Diurnal Variation in Occurrence of Strokes

JOHN MARSHALL, M.D., F.R.C.P.(Ed.), F.R.C.P. (Lond.), D.P.M.

SUMMARY The time of onset of a completed stroke was recorded in 707 patients. Of the 554 cerebral infarctions 40% occurred between midnight and 6 a.m. Onset at night was, if anything, less common among the 153 cases of cerebral hemorrhage.

STUDY OF THE PREVENTION of strokes can proceed along two lines: attention may be devoted to the underlying atherosclerotic or hypertensive vascular disease, seeking ways and means of preventing its development or retarding its progress; alternatively the immediate precipitating factors of strokes may be studied in the hope that, despite the presence of vascular disease, cerebrovascular accidents may be avoided. Possible precipitatory factors are many; in an endeavor to discover which may be of greatest importance Agnoli et al.1 studied the diurnal pattern of time of onset of strokes in a series of 256 patients and found them to occur less frequently during the night hours. As the observation was contrary to a widely held clinical impression, the present study was undertaken to determine the time of onset of stroke in a further series.

Methods

The records of 848 consecutive patients who had experienced a completed stroke of acute onset were examined retrospectively concerning the time of onset. An acute onset was defined as one in which symptoms appeared abruptly and reached their maximum in less than six hours. Patients with a progressive stroke (evolving over six hours or more) or transient ischemic attacks were not included. In 141 patients the information was insufficiently precise, leaving 707 in whom the time of onset was precisely known for inclusion in the present study.

For analysis the day was divided into four periods 00-01 to 06-00 hours, 06-01 to 12-00 hours, 12-01 to 18-00 hours, and 18-01 to 24-00 hours, patients being allotted to one of these periods according to the time of first appearance of symptoms; when the evolution of symptoms (which was always less than six hours) transgressed a time boundary, the patient was allotted to the period in which the symptoms first appeared.

The patients were separated into those whose stroke was caused by a cerebral hemorrhage as shown by blood in the cerebrospinal fluid and those due to non-embolic cerebral infarction. The non-embolic nature of the infarction was judged by the absence from the history as well as from a clinical and electrocardiographic examination of evidence of a source of emboli. Within these categories the patients were further separated into those whose convalescent diastolic blood pressure was below 110 mm Hg and those in whom it was 110 mm Hg or above.

Results

Among the patients with cerebral infarction strokes occurred most commonly during the midnight to 6 a.m. period (table 1). The Chi squared test showed the excess to be significant at the 1 per cent level in both males and females. This was so of both blood pressure groups in the males; in the females the group with diastolic pressure less than 110 mm Hg, though showing a considerable nocturnal excess, did not reach statistical significance.

The patients with cerebral hemorrhage presented a different picture (table 2). There was no increase of frequency of strokes during the hours midnight to 6 a.m. In fact, among the females the reverse was found. Among the males the strokes occurred more or less equally throughout the 24 hours with some increase in the evening period 18-01 to 24-00 hours.

Discussion

The results of this study confirm the widely held clinical impression that cerebral infarction develops most frequently during the night hours. The findings are at variance with those of Agnoli et al.1 who found fewer infarcts developing during the night. The reason for this difference is not absolutely clear. Agnoli et al.1 divided the 24 hours into three periods 10 p.m. to 6 a.m., 6 a.m. to 2 p.m. and 2 p.m. to 10 p.m. rather than four as in the present study — which may account for the discrepancy.

The cause of the nocturnal excess of infarcts in the present study must be speculative. Many biological parameters concerned with cerebral circulation undergo diurnal variation. Prominent among these is blood pressure. A nocturnal fall in blood pressure has been well documented in a number of studies.2-6 A fall in blood pressure should not lead to a fall in cerebral blood flow (CBF) if autoregulation is intact, which it is in patients with cerebrovascular disease except for a few days after an acute cerebrovascular episode. However, though autoregulation is present, there is evidence it may be impaired in patients with cerebrovascular disease.8 Moreover, it is possible that because of impairment of vasomotor reflexes which develops in older people the nocturnal fall in blood pressure is more profound in older age groups. It is conceivable that blood pressure may fall below a somewhat elevated lower limit for autoregulation, leading to a fall in CBF.

CBF is normally lowered during deep sleep though it rises rapidly with the onset of REM sleep.9,10 The fall in CBF during deep sleep presumably reflects decreased metabolic activity of cerebral neurons and need not be considered abnormal. On the other hand, the excess of cerebral infarcts during sleep makes it tempting to suggest that the fall in blood pressure and CBF in patients with vascular disease goes beyond normal limits in some cases possibly because autoregulation is insufficient to cope with the normal nocturnal fall in blood pressure.

