Ejection Fraction Response of the Left Ventricle of the Heart to Acute Cerebrovascular Accident in Patients With Coronary Artery Disease

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SUMMARY The ejection fraction (EF) of the left ventricle was measured by radionuclide ventriculography in 64 patients during an acute cerebrovascular accident. Sixteen patients (12 with coronary artery disease) died within two weeks of the onset of symptoms and had only one EF measurement. In the remaining 48 patients, the EF was also measured two weeks and three months after the acute event. The ejection fraction of the patient who died soon after the acute stroke (52 ± 18) was significantly lower than that of the patients who survived (64 ± 10) (p < 0.01).

Of the patients who survived, 28 without history of coronary disease had an EF of 67 ± 10 during the acute event. It was significantly higher than that measured after two weeks (60 ± 10) (p < 0.01). In 10 patients with history of chronic stable angina pectoris, the EF (59 ± 10) was significantly lower in the first study compared to that measured in the second (69 ± 10) (p < 0.02). Ten patients with no evidence of ischemia but with a history of myocardial infarction had a higher EF (61 ± 11) during the first study as compared to the second (51 ± 11) (p < 0.05). In all patients there was no significant difference in the EF measurements between the second and the third study. It is suggested that the EF response of the left ventricle to the acute cerebrovascular accident is similar to that observed in a stress test. Lowering of the EF during the acute cerebrovascular accident in patients with ischemia may be the explanation for the deleterious effect that stroke sometimes has on the heart. Low ejection fraction appears to be a significant risk factor for death soon after stroke.

Methods

Patients

The study group consisted of 64 consecutive patients (36 men, 28 women, average age 71 ± 5 SD years) with acute cerebrovascular accident admitted to the emergency ward, in whom radionuclide ventriculography (RVG) could be performed. Patients in poor condition who necessitated intensive care and patients who died before radionuclide ventriculography could be performed were not included. All patients had rapid onset of hemiparesis or hemiplegia, or sudden dysphasia or diplopia with or without paresthesia. Symptoms lasted more than 48 hours and in most patients were permanent with some modification in severity. Patients with transient ischemic attacks or mild rapidly reversible symptoms and patients with cerebral hemorrhage were not included.

On admission patients had a neurological examination to establish the diagnosis. Blood pressure was measured prior to each RVG study. EEG and ECG was obtained in all patients. When the diagnosis of acute cerebrovascular accident was not clear, CT was performed and only patients with cerebral thrombosis or cerebral embolism were included in the study group. The RVG was done within the first 24 hours after the onset of symptoms, in the majority of patients within 12 hours. Patients had a repeat RVG two weeks and three months after the first study.

Patients were divided into three groups, based on their cardiac history. Group 1, patients with no history of coronary artery disease; Group 2, patients with typical chronic stable angina pectoris who were treated by beta blockers and nitrates before and after admission; and Group 3, patients with no ischemia but with a history of myocardial infarction.

Sixteen patients (6 men, 10 women, average age 75 ± 4 years) died before two weeks and had only one EF study. Of these, 4 belonged to group 1, 8 to group 2 and 4 to group 3. In the surviving 48 patients, 28 belonged to group 1, 10 to group 2 and 10 to group 3.

Radionuclide Ventriculography

The method used for performing equilibrium gated radionuclide ventriculography has previously been de-
scribed by us.\textsuperscript{10} Twenty millicuries (740 MBq) of Tc-99m labeled red blood cells were injected i.v. and a standard field of view gamma camera interfaced to a mini-computer was used to obtain the data. A low energy, medium resolution parallel hole collimator was used. The left anterior oblique view with 15° caudal angulation was used for data analysis. The cardiac cycle was divided into 20 equal frames and 5 million counts were collected for each view. Time-activity curves were generated for the left ventricle and the ejection fraction (EF) was calculated after background correction. The ejection fraction during the acute stage was designated EF-1, after two weeks EF-2 and after three months EF-3.

Statistical Methods

The average EF of patients who died was compared to those who survived and the significance was measured using Student's two tailed t test. The EF of patients who survived measured during the acute event (EF-1) in groups 1, 2 and 3 was compared to that done after two weeks (EF-2) which was considered the base-line ejection fraction. Using Student's paired t test, the significance of difference between the mean EF-1 and the base-line EF-2 was calculated. The mean EF-3 was also compared to EF-2 in order to detect if there were any significant changes at different periods after the acute stage. Also, we compared the differences between the EF of the three groups using one way analysis of variance and a post hoc Neuman Keuls test.

