Prognosis in Coronary Artery Disease
Angiographic, Hemodynamic, and Clinical Factors

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SUMMARY
Evaluation of the results of surgery for coronary artery disease requires a knowledge of the clinical course of patients not having this mode of treatment. To obtain such information we performed a retrospective analysis of the fate of 266 patients with arteriographically documented significant stenosis followed from one to ten years. For the entire group the five year survival was 73%. Subdivided into single, double or triple vessel disease categories the percent five year survival rates were respectively 92, 65 and 55. A history of angina pectoris or myocardial infarction prior to angiography did not affect survival. However, hypertension, congestive heart failure, abnormal hemodynamics or left ventricular asynergy were all associated with a diminished five year survival, the values being respectively 61%, 38%, 62% and 58%. These results should be of value in assessing the prognosis of nonsurgically treated patients with coronary artery disease.

Additional Indexing Words:
Angina pectoris  Myocardial infarction  Left ventriculography
Congestive heart failure  Systemic hypertension  Coronary artery surgery

SINCE THE original report by Herrick and Nuzum many investigators have studied the natural history of coronary artery disease by following the course of patients after a presenting clinical event such as acute myocardial infarction or the onset of angina pectoris. Data representative of the general population are those of the Framingham study, which indicates a 4% mortality risk per year following onset of angina pectoris or after the hospital phase of myocardial infarction. However, only limited information is presently available which relates the clinical course of patients with coronary artery disease to its angiographically determined severity. In spite of the uncertainty as to the prognostic significance of arteriographically documented coronary lesions, the appearance of the coronary angiogram is a major factor in decisions concerning surgical procedures for coronary heart disease. There is thus a need for more information correlating angiographic anatomy with the clinical course of patients with coronary atherosclerosis.

During the period 1964–70, significant coronary artery disease (defined as greater than 50% stenosis in at least one main vessel) was detected in 266 subjects studied in our laboratory who did not have subsequent surgical myocardial revascularization procedures. Based on the fate of these patients we have attempted to determine the prognostic significance of coronary arteriographic lesions. In addition we were able to correlate their survival with hemodynamic measurements, left ventriculography and clinical status at the time of angiography.

Methods
Patient Population
From 1964 to 1970, 1190 coronary angiograms were undertaken in our laboratory. The indications for angiography were to assess potential candidates for myocardial revascularization procedures (usually a Vineberg implant), to re-evaluate patients who had been subjected to this operation, to diagnose subjects with chest pain of uncertain cause, to evaluate patients being considered for valve surgery, and to clarify the significance of nonspecific electrocardiographic abnormalities in subjects at high risk occupation (air force pilots). There were 552 patients with significant coronary artery stenosis and no other type of cardiac disease. Myocardial revascularization procedures were performed in 231 subjects. With the exclusion of 21 subjects because of insufficient clinical information and 34 due to inadequate coronary angiograms, there were 266 patients remaining in the study group. Seven of these patients, with significant main left coronary artery obstruction, were analyzed separately, and thus the study group was composed of 259 subjects. There were 225 males and 34 females with a mean age of 50 and range of 25 to 70 years. The age
distribution by decades in males and females is indicated in table 1.

Data Acquisition

This study was performed in a retrospective manner. All clinical data were evaluated by one of the authors. Preangiotic information concerning myocardial infarction, angina pectoris, blood pressure and electrocardiographic diagnosis was obtained from the patients’ hospital charts. Angina was classified as provoked by heavy exertion (grade 1), occurring with ordinary activity (grade 2), present on mild exertion (grade 3) or occurring at rest (grade 4). Standard electrocardiographic and enzyme criteria were used for the diagnosis of myocardial infarction.

Patients were classified as having heart failure if they required continuing administration of digitalis with or without diuretics on a chronic basis to remain free of pulmonary congestion or peripheral edema. Hypertension was considered significant if the resting systolic or diastolic pressures were greater than 150 or 90 mm. Hg, respectively. The coronary angiograms of all the patients were reviewed by at least one of the authors and by both if there was doubt as to the extent of a lesion. Most of the angiograms were performed according to the Sones technique although a small number were done by the Judkins method. In the majority both the right and left coronary arteries and their main branches were studied in at least two oblique projections (RAO 30° and LAO 60°). However, in some of the earlier studies views of an artery were obtained in only one projection, which could have resulted in underestimation of stenosis. The vessels classified as the main left, the left anterior descending, the circumflex or its marginal branch if it was the principal continuation, and the right coronary artery. A narrowing of more than 50% was considered significant. These stenoses were further subdivided into the following categories: > 50% < 75%, ≥ 75% < 100%, and 100% obstruction.