This hypothesis receives some support from the fact that a nocturnal excess of strokes was not seen in patients with...
cerebral hemorrhage. The level of blood pressure is generally higher in patients with cerebral hemorrhage than it is in those with infarction. This may have the effect of protecting patients from nocturnal infarction though the high blood pressure exposes them to the risk of cerebral hemorrhage particularly during waking hours.

A merit of the present hypothesis is that it is susceptible to testing in the clinical situation. The development of methods of continuous monitoring of blood pressure and the electrocardiogram and of intravenous isotope clearance techniques of measuring CBF makes it easier than it was to measure blood pressure and CBF during normal sleep. Studies to determine whether patients with cerebrovascular disease experience a more profound fall of blood pressure during the night and whether this causes a fall in CBF, could be undertaken since one-third to one-half of cerebral infarcts occur at night.

Acknowledgments

I wish to thank Miss Beryl Laatz for invaluable secretarial assistance.

References


![Table 1 Diurnal Variation in Time of Onset of Cerebral Infarction](image)

<table>
<thead>
<tr>
<th>Time (hours)</th>
<th>Diastolic blood pressure 110 mm Hg or more No.</th>
<th>Percent</th>
<th>Diastolic blood pressure less than 110 mm Hg No.</th>
<th>Percent</th>
<th>All cases No.</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>MALES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00-01 - 06-00</td>
<td>42</td>
<td>39.2</td>
<td>108</td>
<td>45.3</td>
<td>150</td>
<td>43.4</td>
</tr>
<tr>
<td>06-01 - 12-00</td>
<td>29</td>
<td>27.1</td>
<td>53</td>
<td>22.2</td>
<td>82</td>
<td>23.7</td>
</tr>
<tr>
<td>12-01 - 18-00</td>
<td>13</td>
<td>12.1</td>
<td>37</td>
<td>15.5</td>
<td>50</td>
<td>14.4</td>
</tr>
<tr>
<td>18-01 - 24-00</td>
<td>23</td>
<td>21.5</td>
<td>40</td>
<td>16.8</td>
<td>63</td>
<td>18.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEMALES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00-01 - 06-00</td>
<td>27</td>
<td>34.6</td>
<td>49</td>
<td>37.4</td>
<td>76</td>
<td>38.0</td>
</tr>
<tr>
<td>06-01 - 12-00</td>
<td>16</td>
<td>20.5</td>
<td>38</td>
<td>29.0</td>
<td>54</td>
<td>25.8</td>
</tr>
<tr>
<td>12-01 - 18-00</td>
<td>17</td>
<td>21.7</td>
<td>18</td>
<td>13.7</td>
<td>35</td>
<td>16.7</td>
</tr>
<tr>
<td>18-01 - 24-00</td>
<td>18</td>
<td>23.0</td>
<td>26</td>
<td>19.8</td>
<td>44</td>
<td>21.0</td>
</tr>
</tbody>
</table>

Table 1

![Table 2 Diurnal Variation in Time of Onset of Cerebral Hemorrhage](image)

<table>
<thead>
<tr>
<th>Time (hours)</th>
<th>Diastolic blood pressure 110 mm Hg or more No.</th>
<th>Percent</th>
<th>Diastolic blood pressure less than 110 mm Hg No.</th>
<th>Percent</th>
<th>All cases No.</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>MALES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00-01 - 06-00</td>
<td>7</td>
<td>18.4</td>
<td>12</td>
<td>26.1</td>
<td>19</td>
<td>22.6</td>
</tr>
<tr>
<td>06-01 - 12-00</td>
<td>11</td>
<td>29.0</td>
<td>7</td>
<td>15.2</td>
<td>19</td>
<td>21.4</td>
</tr>
<tr>
<td>12-01 - 18-00</td>
<td>5</td>
<td>13.2</td>
<td>12</td>
<td>26.1</td>
<td>17</td>
<td>20.2</td>
</tr>
<tr>
<td>18-01 - 24-00</td>
<td>15</td>
<td>39.5</td>
<td>15</td>
<td>32.6</td>
<td>30</td>
<td>35.7</td>
</tr>
</tbody>
</table>

Table 2

![Acknowledgments](image)
Diurnal variation in occurrence of strokes.

J Marshall

*Stroke*. 1977;8:230-231
doi: 10.1161/01.STR.8.2.230

*Stroke* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1977 American Heart Association, Inc. All rights reserved.
Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the
World Wide Web at:
http://stroke.ahajournals.org/content/8/2/230

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in
*Stroke* can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office.
Once the online version of the published article for which permission is being requested is located, click Request
Permissions in the middle column of the Web page under Services. Further information about this process is
available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to *Stroke* is online at:
http://stroke.ahajournals.org//subscriptions/