Results

Death in all 16 patients was associated with gradual or sudden worsening of neurological symptoms. In 2 patients, pneumonia was also diagnosed prior to death. The average EF of the patients who died within two weeks of entering the study was 52 ± 18 and was significantly lower ($p < 0.01$) than that of patients who survived (64 ± 10).

The average EF of patients who died was: in group 1 — 59 ± 14 (4 patients); in group 2 — 42 ± 16 (8 patients); and in group 3 — 61 ± 15 (4 patients).

In the surviving patients (table 1, fig. 1) 28 in group 1 having no evidence of coronary artery disease had mean EF-1 of 67 ± 10, mean EF-2 of 60 ± 10 and mean EF-3 of 61 ± 11. As shown in table 1 and figure

<table>
<thead>
<tr>
<th>Group</th>
<th>No. of patients</th>
<th>EF-1</th>
<th>EF-2</th>
<th>EF-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No evidence of coronary artery disease</td>
<td>28</td>
<td>$67 \pm 10$</td>
<td>$60 \pm 10$</td>
<td>$62 \pm 11$</td>
</tr>
<tr>
<td>$p &lt; 0.01$</td>
<td>N.S.*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. History of angina</td>
<td>10</td>
<td>$59 \pm 10$</td>
<td>$69 \pm 10$</td>
<td>$66 \pm 11$</td>
</tr>
<tr>
<td>$p &lt; 0.02$</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. History of MI but no angina</td>
<td>10</td>
<td>$61 \pm 11$</td>
<td>$51 \pm 11$</td>
<td>$53 \pm 11$</td>
</tr>
<tr>
<td>$p &lt; 0.05$</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* N.S. = not significant.

\textbf{FIGURE 1.} EF-1 and EF-2 in (a) patients with no history of coronary artery disease (group-1), (b) patients with chronic stable angina (group-2) and (c) patients with history of myocardial infarction but no ischemia (group-3).
1, EF-2 was significantly lower than EF-1 \((p < 0.01)\) but was not different from EF-3.

In the 10 patients of group 2 (patients with history of angina), mean EF-2 \((69 \pm 10)\) was significantly higher \((p < 0.02)\) than mean EF-1 \((59 \pm 10)\), but not significantly different than mean EF-3 \((66 \pm 11)\).

In the 10 patients of group 3 (myocardial infarction but no history of angina) mean EF-2 \((51 \pm 11)\) was significantly lower \((p < 0.05)\) than EF-1 \((61 \pm 11)\), but not significantly lower than mean EF-3 \((53 \pm 11)\).

The difference between the ejection fraction (EF-1–EF-2) for the three groups was calculated. One way analysis of variance yielded a statistically significant \(F\) value \((F = 10.8, p < 0.001)\). A subsequent post hoc Neuman–Keuls test yielded a standardized range \(q\) value of 6.0 for the difference between group 1 and group 2 \((p < 0.05)\). The \(q\) value for the difference between group 2 and group 3 was also significant \((q = 5.5, p < 0.05)\). No significant difference was found between group 1 and group 3.

In each of the groups there was no significant difference in systolic or diastolic blood pressure, measured prior to the RVG, between measurement 1 and 2. Neither was there a significant difference between Groups 1, 2 and 3 (table 2).

### Discussion

Radionuclide ventriculography is a non-invasive method for evaluating cardiac performance. The EF estimated during this study is the most widely used measure of left ventricular contractile function, especially in patients with suspected or known coronary artery disease.\(^{11,12}\) It is also a great value in assessing the response of the heart to various systemic diseases and the effect of treatment on these diseases.\(^{13,14}\) Stress RVG studies have been used extensively for diagnosis of coronary artery disease.

While the effect of stroke on cardiac rhythm has been well documented, the response of the left ventricle to an acute cerebrovascular accident has not been investigated. It has been suggested, though, that a stroke might have a deleterious effect on the heart.\(^{3,4}\) A major difficulty in obtaining this information is the lack of a pre-stroke baseline measure of left ventricular performance. The ejection fraction in this age group has a wide baseline range.\(^{15}\) In our study this problem was overcome by measuring the EF during the acute event and two weeks later.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Blood Pressure and Heart Rate during Acute Cerebrovascular Accident and after Two Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>Study 1 BP*         HR†</td>
</tr>
<tr>
<td>1</td>
<td>154/90            79        N.S.‡</td>
</tr>
<tr>
<td>2</td>
<td>150/88            74        N.S.‡</td>
</tr>
<tr>
<td>3</td>
<td>158/94            76        N.S.‡</td>
</tr>
</tbody>
</table>

\( BP = \) blood pressure; \( HR = \) heart rate; \( N.S. = \) not significant.

months later showed that the EF stabilized after two weeks following the acute stroke, and this was considered the baseline ejection fraction. This method thus enabled us to record reversible changes in EF during the stroke period.

