PATHOPHYSIOLOGY AND NATURAL HISTORY
CORONARY ARTERY DISEASE

Continued high incidence of coronary artery disease at autopsy in Olmsted County, Minnesota, 1950 to 1979

LILA ELVEBACK, PH.D., AND J. T. LIE, M.D.

ABSTRACT The autopsy records of all people over 30 years old who died and underwent autopsy in Olmsted County from 1950 through 1979 were reviewed (n = 5558, autopsy rate approximately 50%). The hearts of 530 subjects were reexamined for the severity of coronary artery disease and this determination was compared with the recorded grade. After both record and specimen review the three major coronary arteries were graded according to percent reduction in luminal area (1 = 0 to 25%; 2 = 26% to 50%; 3 = 51% to 75%; 4 = 76% to 99%; 5 = occlusion). Grades 4 and 5 were designated as significant coronary disease (SCD), and 94% to 99% of diagnoses of SCD were confirmed on reexamination. The percentage of people with SCD increased during the period 1950 to 1969 and remained high in the 1970s. Cohort analysis showed an increase in the disease in all age groups (except in the 30- to 49-year-old group for the later decades of birth). There was no change in the prevalence of myocardial infarction scars over the study period.


IN 1978 the National Institutes of Health sponsored the Conference on the Decline of Coronary Heart Disease Mortality1 to explore possible factors contributing to the greater than 20% decrease in mortality for the disease that began in the United States in 1968. Changes in lifestyle resulting in modification of risk factors and advances in medical care are known to have occurred but are difficult to quantify, particularly before 1965. Various types of studies were proposed and some have since been implemented, including surveillance of the incidence of myocardial infarction and studies of autopsy results.

The report that follows covers a study of the autopsy information on all deaths in Olmsted County, MN, of people age 30 and over that underwent autopsy during the 30 year period from 1950 to 1979.

Olmsted County, which includes the city of Rochester, had a population of 48,228 in 1950 and 92,006 in 1980. The population is essentially all white. Approximately two-thirds of the residents live in Rochester. The county autopsy rate for deaths at age 30 and over was approximately 50% over the study period. Rochester experienced essentially the same decline in coronary heart disease (CHD) mortality as that seen nationally.1 The incidence rate for CHD in Rochester declined sharply about 10 years before the beginning of the decline in mortality, and survivorship in the incidence cohorts has improved markedly.2

Material and methods

Autopsy methods. All autopsy examinations of people dying in the hospital or in nursing homes and of coroner’s cases in Olmsted County were performed in the Medical Sciences Department of Pathology, Mayo Clinic. A uniform and comprehensive system of autopsy techniques has been developed and standardized, as described in a standard text.3

Anatomic examination of the coronary arteries. The major extramural coronary arteries were examined by serial transverse sectioning at 5 mm intervals. Arteries with extensive calcification were dissected out intact and decalcified before sectioning. The right (RCA), left anterior descending (LAD), and left circumflex (LCX) coronary arteries were graded in ascending order of reduction in cross-sectional luminal area by visual inspection by each prosector at the time of autopsy as follows: grade 1 = up to 25% reduction in luminal area; grade 2 = 26% to 50% reduction in luminal area; grade 3 = 51% to 75% reduction in luminal area; grade 4 = 76% to 99% reduction in luminal area; grade 5 = complete luminal occlusion.

Selection for autopsy. The decision as to whether or not an autopsy was to be done was made on a case-to-case basis, with both the attending physician and the family taking part. While autopsy rates have varied over the study period they have remained high for Olmsted County residents.

The autopsy rate over the period from 1950 to 1979 for the age group 30 and over varied between 44% and 54%. The mean age of death increased for all Olmsted County residents by 4 years over the study period and for the autopsy series by 3.9 years. Variations in the sex ratio were minor. The autopsy rates were higher in men than in women and decreased with age.

The autopsy rates for those dying as a result of CHD, all cardiovascular disease, cancer, accidents, and violence, and

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from all other causes are given in table 1. There were differences over the six 5 year periods in percentages of those dying from each of the causes. In the case of cardiovascular disease the differences, while statistically significant, were not very large; in the case of accidents and violence the differences were not significant.

There was also variation over time in the distribution of all Olmsted County deaths by cause (table 1). The percentages in the total column have been used for adjustment of the rates of significant coronary disease in table 4.