Left ventriculograms performed in the 30° RAO projection were available in 170 cases and these were classified simply as normal or abnormal for purposes of analysis. A ventriculogram was termed abnormal if it showed one or more of the following: generalized or local hypokinesis, akinetic areas, or dyskinesis. Hemodynamic data were also available for 213 patients. Resting left ventricular end-diastolic pressure was recorded in all patients having hemodynamic tests and was the only measurement in 104 patients; 45 had atrial pacing studies and 69 had supine bicycle ergometer exercise. Five subjects had both pacing and exercise tests.

Follow-up information concerning angina pectoris, myocardial infarction, congestive heart failure, and survival after angiography was obtained from hospital charts, by form letters to referring physicians or by telephone calls to the physicians, the patients or their families. Deaths were classified as cardiac or noncardiac. The cardiac deaths included those occurring suddenly (defined as death before the patient could be hospitalized), fatal complications of known acute myocardial infarction and those due to chronic congestive failure. Probably some of the sudden deaths were truly noncardiac although considering the selected population under study this would be a small number.

Analysis of Data

The clinical, angiographic and hemodynamic data were recorded on a standard form and transferred onto IBM cards. The mean duration of follow-up after angiography was 51 months with a range of 1 to 110 months. The number of patients for whom data were available during subsequent yearly intervals decreased progressively. This was the result of 71 deaths, 39 patients lost to follow-up some time after angiography and because those studied more recently were followed for a shorter period. The effects of including patients lost to follow-up after angiography on the results of the study are not known. As these individuals were lost because they had moved and did not maintain contact with their referring physicians, it was not thought that they would bias the results. Survival tables were produced on an IBM-360 model 50 computer using a BMD (Biomedical) computer program package developed by UCLA (BMD Computer Programs, Number 01S, University of California Press).

For purposes of analysis the entire group was subdivided according to the presence of significant single vessel disease (one of left anterior descending, right coronary artery or circumflex), double vessel disease (two of these vessels) or triple vessel disease (all of these vessels). We were then in a position to correlate survival after the arteriogram with the severity of coronary artery involvement. Survival tables were also constructed to determine if the presence or absence of certain clinical, hemodynamic or ventriculographic abnormalities had a significant influence on prognosis. The data concerning the seven patients with significant main left coronary disease were analyzed separately.

Statistical analysis was performed in the following manner. From the survival tables we estimated the probability of survival in one year based on the data obtained during the first five years after angiography. We then used standard tables to obtain 95% confidence limits on the probability of survival. These limits were compared for different groups and if there was no overlap there was considered to be a significant difference between survival for these groups.

Results

1. Group Characteristics

In table 2 the extent and distribution of significant coronary artery involvement for the entire group are summarized. There were 101 individuals with single vessel involvement, 94 with double vessel disease and 64 with triple vessel stenosis.

Of the 259 subjects in this study 207 (80%) experienced angina pectoris some time before coronary arteriography. During the three months prior to angiography angina was present in 181 (70%) subjects and in this group angina of grades 1, 2, 3, and 4 occurred in 6, 42, 24, and 28%, respectively. The

Table 1

| Age and Sex Distribution for 259 Subjects with Coronary Artery Disease |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Decade                          | 20-29           | 30-39           | 40-49           | 50-59           | 60-69           | 70-79           | Total           |
| Number of males                 | 1               | 26              | 98              | 72              | 29              | 2               | 228             |
| Number of females               | 1               | 1               | 7               | 13              | 9               | 0               | 31              |

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average duration of angina was 40 months (range 1-120 months). A history of myocardial infarction was present in 138 (53%) subjects. There were 24 (9%) with two previous infarctions and five (2%) with three such episodes. The first infarction occurred from three to 120 months (average 30 months) prior to angiography. Eighty-eight (64%) of the 138 patients with previous infarction also had angina during the three months before angiography.

Forty-seven (18%) of the group were hypertensive. Twenty-eight (11%) of the 259 subjects required continuing use of a cardiac glycoside and usually also diuretics for treatment of congestive heart failure. Twenty-four of the subjects with heart failure had determination of resting left ventricular end-diastolic pressure and in 21 (88%) it was abnormal. Two hundred and thirteen patients had a resting left ventricular end-diastolic pressure recorded and in 58 (27%) the result was abnormal. Twenty-seven (60%) of the 45 pacing tests and 55 (80%) of the 69 exercise studies were abnormal. Eighty-five (50%) of the 170 ventriculograms and 187 (72%) of the electrocardiograms were abnormal.