Our results indicate that patients with a history of angina pectoris responded to acute stroke by lowering their EF, while patients with no history of heart disease or patients with history of infarction but no evidence of ischemia responded by elevating their EF. This pattern of EF response is similar to that seen in stress testing.\(^{11,12,16,17}\) The fact that there were no significant changes in blood pressure and heart rate between the first and second study suggests that the response of the left ventricle was probably not mediated by catecholamines. Such a response has been described after mental stress.\(^{17}\) The reduction of EF is probably caused by ischemia in patients with stenotic coronary arteries. The mechanism producing ischemia in stroke patients remains to be defined.

Coronary artery disease and CVA have the same risk factors. Vessel atheromata are common to both diseases.\(^{5,12,18,19}\) The association between these two diseases in our material (50%, 32/64) is somewhat lower than the 70% reported by Britton et al.\(^{7}\) This might be explained by the fact that patients in poor condition and those who died before the first study could be done were not included in our study. These were probably patients with severe vascular disease.

The EF of the patients who died within two weeks after the acute stroke was significantly lower than that of the patients who survived \((52 vs 64, p < 0.01)\). This indicates that the existence of a low EF is a significant risk factor soon after stroke. Twelve of the 16 patients who died had a history of ischemic heart disease. While the Framingham study\(^{18}\) showed that coronary artery disease and congestive heart failure increase the risk of stroke in general and subsequent mortality, we failed to find any direct information in the literature on cardiac function during the acute stroke as a risk factor. Although, there is some hint of it in the study of Abu Zeid et al.,\(^{20}\) who found that enlargement of the heart on chest x-rays was a factor adversely affecting the survival of patients with stroke during the first year.

Decreased perfusion to the brain has been suggested as playing a role in patients with congestive heart disease prone to stroke\(^{18}\). This may also explain the association between the low EF found in the patients in our study who died and the symptoms of extension of the brain infarction found in them prior to death.

In conclusion, the results of this study suggest that the deleterious effect that stroke has on the heart appears to be through the lowering of the EF during the acute event, which is evident in patients with coronary ischemia. It is also suggested that low EF is a risk factor for death soon after the stroke.

### Acknowledgments

We are indebted to J. Anthony Parker, M.D., Ph.D. of the Beth Israel Hospital, Boston, Lionel Liberman, M.D., Ph.D. of the Chaim Sheba...
Central Nervous System Complications of Percutaneous Transluminal Coronary Angioplasty

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SUMMARY During 1968 consecutive percutaneous transluminal coronary angioplasty (PTCA) procedures, 4 patients (0.2%) suffered a focal central nervous system complication. Two patients had a hemisphere infarct, one a brainstem infarct and one a hemisphere transient ischemic attack. Embolism was the likely mechanism in 3 cases; in 1 air was injected through the guiding catheter, and in 2 post-coronary bypass cases the ascending aorta was "scraped" with the guiding catheter while searching for a graft ostium. In 1 case the event occurred after a successful PTCA during a period of hypotension. Neurologic complications are rare during PTCA but will occasionally occur as the procedure is performed more frequently.

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PERCUTANEOUS TRANSLUMINAL ANGIOPLASTY was developed by Dotter and Judkins in 1964.1 Its purpose was to dilate atherosclerotic obstructions in peripheral arteries utilizing coaxial catheters of increasing diameter. Innovations in catheter design and modifications in technique led to the performance of angioplasty for proximal stenosis of coronary arteries.2 3

The number of percutaneous transluminal coronary angioplasties (PTCA) performed in the United States has increased markedly in the past five years. Rare complications will become more visible as the number of patients treated increases, yet analysis of neurologic events during PTCA has been virtually ignored.

In this report we discuss the frequency and types of complications seen in a large consecutive series of patients undergoing PTCA at the Cleveland Clinic.

Methods

A. PTCA Registry

Data on all patients undergoing PTCA at the Cleveland Clinic is logged into a prospective registry. All patients undergo an initial history and physical exami-
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