Record review. The autopsy records for all residents of Olmsted County 30 years old and over undergoing the procedure in the period 1950 to 1979 were reviewed. Data abstracted were date of death, age at death, sex, height, weight, heart weight, grade of lesion in the RCA, LAD, and LCx arteries, and evidence of recent or old myocardial infarction. For all patients undergoing autopsy the death certificates were filled out by the pathologists who performed the autopsy. The certificates were coded by cause of death according to the eighth revision of the International Classification of Diseases Adapted. There were 5558 Olmsted County residents of age 30 or older who underwent autopsy during the study period. The autopsy rate for these residents varied from 44% to 54% over the study period.

Specimen review. To control procedural changes over time, 530 specimens were retrieved and reexamined by one of the authors (J. T. L.). Of these 530 deaths, 339 were the result of CHD, 161 were accidental deaths, and 30 were deaths from other causes. The severity of coronary artery disease was reassessed by the grading method described above. The anatomic review was carried out without knowledge of the original findings as recorded in the autopsy protocols. Comparisons of the reassessed grades and the recorded grades of coronary artery disease were made only after the completion of the specimen review process.

Results

Record review (n = 5558 autopsies). Table 1 gives the distribution of causes of death (ischemic heart disease [IHD], cardiovascular disease, cancer, accidental death, and death from all other causes). The proportional mortality rates for IHD were higher in men (33%) than in women (22%) and increased at the end of the study period in both sexes.

Table 2 gives a comparison, based on the maximum grade of stenosis per person, of results of the record and specimen reviews. It is apparent that the most reliable data we have from the record review are on the percentage of persons with grades 4 or 5 stenosis (over 75% reduction in luminal diameter), since 99% of the time these findings were confirmed at specimen review. Grades 4 and 5 have been designated here as indicating significant coronary disease (SCD).

Among the 530 persons for which both records and

### TABLE 1

Distribution and rates by cause of death

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CVD = cardiovascular disease (includes CHD and stroke).

†Accidents† include other violent deaths.

*All Olmsted County deaths. Source: Minnesota Center for Health Statistics.

### TABLE 2

Agreement between record and specimen reviews on maximum grade of stenosis per person in the RCA, LAD, and LCx coronary arteries

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<td>23</td>
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<td>9</td>
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<td>0</td>
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<td>146</td>
<td>196</td>
</tr>
<tr>
<td>Total</td>
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<td>65</td>
<td>181</td>
<td>238</td>
<td>524</td>
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</table>

*There were six cases in which all three arteries were not available for specimen review.
specimens were reviewed, 316 records indicated SCD of at least one of the coronary arteries (RCA, LAD, or LCx). In all but four, or in 98.7%, the presence of SCD was confirmed at specimen review, with essentially no change in the confirmation rate with the calendar year of death.

If, on the other hand, we consider the 419 persons in whom grade 4 or 5 lesions were detected at specimen review, we find that SCD was underreported: only 75% of the 419 cases were noted in the record (68% in the 1950s, 75% in the 1960s, and 79% in the 1970s).

The percentage of persons with SCD (grades 4 and 5). The percentage of autopsied hearts with grade 4 or 5 lesions, corrected for underreporting, is given by age, sex, and decade of death in table 3. The rates increase in each of the eight age-sex subgroups. In men the highest rates and the greatest percentage increase were in the age group 60 to 69. In women the highest rates and the greatest percentage increase were in the 70 years and over group.

Overall results, corrected for age, sex, cause of death, and underreporting, are shown in table 4 and figure 1. The results for all causes indicate a 30% increase in the prevalence of SCD from the period 1950 to 1954 to the period 1965 to 1969, and a further 20% change during the 1970s. In those dying from cardiovascular causes the percentage with SCD almost doubled over the study period. Cancer, accidents, and death from all other causes together represent about 50% of the autopsy results and the rates for SCD are much lower among these, but in each case the rate increased.

Cohort analysis of the percentage of SCD. Figure 2 shows the percentage of SCD for each age group by decade of birth for all of the 5558 autopsies. For each group of people over 50 years old, the proportion with SCD increased with the year of birth. In the small age group of those 30 to 49 years old and born after 1900, there was a nonsignificant decrease from 37% to 21%.

Cohort analysis for the 1573 IHD deaths and the 3985 deaths from other causes also showed increases for all groups 50 years old and over. The deaths from IHD at ages 30 to 49 years showed a small but nonsignificant decrease, while incidence of death from other causes showed essentially no change in this age group.