In our analysis of factors affecting survival the main body of 259 subjects will be divided into subsets according to clinical, hemodynamic and angiographic abnormalities. To assess their comparability table 3 lists the average age, sex distribution and severity of coronary artery disease in each of these groups. The mean age and sex distribution are very similar in all subsets. With the exception of those with angina grades 1-2 or myocardial infarction, all groups listed in table 3 tended to have a higher incidence of multiple vessel involvement than in the entire population.

### Table 2

**Severity of Coronary Artery Disease in 259 Subjects**

<table>
<thead>
<tr>
<th>Number of vessels involved</th>
<th>Single number</th>
<th>Double number</th>
<th>Triple number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessels involved</td>
<td>R 41</td>
<td>R + LAD 45</td>
<td>R + LAD + C 64</td>
</tr>
<tr>
<td></td>
<td>LAD 51</td>
<td>R + C 23</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>C 9</td>
<td>LAD + C 26</td>
<td>10</td>
</tr>
<tr>
<td>Totals</td>
<td>101</td>
<td>94</td>
<td>64</td>
</tr>
</tbody>
</table>

**Abbreviations:** C = circumflex; LAD = left anterior descending; R = right coronary artery.

### Table 3

**Characteristics of Subgroups**

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Number of subjects</th>
<th>Mean age (years)</th>
<th>Males/total group</th>
<th>SVD</th>
<th>Extent of vessel involvement %</th>
<th>DVD</th>
<th>TVD</th>
</tr>
</thead>
<tbody>
<tr>
<td>All subjects</td>
<td>259</td>
<td>50</td>
<td>.89</td>
<td>39</td>
<td>36</td>
<td>25</td>
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<tr>
<td>SVD</td>
<td>101</td>
<td>48</td>
<td>.85</td>
<td>100</td>
<td>—</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DVD</td>
<td>94</td>
<td>49</td>
<td>.91</td>
<td>—</td>
<td>100</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>TVD</td>
<td>64</td>
<td>53</td>
<td>.87</td>
<td>—</td>
<td>—</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Sudden death</td>
<td>24</td>
<td>53</td>
<td>.96</td>
<td>8</td>
<td>33</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>Cardiac deaths not sudden</td>
<td>39</td>
<td>53</td>
<td>.85</td>
<td>12</td>
<td>50</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>All AP</td>
<td>181</td>
<td>50</td>
<td>.86</td>
<td>31</td>
<td>39</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>AP Gr 1-2</td>
<td>83</td>
<td>50</td>
<td>.87</td>
<td>38</td>
<td>40</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>AP Gr 3-4</td>
<td>98</td>
<td>51</td>
<td>.86</td>
<td>25</td>
<td>38</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>AP Gr 4</td>
<td>80</td>
<td>50</td>
<td>.88</td>
<td>32</td>
<td>38</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>MI</td>
<td>138</td>
<td>48</td>
<td>.94</td>
<td>41</td>
<td>34</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>MI and AP</td>
<td>88</td>
<td>49</td>
<td>.94</td>
<td>30</td>
<td>36</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>CHF</td>
<td>28</td>
<td>52</td>
<td>.92</td>
<td>15</td>
<td>35</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>BP &gt; 150/90</td>
<td>47</td>
<td>52</td>
<td>.77</td>
<td>30</td>
<td>36</td>
<td>34</td>
<td></td>
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<tr>
<td>Abnormal ECG</td>
<td>157</td>
<td>49</td>
<td>.90</td>
<td>28</td>
<td>27</td>
<td>45</td>
<td></td>
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<tr>
<td>Abnormal hemodynamics at rest</td>
<td>58</td>
<td>50</td>
<td>.91</td>
<td>33</td>
<td>33</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Abnormal hemodynamics with pacing or exercise</td>
<td>80</td>
<td>50</td>
<td>.98</td>
<td>27</td>
<td>42</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Abnormal left ventriculogram</td>
<td>85</td>
<td>48</td>
<td>.94</td>
<td>33</td>
<td>38</td>
<td>29</td>
<td></td>
</tr>
</tbody>
</table>

**Abbreviations:** AP = angina pectoris during 3 mos before angiogram, AP grading as in text; BP = systemic arterial pressure; CHF = congestive heart failure; ECG = electrocardiogram; MI = myocardial infarction before angiogram; SVD = single vessel disease; DVD = double vessel disease; TVD = triple vessel disease.
The most striking variations occur in the subjects with congestive failure and in the nonsurvivors. These two groups had a much lower incidence of single vessel disease and higher frequency of multiple artery involvement than the others.

2. Survival Data

There were 71 patients who died during the follow-up period. The numbers dying from various causes are indicated in table 4. Only 11% of the deaths were known to be noncardiac. Most of the 24 sudden deaths were probably cardiac considering the nature of the population under study.

