RECENT STUDIES show that early anticoagulation can safely be used in cardiac embolic strokes.14 The timing of such treatment, however, remains controversial.24 Incidental clinical reports on cerebral complications of anticoagulant therapy25,26 and autopsy studies support the fear for such complications because a high rate of hemorrhagic infarcts was related to embolic stroke.14 On CT, however, hemorrhagic infarction is rarely seen15,18 even in embolic stroke.1,2,4 Furthermore, hemorrhagic infarction is most prevalent in large infarcts with mass effect.19 Embolic strokes relatively often result in large infarcts with bad outcome.14,20-24 Therefore, autopsy findings are probably biased in establishing a high rate of embolic cause in cases with hemorrhagic infarction. The finding of many more embolic strokes in autopsy studies12,13,20,25 than in clinical and epidemiological studies22,26,27 also suggest such bias. Alternatively, the incidence of clinical emboli might be underestimated because of the difference between autopsy and clinical criteria for cardioembolic infarction. Moreover, CT might miss minor hemorrhagic infarction. On the other hand a substantial number of patients with clinically diagnosed cardioembolic stroke have concomitant carotid artery disease as a possible cause of their stroke.2,28 Clinically the number of cardioembolic strokes might well be overestimated. If the presence of hemorrhages in an infarction is primarily a function of the size of the infarct, one ought to find hemorrhagic infarction more often in cases dying from the direct consequence of large infarction which is brain herniation, regardless of the cause of the infarct. Therefore, in a consecutive autopsy series of ischemic stroke, we studied the incidence of hemorrhagic infarction in patients with and without brain herniation.

Methods

Clinical data and autopsy findings of patients who died between 01-01-1979 and 01-01-1985 within 15 days following a supra-tentorial cerebral infarct, the presence of hemorrhagic infarction at autopsy was related to a cardiac embolic cause of the infarct, and to the cause of death. Hemorrhagic infarcts were more common among patients dying from brain herniation than among those dying from a non-cerebral cause. Cardiac embolic strokes were more often hemorrhagic at autopsy than strokes without such cause; this could be explained by a significant higher rate of brain herniation and death after embolic stroke. On the other hand infarcts with extended hemorrhages more often tended to have a cardiac than a non-cardiac cause. These data, together with earlier clinical findings suggest that autopsy studies are biased in relating hemorrhagic infarction almost exclusively to a cardiac embolic cause of stroke, although cardiac emboli may produce more extended hemorrhages.

Cerebral Hemorrhagic Infarction at Autopsy: Cardiac Embolic Cause and the Relationship to the Cause of Death

J. LODDER, M.D.,* B. KRINE-KUBAT, M.D.,* AND J. BROEKMAN, M.D.†

SUMMARY In 48 patients dying within 15 days following a supra-tentorial cerebral infarct, the presence of hemorrhagic infarction at autopsy was related to a cardiac embolic cause of the infarct, and to the cause of death. Hemorrhagic infarcts were more common among patients dying from brain herniation than among those dying from a non-cerebral cause. Cardiac embolic strokes were more often hemorrhagic at autopsy than strokes without such cause; this could be explained by a significant higher rate of brain herniation and death after embolic stroke. On the other hand infarcts with extended hemorrhages more often tended to have a cardiac than a non-cardiac cause. These data, together with earlier clinical findings suggest that autopsy studies are biased in relating hemorrhagic infarction almost exclusively to a cardiac embolic cause of stroke, although cardiac emboli may produce more extended hemorrhages.

Note: The full text of the article is not provided here. The above text is a summary and the complete version can be found in the referenced source.
HEMORRHAGIC INFARCTION & CARDIAC EMBOLIC STROKE

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FIGURE 1. Large confluent hemorrhages in a left-sided infarct that was caused by a cardiac embolus in a 63-year-old female.