Agreement between record and specimen reviews on the detection of myocardial infarction scars. Myocardial infarction was detected in 287 of the 530 autopsied hearts on both record and specimen review, but when the specimen review alone was considered, 317 infarctions were detected. The presence of all 287 recorded myocardial infarctions were confirmed on specimen review, but the record noted only 91% of the 317 found on specimen review. For the six 5 year periods the completeness of the records was 93%, 90%, 90%, 88%, 89%, and 97%, with no indication of differences or a developing trend over the study period.

The adjusted prevalence rates (table 4) show little change over time. The rates for myocardial infarction increased with age and were higher in men. However, for those who died of IHD no differences by age or sex were present.

**Discussion**

The incidence of SCD in the living population is unknown since data are available only on those persons seeking medical attention and receiving a diagnosis of CHD. The data presented here are based on results of autopsy of 50% of residents who died. While the record review diagnoses of SCD are very well supported by reexamination of autopsy specimens, there is significant underreporting of SCD in the records, particularly in the records from the early years of the study period.

The method of selection of the specimens for autopsy is largely undefined and depends in each case on several factors. The only information available to us at this time is age, sex, and cause of death. Insofar as
these variables are concerned, it should be noted that the corrected rates adjusted for the cause of death distribution for all Olmsted County residents is relatively representative of the all-deaths series.

The results of the Rochester Coronary Heart Disease Study\(^2\) over the same period show a decline in the CHD mortality that parallels that in the United States. The incidence study, which is based on 3659 cases over the period from 1950 to 1979, shows a marked decline in the incidence of CHD approximately 10 years earlier than the beginning of the decline in mortality and little change since that time except for a continued decline in sudden unexpected deaths. However, more recent and marked improvement in survivorship of patients with heart disease has contributed to the decline in mortality. The 30 day myocardial infarction fatality rate decreased by 50% from the period 1965 to 1969 to that from 1970 to 1975. This decline has not changed the long-term survivorship of the 30 day survivors of myocardial infarction, which is not significantly different from that for 1965 to 1969. In addition, those whose first manifestation of coronary disease was classic angina pectoris have shown a decrease in subsequent myocardial infarctions and a resulting marked improvement in long-term survivorship, despite a small increase in the age at diagnosis of angina.

The autopsy results show increasing prevalence of SCD in those dying from CHD, cardiovascular disease, cancer, accidents, and all other causes.

FIGURE 1. Prevalence of SCD at autopsy, corrected for underreporting, by cause of death, and for each 5 year period from 1950 to 1979. Note that CHD is included as a cardiovascular disease.

FIGURE 2. Percentage frequency of grade 4 and 5 stenoses by decade of birth and age at death, corrected for underreporting in the records. Note that, for the youngest group, the first point is based on very few cases and the trend is not significant.
Insofar as autopsy data reflect trends in the prevalence of CHD, they suggest that while there has been a major improvement in survivorship in CHD patients and a fall in mortality, as yet there has been no decline in the progression of the atherosclerotic process during life. In view of such prolonged survivorship, progression of disease might be expected and could account for the lack of decline in SCD at autopsy.

The improved survivorship may be due in part to changes in medical care and development of new drugs and in part to changes in lifestyle. If changes in lifestyle have their maximum effect when adopted early in adult life, the beneficial effect on the incidence of coronary disease may become evident at autopsy in persons born in the 1940s and 1950s.

Results of a previous study. This finding is in conflict with that of Strong and Guzman,4 who found a decrease in the prevalence of heart disease in white men 25 to 44 years old between the periods 1960 to 1964 and 1968 to 1972. They reported on raised lesions of the coronary intimal surface, while our results are based on the percentage reduction in luminal area. Seventy percent of their cases were from the office of the coroner while in our study only 15% were coroners‘ cases. Our youngest group, age 30 to 49, showed a small increase. If we consider the very few men included in our study who were 30 to 44 years old in 1960 to 1964 and 1968 to 1972, we also find an increase in the percentage with stenoses of grades 4 or 5 (3/26 and 13/49). We did not study the age group 25 to 29. When differences in the groups studied and in autopsy methodologies are considered it is not surprising that the results of these two studies differ.

Further research is needed to help with the difficult task of clarifying the relative contributions of improving lifestyle and improved medical care to the decline in mortality for CHD.

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References
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