In table 5 the clinical, hemodynamic and angiographic characteristics of the entire group and of the nonsurvivors are compared. In addition to the more severe coronary artery disease already alluded to in table 3, patients suffering cardiac deaths had a higher incidence of congestive failure, hypertension, electrocardiographic, hemodynamic and ventriculographic abnormalities than the entire group. As already noted in the discussion of table 3 these same factors were associated with a higher incidence of multiple coronary vessel involvement and thus their influence on survival is not separable from the effects of the coronary disease with which they are associated. In contrast, neither angina pectoris nor prior myocardial infarction appear to influence survival.

There was no tendency for a particular artery to be associated with sudden death. The relation between cardiac death and the severity of individual coronary lesions (≥ 75 < 100% stenosis and 100% obstruction) was also examined. These data, summarized in table 6, reflect the higher incidence of coronary involvement of both types in the cardiac death group and show no predilection for death to be associated with near complete or complete obstruction.

Table 7 and figure 1 relate duration of survival to the extent of coronary artery disease. At the end of five years the percentages surviving for the groups with single, double, and triple vessel involvement were 92, 65, and 55, respectively. For the entire group the five year survival was 73%. Clearly, survival is better with single vessel involvement (P < 0.01). However, the difference between double and triple vessel disease was not statistically significant. When only lesions of 75% or more stenosis were considered the survivals at five years for single, double, and triple vessel disease were 91, 59 and 45%, respectively.

Table 8 and figure 2 show the survival duration data for single vessel disease classified according to individual arteries. The group with isolated circumflex

### Table 4

**Causes of Death**

<table>
<thead>
<tr>
<th>Cause</th>
<th>Number</th>
<th>% of deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noncardiac</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Sudden (outside hospital)</td>
<td>24</td>
<td>34</td>
</tr>
<tr>
<td>Chronic congestive heart failure</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>Acute myocardial infarction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrhythmia</td>
<td>16</td>
<td>23</td>
</tr>
<tr>
<td>Pump failure</td>
<td>13</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>71</td>
<td>100</td>
</tr>
</tbody>
</table>

### Table 5

**Comparison of Entire Group and Nonsurvivors**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>All subjects (259)</th>
<th>Not sudden (59)</th>
<th>Sudden (24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (years)</td>
<td>50</td>
<td>53</td>
<td>53</td>
</tr>
<tr>
<td>Males/total group</td>
<td>.89</td>
<td>.85</td>
<td>.96</td>
</tr>
<tr>
<td>SVD %</td>
<td>39</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>DVD %</td>
<td>36</td>
<td>50</td>
<td>33</td>
</tr>
<tr>
<td>TVD %</td>
<td>25</td>
<td>38</td>
<td>59</td>
</tr>
<tr>
<td>All AP %</td>
<td>70</td>
<td>75</td>
<td>68</td>
</tr>
<tr>
<td>AP Gr 1–2 %</td>
<td>26</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>AP Gr 3–4 %</td>
<td>36</td>
<td>45</td>
<td>42</td>
</tr>
<tr>
<td>AP Gr 5 %</td>
<td>19</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>MI %</td>
<td>53</td>
<td>55</td>
<td>62</td>
</tr>
<tr>
<td>CHF %</td>
<td>11</td>
<td>28</td>
<td>33</td>
</tr>
<tr>
<td>BP &gt; 150/90 %</td>
<td>18</td>
<td>28</td>
<td>25</td>
</tr>
<tr>
<td>Abnormal ECG %</td>
<td>72</td>
<td>100</td>
<td>76</td>
</tr>
<tr>
<td>Abnormal hemodynamics at rest %</td>
<td>27 (58/212)*</td>
<td>50 (17/33)</td>
<td>48 (10/21)</td>
</tr>
<tr>
<td>Abnormal hemodynamics with pacing or exercise %</td>
<td>73 (80/109)</td>
<td>100 (17/17)</td>
<td>100 (7/7)</td>
</tr>
<tr>
<td>Abnormal left ventriculogram %</td>
<td>50 (85/170)</td>
<td>83 (19/23)</td>
<td>77 (10/13)</td>
</tr>
</tbody>
</table>

Abbreviations as in table 3.

*Numbers given in parentheses when entire group was not assessed for specified characteristic.
Table 6

Effects of Severity of Stenosis on Mortality

<table>
<thead>
<tr>
<th></th>
<th>Survivors (188 subjects)</th>
<th>Cardiac deaths (63 subjects)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of vessels involved</td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>Percent of group with ( \geq 75 &lt; 100% ) obstruction</td>
<td>43 15 2 47 21 6</td>
<td></td>
</tr>
<tr>
<td>Percent of group with ( 100% ) obstruction</td>
<td>49 6 0 47 22 0</td>
<td></td>
</tr>
</tbody>
</table>

stenosis is not plotted in figure 2 because of the small size of the group. The five year survival for those with isolated involvement of the main right coronary artery was 98%, while the comparable figure for left anterior descending disease was 87%. This difference was not statistically significant. It is of interest that there was only one known death in the group with isolated right coronary artery disease in the nine year period and this occurred in the first year.