Embolic cause of the infarct on clinical grounds such as: rheumatic heart disease, paroxysmal or chronic atrial fibrillation, aortic or mitral valve stenosis or prosthesis, myocardial infarction in the preceeding two weeks, and myocarditis; whether the cause of death was 'cerebral' when the patient had died from central, or uncinate herniation, or 'non-cerebral'. On the basis of clinical and pathology data the definite cause of death was chosen. We considered the question when anticoagulation should be started in patients with cardiac embolic stroke as most relevant. Therefore, we made the diagnosis 'cardiac embolic stroke' on clinical grounds. No attempt was made to separate embolic strokes caused otherwise since it would not effect the clinical decision about anticoagulation.

Results

Data are expressed as median with range. There were 25 males and 23 females aged 73 (39-90) year. Interval from stroke till death was 6 (0-15) days for all cases, 4 (0-14) days for patients dying from brain herniation, and 8 (0-15) days for patients dying from non-cerebral causes (p < 0.01; two-tailed RIZED test). Non-cerebral causes were: pneumonia: 8, myocardial infarction: 6, pulmonary embolus: 2, sepsis/shock: 3, hepatic coma: 1, diabetic coma: 1. The number of cases with cerebral or non-cerebral cause of death, and the corresponding numbers of either HI or IN are shown in table 1. Almost all patients with HI at autopsy had died from brain herniation (15/16, = 94%). Fifteen of 27 patients (56%) dying from brain herniation had HI at autopsy against one of 21 patients (5%) who died from a non-cerebral cause (p < 0.001; $X^2$-test). Table 2 gives the data on the cause of death, and the aspect of the infarct at autopsy separately for patients with a cardiac embolic cause of stroke and patients without such a cause. Of the 16 cases with HI 10 had a cardiac embolic cause (63%). Ten of 19 (53%) with a cardiac embolic stroke had HI at autopsy against only six of 29 cases (21%) in the remaining group (p < 0.05; $X^2$-test). However, 14 of 19 patients (74%) with a cardiac embolic stroke died from brain herniation against 13 of 29 (45%) with non-cardiac cause. Since we expected the difference in this direction, one-tailed testing sufficed to establish the difference to be significant below the five percent level ($X^2$-test). In patients dying from brain herniation HI was equally present in

### Table 1

<table>
<thead>
<tr>
<th>Autopsy Findings in Patients Dying from Brain Herniation or from a Non-cerebral Cause, within 15 Days following a Supra-tentorial Brain Infarct</th>
</tr>
</thead>
<tbody>
<tr>
<td>brain herniation: 27</td>
</tr>
<tr>
<td>non-cerebral death: 21</td>
</tr>
<tr>
<td>HI = hemorrhagic infarction; IN = ischemic necrosis.</td>
</tr>
</tbody>
</table>

### Table 2

<table>
<thead>
<tr>
<th>Autopsy Findings in Patients with, and without a Cardiac Embolic Caused Stroke who Died within 15 Days following the Stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td>brain herniation: 14</td>
</tr>
<tr>
<td>non-cerebral death: 13</td>
</tr>
<tr>
<td>Cardiac embolic stroke: 19</td>
</tr>
<tr>
<td>non-cerebral death: 4</td>
</tr>
<tr>
<td>HI = hemorrhagic infarction; IN = ischemic necrosis.</td>
</tr>
</tbody>
</table>

FIGURE 2. Small areas of petechial hemorrhages in a large, left-sided infarct that resulted from internal carotid artery thrombosis in a 68-year-old female.
the group of cases with a cardiac cause of stroke (9/14, 64%), and those without such cause of stroke (6/13, 46%).

However, in these patients 6 of 9 (67%) with a cardioembolic stroke had large confluent hemorrhages, and only 2 of 6 (36%) patients with a non-cardiac cause of stroke.

