, respectively. A total of eight patients with spinal cord infarctions (mean age ± SD 67.1 ± 14.3 years, two were men) met our case definition. A total of four patients with spinal infarction residing in Stearns and Benton Counties were included to calculate the incidences. The positive predictive value of ICD-9-CM code 336.1 as primary diagnosis code for identification of spinal cord infarction was 0.1. The diagnosis was categorized as probable and possible in
six and two patients, respectively. Six were primary spinal cord infarctions, and two were secondary spinal cord infarctions consequent to aortic graft placement and embolic phenomenon. The time intervals between symptom onset and hospital arrival was <6, 6–24, and >24 h in three, three, and two patients, respectively (see Table

### Table 1. Demographic, Clinical, and Neuroimaging Characteristics of Patients with Spinal Cord Infarction Admitted to St. Cloud Hospital 2010–2014

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Gender</th>
<th>Presenting symptoms</th>
<th>Time interval between symptom onset and presentation (hours)</th>
<th>ASIA^2-Impairment Scale of disability</th>
<th>Cardiovascular risk factors</th>
<th>Diagnosed by</th>
<th>Findings on imaging (MRI/CT)</th>
<th>Location/level of infarction</th>
<th>Etiology if known</th>
<th>Spinal angiogram performed; findings</th>
<th>Final outcome at discharge (ASIA-Impairment Scale)</th>
<th>Final outcome at one month (ASIA-Impairment Scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>76</td>
<td>F</td>
<td>Lower extremities weakness, Loss of bowel control</td>
<td>6–24</td>
<td>d</td>
<td>Hypertension, atrial fibrillation, stroke, congestive heart failure, ventricular arrhythmia, CT myelogram</td>
<td>MRI</td>
<td>Hyperintensity on T2-weighted images</td>
<td>C7–T6</td>
<td>None</td>
<td>No</td>
<td>d</td>
<td>No follow-up</td>
</tr>
<tr>
<td>78</td>
<td>F</td>
<td>Lower extremities weakness</td>
<td>6–24</td>
<td>b</td>
<td>Diabetes mellitus</td>
<td>MRI</td>
<td>Restricted diffusion on diffusion weighted images</td>
<td>L1</td>
<td>None</td>
<td>No</td>
<td>b</td>
<td>No follow-up</td>
</tr>
<tr>
<td>43</td>
<td>F</td>
<td>Left lower extremities weakness and paresis</td>
<td>&gt;24</td>
<td>c</td>
<td>Diabetic artery disease, myocardial infarction, stroke, hypertension, hyperlipidemia</td>
<td>MRI</td>
<td>Hyperintensity on T2-weighted images</td>
<td>C7–T1</td>
<td>None</td>
<td>No</td>
<td>d</td>
<td>No follow-up</td>
</tr>
<tr>
<td>77</td>
<td>M</td>
<td>Diffuse leg weakness</td>
<td>&lt;6</td>
<td>d</td>
<td>Diabetes mellitus, atrial fibrillation</td>
<td>MRI</td>
<td>Hyperintensity on T2-weighted images</td>
<td>T4–T6</td>
<td>None</td>
<td>No</td>
<td>d</td>
<td>No follow-up</td>
</tr>
<tr>
<td>73</td>
<td>F</td>
<td>Sudden leg weakness bilaterally</td>
<td>&gt;24</td>
<td>b</td>
<td>Coronary artery disease</td>
<td>MRI</td>
<td>Hyperintensity on T2-weighted images</td>
<td>C7–T2</td>
<td>None</td>
<td>No</td>
<td>d</td>
<td>No follow-up</td>
</tr>
<tr>
<td>65</td>
<td>M</td>
<td>Lower extremities weak post cardiac catheterization</td>
<td>&lt;6</td>
<td>c</td>
<td>None</td>
<td>MRI</td>
<td>Hyperintensity on T2-weighted images</td>
<td>T1–T6</td>
<td>None</td>
<td>No</td>
<td>d</td>
<td>No follow-up</td>
</tr>
<tr>
<td>47</td>
<td>F</td>
<td>Lower extremities weak post spineleic aneurysm repair</td>
<td>&lt;6</td>
<td>c</td>
<td>Peripheral artery disease, Hypertension, atrial fibrillation, systolic congestive heart failure, coronary artery disease, carotid stenosis, splenic infarct</td>
<td>Not Available</td>
<td>Not Available</td>
<td>No follow-up</td>
<td>No follow-up</td>
<td>No</td>
<td>d</td>
<td>No follow-up</td>
</tr>
</tbody>
</table>

Abbreviations used: MRI - magnetic resonance imaging; CT - computed tomography.