Survival duration was also correlated with clinical, hemodynamic and ventriculographic data. The cumulative survival at five years after angiography for the 78 subjects without angina was 76%, for the 181 with angina of any severity 72%, and for the 47 with angina occurring at rest prior to angiography 71%. These small differences are not significant. Similarly, a prior history of infarction had only a small effect on the five year survival. The 121 subjects without

![Figure 1](http://circ.ahajournals.org/)

Survival related to extent of coronary artery involvement. CAD = coronary artery disease; SVD = single vessel disease; DVD = double vessel disease; TVD = triple vessel disease.

Table 7

Survived Related to Number of Vessels Involved

<table>
<thead>
<tr>
<th>Vessels Involved</th>
<th>All subjects</th>
<th>SVD</th>
<th>DVD</th>
<th>TVD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alive at start</td>
<td>Deaths</td>
<td>Cumulative</td>
<td>Deaths</td>
</tr>
<tr>
<td>0</td>
<td>103</td>
<td>90</td>
<td>95</td>
<td>92</td>
</tr>
<tr>
<td>1</td>
<td>208</td>
<td>159</td>
<td>167</td>
<td>165</td>
</tr>
<tr>
<td>2</td>
<td>206</td>
<td>110</td>
<td>107</td>
<td>105</td>
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<tr>
<td>3</td>
<td>200</td>
<td>97</td>
<td>97</td>
<td>96</td>
</tr>
</tbody>
</table>

Abbreviations: SVD = single vessel disease; DVD = double vessel disease; TVD = triple vessel disease.
PROGNOSIS IN CORONARY ARTERY DISEASE

Table 8

Survival Related to Type of Single Vessel Disease

<table>
<thead>
<tr>
<th>Years after angiogram</th>
<th>Alive at start</th>
<th>Deaths</th>
<th>Cumulative survival %</th>
<th>Alive at start</th>
<th>Deaths</th>
<th>Cumulative survival %</th>
<th>Alive at start</th>
<th>Deaths</th>
<th>Cumulative survival %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>51</td>
<td>4</td>
<td>92</td>
<td>41</td>
<td>1</td>
<td>98</td>
<td>9</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>1-2</td>
<td>46</td>
<td>0</td>
<td>92</td>
<td>39</td>
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<td>92</td>
<td>36</td>
<td>0</td>
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<td>3-4</td>
<td>42</td>
<td>1</td>
<td>90</td>
<td>33</td>
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<td>98</td>
<td>8</td>
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<td>4-5</td>
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<td>87</td>
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<td>8-9</td>
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<td>1</td>
<td>56</td>
<td>4</td>
<td>0</td>
<td>98</td>
<td>1</td>
<td>0</td>
<td>78</td>
</tr>
</tbody>
</table>

Abbreviations: LAD = left anterior descending artery; R = right coronary artery; C = circumflex artery.

The effects of abnormal hemodynamics and ventriculography are summarized in table 11 and figure 4. The results of left ventriculography were clearly

Table 9

Effects of Angina or Infarction on Survival

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of subjects at start</th>
<th>% 5 yr Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>All subjects</td>
<td>259</td>
<td>73</td>
</tr>
<tr>
<td>No MI or AP</td>
<td>28</td>
<td>77</td>
</tr>
<tr>
<td>MI but no AP</td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>AP but no MI</td>
<td>93</td>
<td>76</td>
</tr>
<tr>
<td>MI and AP</td>
<td>88</td>
<td>67</td>
</tr>
<tr>
<td>All SVD</td>
<td>101</td>
<td>92</td>
</tr>
<tr>
<td>With AP Gr 1-2</td>
<td>32</td>
<td>100</td>
</tr>
<tr>
<td>With AP Gr 3-4</td>
<td>25</td>
<td>88</td>
</tr>
<tr>
<td>With AP Gr 4</td>
<td>16</td>
<td>92</td>
</tr>
<tr>
<td>With no AP</td>
<td>44</td>
<td>99</td>
</tr>
<tr>
<td>All DVD</td>
<td>94</td>
<td>65</td>
</tr>
<tr>
<td>With AP Gr 1-2</td>
<td>34</td>
<td>65</td>
</tr>
<tr>
<td>With AP Gr 3-4</td>
<td>37</td>
<td>63</td>
</tr>
<tr>
<td>With AP Gr 4</td>
<td>19</td>
<td>58</td>
</tr>
<tr>
<td>With no AP</td>
<td>23</td>
<td>65</td>
</tr>
<tr>
<td>All TVD</td>
<td>64</td>
<td>55</td>
</tr>
<tr>
<td>With AP Gr 1-2</td>
<td>17</td>
<td>58</td>
</tr>
<tr>
<td>With AP Gr 3-4</td>
<td>36</td>
<td>55</td>
</tr>
<tr>
<td>With AP Gr 4</td>
<td>15</td>
<td>60</td>
</tr>
<tr>
<td>With no AP</td>
<td>11</td>
<td>33</td>
</tr>
</tbody>
</table>