Discussion

Recently, discussion on the timing of anticoagulant treatment in cardiac embolic stroke has been revived. One of the arguments to oppose early anticoagulation comes from autopsy findings: the close relationship of hemorrhagic infarction with cardiac embolic stroke leads to the fear of cerebral bleeding should anticoagulants be started. The concept of hemorrhagic infarction indicating an embolic cause was introduced by Fisher and Adams. In an autopsy series they found that 63 hemorrhagic infarcts (95%) had an embolic cause, and 66 of 132 embolic strokes (54%) were hemorrhagic infaracts. The authors neither mentioned the interval from stroke till death nor wether patients died from brain herniation. They did not define 'embolic stroke', but most probably they referred to cardiac embolic strokes. Because Fisher and Adams found no obstruction in the feeding vessel to the infarcted area in ten cases, they proposed a pathophysiological mechanism of hemorrhagic infarction that was further validated by autopsy and angiography studies. At autopsy Adams and Van der Eecken found hemorrhagic infarcts in 26 of 57 cases (65%) after a cardiac embolic stroke. They also did not mention the interval between stroke and death, nor the direct cause of death. Jørgensen and Torvik found a cardiac embolic cause in 42 of 54 (78%) hemorrhagic infarcts, and hemorrhagic infarcts in 42 of 59 (71%) cardioembolic strokes. Aggregated data of the three above-mentioned studies indicate that 134 of 239 (56%) embolic infarcts were hemorrhagic, and 105 of 120 (88%) hemorrhagic infarcts had a cardiac embolic cause. If more than half of all clinically diagnosed cardiac embolic strokes would consist of hemorrhagic infarcts a valid argument against early anticoagulation after such stroke would be offered. However, the following arguments dispute this extrapolation. In the series of Jørgensen and Torvik, 47 percent of 79 'recent' large infarcts had a cardiac embolic cause against only 19 percent of 129 'old' lesions. Obviously, patients with a cardiac embolic stroke had a greater chance of dying and consequently coming to autopsy than patients with brain infarcts from other causes. Recent clinical studies indicate likewise. Since CT studies indicate that hemorrhagic infarction is related to large infarcts, hemorrhagic infarcts found at autopsy are likely to have had a cardiac embolic cause. The finding of far more cardiac embolic strokes in autopsy series than in clinical and epidemiological studies further suggest such bias.

In the present series 63% of cases with hemorrhagic infarction had a cardiac embolic cause, which is somewhat lower than in the abovementioned studies. Fifty-three percent of patients with a cardiac embolic stroke had a hemorrhagic infarct at autopsy against only twenty-one percent without such cause. However, almost all cases with hemorrhagic infarction died from brain herniation. Patients with a cardiac embolic cause of stroke died from brain herniation more often than those without such cause. In cases dying from brain herniation, hemorrhagic infarction was equally frequent in the group with a cardiac embolic cause of stroke, as it was in the group without such cause. Therefore, the relative finding of a high rate of hemorrhagic infarction in fatal cardiac embolic strokes is related to the higher rate of brain herniation as the cause of death after such stroke, relative to fatal strokes caused otherwise. However, until now the degree of HI was not considered in relating HI to a cardiac embolic cause. Hart suggested that hemorrhagic infarcts with extended hemorrhages are most probably due to a cardiac emboli. Although our numbers are small, they sustain Hart’s suggestion: of the patients who died from brain herniation six of nine (67%) cases with larger hemorrhages had a cardioembolic cause, and only two of six (33%) cases without such cause. Thus, although autopsy studies are biased in relating HI to a cardioembolic cause, compared with non-cardiac strokes fatal cardiac emboli may result more often in HI with extended hemorrhages.

Whether the same holds true for non-fatal cardioembolic strokes and, if so, whether this finding would effect anticoagulant treatment regime remains to be shown. Until then, the view of Toole, that the outcome of autopsy studies should not be used as an argument against early anticoagulant treatment in cardioembolic stroke, still stands. The more so as clinical studies have shown that such treatment is safe, provided proper exclusion criteria are applied.

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