^1 Patients residing in Stearns and Benton Counties and used for calculating the incidences.

^2 American Spinal Injury Association.
The severities of deficits based on ASIA Impairment Scale were grade b (n = 3), c (n = 3), and d (n = 2). The location of infarction was classified as cervical (c7-t1 in 1, c7-t2 in 1, and c7-t6 in 1), thoracic (T1-T6 in 1, T4-T6 in 1, and T9 level in 1), lumbar (L1 in 1), and not available in one patient, respectively. The abnormality on MRI was hyperintensity on T2-weighted MRI in five patients and restricted diffusion in one patient with probable spinal cord infarction. No events of deep venous thrombosis or pulmonary embolism were observed during hospitalization.

There were four probable and possible spinal cord infarction cases in Stearns and Benton Counties among 189,093 resident populations, providing a crude incidence of 0.6 [95% CI 0.01–2.4] per 100,000 person-years. The age- and sex-adjusted incidence of spinal cord infarction was 3.1 [95% CI 1.6–7.2] per 100,000 person-years. The age- and sex-adjusted incidence of probable and possible spinal cord infarction cases were 1.6 [95% CI 0.6–3.6] and 1.5 [95% CI 0.6–3.6] per 100,000 person-years, respectively. The age-adjusted incidences among men and women were 1.5 [95% CI 0.6–3.7] and 4.6 [95% CI 2.2–8.7] per 100,000 person-years, respectively. The age- and sex-adjusted incidences of primary and secondary spinal cord infarction were 1.5 [95% CI 0.6–3.6] and 1.6 [95% CI 0.6–3.6] per 100,000 person-years, respectively. No case fatality was observed at one month.

4. Discussion

The age- and sex-adjusted incidence of spinal cord infarction cases in Benton and Sterns Counties was estimated to be 3.1 per 100,000 persons in our analysis. If we assume that there are 245,201,076 adult persons in the United States according to the 2014 census [15], a conservative estimate would suggest that there are approximately 7600 patients every year who develop spinal cord infarction. The 95% CI suggested that the true value of incidence based on precision of estimate may range between 1.6 and 7.2 per 100,000 persons. The only estimate for comparison is the incidence of spinal cord infarction associated with aortic repair, which was approximately 76 patients every year in the United States [16]. The estimates are, in fact, for first-ever hospitalized spinal cord infarction. In comparison, the overall rates for occurrence of total stroke (first-ever and recurrent) range between 259 and 269 per 100,000 population (age- and sex-adjusted) in the United States [17,18]. The incidence of first-ever hospital-ascertained stroke is estimated at 189 per 100,000 in 2005 [19]. The estimated number of patients who develop strokes every year in the United States is 795,000 persons [20].

There are certain issues regarding interpretation of the results. Our method of case ascertainment was based on review of clinical and imaging findings; therefore, the accuracy of diagnosis is high. However, we identified the cases based on ICD-9-CM codes and found a relatively low positive predictive value. We do not know if there are other spinal cord infarction cases that are coded using other codes and, therefore, not identified in our analysis. The possibility that estimated incidence in our study may be an underestimate of the actual incidence cannot be excluded. Our study only includes events that resulted in hospital admission. An undetermined fraction of spinal cord infarction events may not result in hospital admission. The precision of estimate is somewhat difficult, because spinal cord infarction is an infrequent diagnosis and even multiple years only yielded four cases (one case per year) in Stearns and Benton counties. The number of cases is similar to the report by the Study Group on Spinal Cord Infarction of the French Neurovascular Society [8]. This study identified 28 patients with spinal cord infarction in 16 centers over two years (almost one patient per hospital per year). Similarly, another single-center study from China [21] identified 24 patients with spinal cord infarction over 14 years (1.7 cases per year). A single-center study from Lausanne, Switzerland [22] identified 27 patients over a 14-year period (1.9 patients per year). Another single-center study in Turkey [23] identified 36 patients over a 10-year period (3.6 patients per year).

The data provided may be a resource for researchers, clinicians, and healthcare policy makers who seek to understand the incidence and burden of spinal cord infarction and subsequently develop prevention and treatment strategies.

References