Abbreviations as in table 3.

Figure 2

Survival related to type of isolated coronary artery disease. LAD = left anterior descending coronary artery; R = right coronary artery.

Circulation, Volume 51, January 1975
Survival with coronary artery disease related to heart failure and blood pressure. CHF = congestive heart failure; BP = blood pressure.

### Table 10

<table>
<thead>
<tr>
<th>Years after angiography</th>
<th>Alive at start</th>
<th>Deaths</th>
<th>Without CHF</th>
<th>Cumulative survival %</th>
<th>Alive at start</th>
<th>Deaths</th>
<th>With CHF</th>
<th>Cumulative survival %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>231</td>
<td>61</td>
<td>16</td>
<td>94%</td>
<td>212</td>
<td>60</td>
<td>2</td>
<td>88%</td>
</tr>
<tr>
<td>1-2</td>
<td>212</td>
<td>53</td>
<td>12</td>
<td>85%</td>
<td>191</td>
<td>49</td>
<td>3</td>
<td>77%</td>
</tr>
<tr>
<td>2-3</td>
<td>191</td>
<td>49</td>
<td>13</td>
<td>83%</td>
<td>172</td>
<td>45</td>
<td>1</td>
<td>75%</td>
</tr>
<tr>
<td>3-4</td>
<td>172</td>
<td>45</td>
<td>15</td>
<td>83%</td>
<td>150</td>
<td>38</td>
<td>1</td>
<td>74%</td>
</tr>
<tr>
<td>4-5</td>
<td>150</td>
<td>38</td>
<td>16</td>
<td>83%</td>
<td>130</td>
<td>27</td>
<td>1</td>
<td>74%</td>
</tr>
<tr>
<td>5-6</td>
<td>130</td>
<td>27</td>
<td>16</td>
<td>83%</td>
<td>112</td>
<td>24</td>
<td>1</td>
<td>74%</td>
</tr>
<tr>
<td>6-7</td>
<td>112</td>
<td>24</td>
<td>21</td>
<td>83%</td>
<td>94</td>
<td>20</td>
<td>1</td>
<td>74%</td>
</tr>
<tr>
<td>7-8</td>
<td>94</td>
<td>20</td>
<td>21</td>
<td>83%</td>
<td>77</td>
<td>18</td>
<td>0</td>
<td>74%</td>
</tr>
<tr>
<td>8-9</td>
<td>77</td>
<td>18</td>
<td>22</td>
<td>83%</td>
<td>62</td>
<td>16</td>
<td>1</td>
<td>74%</td>
</tr>
<tr>
<td>9-10</td>
<td>62</td>
<td>16</td>
<td>22</td>
<td>83%</td>
<td>45</td>
<td>12</td>
<td>0</td>
<td>74%</td>
</tr>
<tr>
<td>10-12</td>
<td>45</td>
<td>12</td>
<td>22</td>
<td>83%</td>
<td>30</td>
<td>9</td>
<td>0</td>
<td>74%</td>
</tr>
<tr>
<td>12-15</td>
<td>30</td>
<td>9</td>
<td>22</td>
<td>83%</td>
<td>15</td>
<td>6</td>
<td>0</td>
<td>74%</td>
</tr>
<tr>
<td>15-20</td>
<td>15</td>
<td>6</td>
<td>22</td>
<td>83%</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>74%</td>
</tr>
</tbody>
</table>

**Abbreviations:** BP = systemic arterial blood pressure; CHF = congestive heart failure.

3. Complications during Follow-up Period

Survival information was obtained in 259 subjects in this study but only in 235 were other data available concerning complications of coronary artery disease during the follow-up period. Electrocardiographic diagnoses could be determined in 112 individuals at the time of their last assessment. Table 12 relates the occurrence of myocardial infarction since angiography, grade of angina, presence of congestive cardiac failure and electrocardiographic diagnosis at the time of last follow-up to the severity of vessel involvement. It can be appreciated from this table that any of these complications or an abnormal electrocardiogram occurred most frequently in the subjects with more severe coronary artery involvement.

Of the 163 patients with grades 1–4 angina three months before angiography for whom follow-up information was available 40 (25%) had no angina at the time of last follow-up and 16 (10%) had angina of greater severity (at least 1 grade higher). Of the 72 subjects not having angina during the three months before angiography, 25 (35%) did experience this symptom during the three months before last assessment.
PROGNOSIS IN CORONARY ARTERY DISEASE

4. Subjects with Main Left Coronary Stenosis

The seven subjects with main left coronary artery stenosis had a mean age of 55 years. There were no females in the group and there was only one hypertensive patient. All seven subjects had angina of at least grade 2 severity for an average of 53 months (range 6–120 months) and four of them had a myocardial infarction 60–84 months before angiography. In addition to main left stenosis, three subjects had triple vessel disease, two had double vessel involvement and one had only circumflex disease. Two patients had a normal electrocardiogram and two had chronic congestive heart failure. Of the five patients having hemodynamic measurements two were normal but these subjects did not have pacing or exercise studies.

Six of the seven patients with main left coronary disease died during the follow-up period at an average of 29 months (range 3–59 months) after angiography. Five of the deaths were sudden and one was attributed to heart failure. One subject, who had circumflex disease in addition to main left stenosis, was lost to follow-up at 12 months. Thus by five years from the time of angiography, six of the seven subjects with main left coronary stenosis had died and the fate of one was unknown.

Discussion

This study has shown that the annual mortality in subjects with coronary artery disease worsens with the angiographic severity of the disease. Subjects with single vessel disease had a relatively good prognosis as 92% survived for five years while triple vessel disease
was associated with only 55% survival during the same interval. The group with double vessel involvement had an intermediate prognosis for five year survival of 65%. When only lesions of 75% or more stenosis were considered significant then the prognosis was worse, with five year survival percentages for single, double and triple vessel disease of 91, 59 and 45, respectively. These three subgroups all had a poorer prognosis than that found for a series of subjects with normal coronary angiograms (0.6% five year mortality) and that of patients with > 30% but < 50% coronary stenosis (5.3% five year mortality). The subjects with main left disease fared very badly as there were no survivors at five years.

Friesinger and associates correlated clinical course with coronary arteriographic findings in 224 patients, 102 of whom had no areas of stenosis. Although their system for grading arteriographic lesions differed from ours, patients that they considered to have significant disease had a five year survival of 73% which is identical to our data. Only one cardiac death occurred in their 32 patients with single vessel disease followed at least five and up to 12 years. Our group of 101 subjects with single vessel disease did almost as well with a 92% five year survival. The five year survival of 55% for those with triple vessel disease in our group is similar to their patients with high arteriographic scores who had a 53% survival over the same period. Bruschke and associates, using criteria similar to ours for grading arteriographic abnormalities, determined the mortality rate in 590 nonsurgical cases of coronary artery disease followed five to nine years. For subjects with single, double and triple vessel disease the five year survival was 85%, 62%, and 46%, respectively. These results are comparable with ours although in their series the prognosis was slightly poorer in each group. Webster and co-workers reviewed the mortality statistics for a group of 469 patients having 80-100% obstructive coronary lesions. Their results were very similar to our ≥ 75% stenosis group as five year survival with single, double and triple vessel disease was 85, 64 and 45%, respectively. The yearly attrition rate with isolated left anterior descending stenosis in their series was 4% and for the right coronary artery 2.3%. In our patients the corresponding rates were 2.6 and 0.4% considering lesions of > 50% stenosis. Oberman and associates in a retrospective study of 246 patients found a somewhat worse outlook for those with multiple vessel involvement than in our series. Significant data were available for only a two year period in their series, at which time survival rates for single, double and triple vessel disease were 95%, 75% and 65%. However, they did stress the benign nature of single vessel disease as the two year survival for 98 subjects with no demonstrable coronary stenosis of > 50% was

### Table 12

<table>
<thead>
<tr>
<th>Complication</th>
<th>SVD</th>
<th>DVD</th>
<th>TVD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type</td>
<td>Number</td>
<td>Number</td>
</tr>
<tr>
<td>Angina</td>
<td>None</td>
<td>88</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Grade 1</td>
<td>29</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>61</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>29</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>28</td>
<td>1</td>
</tr>
<tr>
<td>All angina</td>
<td>147</td>
<td>42</td>
<td>28</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>None</td>
<td>166</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>Anterior</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Infero-posterior</td>
<td>22</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td>37</td>
<td>8</td>
</tr>
<tr>
<td>All infarctions</td>
<td>69</td>
<td>17</td>
<td>25</td>
</tr>
<tr>
<td>Congestive failure</td>
<td>Absent</td>
<td>191</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>Present</td>
<td>44</td>
<td>9</td>
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<tr>
<td>ECG</td>
<td>Normal</td>
<td>32</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Abnormal</td>
<td>80</td>
<td>29</td>
</tr>
</tbody>
</table>

*All percentages are the proportion having the specified complication with SVD, DVD or TVD.
Abbreviations as in table 3.
identical to their single vessel disease group.

We were unable to show significant additional prognostic value for the presence of angina pectoris or a past history of infarction (see table 9). Even a combination of these factors was associated with only a small difference in five year survival when compared with subjects having neither of these clinical factors (67% compared with 77%). These results have emphasized that in asymptomatic patients or in those with angina pectoris or previous infarction the prognosis is mainly determined by the severity of coronary artery disease. Thus if coronary artery surgery can be shown to prolong survival, then angiographic abnormalities rather than clinical factors should be the main consideration in decisions concerning application of operative therapy. As we did not perform coronary angiography on patients with unstable or crescendo anginal patterns our conclusions cannot be applied to this special group. Humphries and co-workers have also found that for a given level of coronary artery involvement, prognosis for survival was similar whatever the severity of associated angina pectoris. In our series annual mortality for those subjects without angina at the time of angiography or previous infarction was 5% per year while those patients having either of these complications had a 6% annual mortality. The Framingham study has indicated a slightly better outlook of 4% annual mortality for patients with angina. The same attrition rate was present in patients followed subsequent to myocardial infarction. Similarly, a study by Frank and associates of the prognostic value of initial myocardial infarction or onset of angina pectoris revealed an annual mortality of 4%. A history of congestive heart failure or hypertension had prognostic value. Only 38% survived five years after angiography with a history of heart failure and for hypertension this figure was 61%. White also found these clinical factors to indicate a poor outlook. Electrocardiographic, ventriculographic, or hemodynamic abnormalities also indicated a poorer prognosis. When hemodynamic findings were abnormal, five year survival was 63% and for subjects with left ventricular asynergy this was even less at 58%. Clinical, hemodynamic and ventriculographic factors that were accompanied by a poorer prognosis also tended to be associated with more severe coronary involvement than in the group as a whole. Whether their influence on survival was independent of the associated coronary artery disease was not determined. In the series of Brushke and co-workers localized hypokinesis or akinesis was associated with a 69% five year survival, left ventricular aneurysm with a 36% five year survival, and with diffuse contractile abnormalities this fell to 29%.16

In addition to a worse prognosis in the presence of triple vessel disease we have shown that the occurrence of complications of coronary disease such as myocardial infarction, angina pectoris and congestive heart failure during the follow-up period were associated with more severe coronary artery involvement. Considering those patients for whom adequate information was available during the follow-up period, angina disappeared in 25% but became worse in 10% and developed for the first time in 35%.

The results of this study should be useful as a comparison for survival and morbidity in patients treated surgically for coronary artery disease. The excellent prognosis in the group with single vessel disease, particularly those with isolated significant right coronary narrowing, provides a strong argument against the application of surgical treatment to this group. On the other hand, double and triple vessel disease were associated with 35% and 45% five year mortality which is an indication of the poor results of medical therapy in these patients.

A major question concerning the design of this study would be why were those subjects with severe disease not treated surgically? In other words are we dealing with a selected population rather than a group comparable to those being considered for coronary artery bypass surgery today? Many of the patients in this series did not have surgical treatment, which would have been internal mammary implantation at the time they had angiography, because the disease was not considered to be in a suitable location or was not severe enough to warrant operation. In other cases the angiogram was done for diagnostic purposes and not because surgical revascularization was being considered. Some patients refused surgery and others were not offered surgery because of evidence of myocardial scar in the area supplied by the diseased vessel. In other cases the risk of surgery was thought to be too great on the basis of poor myocardial function. To what extent the bias introduced by these selecting factors has favored or worsened the prognosis of our subjects cannot be determined. However until enough time has elapsed for completion of prospective studies, with matched groups treated medically or surgically, retrospective data such as those provided by this study will continue to be of value.

**Acknowledgment**

The authors are grateful to Dr. G. M. FitzGibbon of the National Defence Medical Centre, Ottawa, Ontario, for referral of many of the subjects in this study and for providing access to his excellent clinical records.

**References**

1. HERRICK IB, NIZUMI FR: Angina pectoris: Clinical experience with 200 cases. JAMA 70: 67, 1918
3. Block WJ, Crumpacker EL, Dry TJ, Gage RP: Prognosis of angina pectoris, observations in 6,882 cases. JAMA 150: 259, 1952