Treatment and controversies in angina pectoris: economics of prevention and treatment

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We assume a prevalence of clinical coronary artery disease of 2·5%, that 50% of these patients have angina pectoris and have an assumed mean age of 50 or 60 years, that the annual mortality is 4%, that 50% smoke, that stopping smoking reduces mortality in the smokers by 50%, and that treatment (medical and/or surgical) reduces mortality by 25%. On the basis of these assumptions we calculate benefits in terms of life years gained. Primary prevention through stopping smoking will increase survival of the entire population by 12·5%. This is a substantial gain at no cost. Doctors should do more to achieve this goal. Treatment will add about 1·9 life years per 50-year-old patient treated and about 1·7 life years per 60-year-old patient treated. A gained life year costs less than $4000 in treatment expenses. We calculate that treatment is cost effective in terms of money for the 50-year-old patient who will return to work, but not for the 60-year-old patient. This conclusion must of course be carefully considered in the light of values other than money. Expansion of treatment to low-risk groups may lead to only marginal benefit and lead to less emphasis on prevention. The concept of opportunity cost is discussed using prevention of suicide as an example.

Doctors have become more interested in health economics. We look upon this development with mixed feelings. On the one hand, we appreciate this widening of the medical perspective. On the other hand, we frequently feel that doctors often twist health economics to suit their own purposes. To be more specific, they calculate that costs of treatment – although high and rising – are considerably lower than potential economic surplus from treatment. Thus, they use health economics to argue for ever more resources to their field of interest. Table 1 illustrates this point. It shows a calculation of the total public expenses for cardiovascular diseases in Norway during 1983[1]. The sum is about $682 million and benefits and pensions make up about 61% of this sum. The doctors' idea is to increase expenses for treatment and thus save on payments for sickness, disability and loss of provider. We will show that the whole issue is considerably more complex. We start with some general concepts and then move on to the economics of coronary disease.

The cost-benefit analysis

The cost-benefit analysis is the conceptual basis of the economics of prevention, care and rehabilitation of diseases. The idea is simple: costs are added in the numerator, benefits in the denominator. Both must be in the same units – money. If the fraction is less than one, the treatment is useful. Such calculations have often been used to argue for more resources.

However, there are difficulties both in the numerator and the denominator. They are minor in the numerator: simply to add the right costs. This requires arithmetic and honesty, especially the last. The difficulties in the denominator are overwhelming, because it is necessary to translate the benefits

Table 1 *Public expenses for cardiovascular diseases in Norway during 1983[1] (1 US $ = 9 NOK)*

	US $	%
Hospitals	157·6	23·1
Nursing homes	85·0	12·5
Ambulatory care	19·6	2·9
Sickness benefits	170·6	25·0
Disablements pensions	158·6	23·2
Loss of providers	90·5	13·3
Total	681·9	100·1

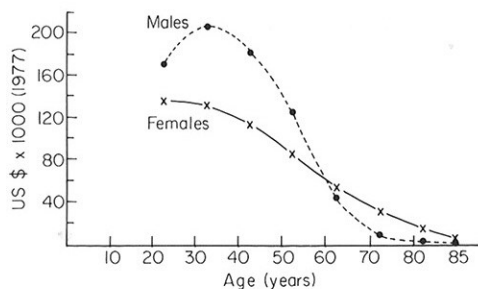The expenses for cardiovascular diseases constitute 13·8% of the total public expenses for disease.

Figure 1 Value of a life at various ages, USA 1977 (calculated by Dolan *et al.*[3]).

into money, for example, life, happiness, absence of pain and all the factors that go to make life worthwhile. This exercise requires reasoning that is so difficult and often so dubious that we prefer not to do it. However, it is often done.

Cost-effectiveness analysis bypasses these dilemmas. The numerator is the same, but the denominator is no longer in money but in terms relevant to medicine, for example, in life years saved adjusted for quality and for discount. Discount is necessary, since people will not pay $1000 today to get $1000 back in five years time. Thus, we are still left with quite dubious calculations. Furthermore, it is not possible to compare projects with different denominators, for example, gained life years for the elderly with better job opportunities for the young.

In spite of all these difficulties, we believe the systematic thinking involved in such analyses is of value.

The value of life

Controlled clinical studies in coronary artery disease usually conclude with a table or a graph showing reductions in mortality[2]. On the basis of such results one can calculate gained life years. This takes us into the distasteful discussion about the value of human life. In economic terms, the value of life should be measured in potential production. As an example, Fig. 1 shows some recent American calculations[3]. The coronary patients are not young. The mean age in surgical series is often about 50 years. The annual mortality in groups of patients who are treated for stable coronary disease is only

about 1–2%. Thus, the gained life years come at an advanced age for most patients, at the tail of these curves.

Since we are particularly interested in the care of the elderly, we detest such calculations. Nevertheless, we show them for two reasons. First, we want to illustrate the severe limitations of cost-benefit analyses in which human life is in the denominator. Secondly, we want to show that if one argues for a particular treatment with economic arguments, the benefits in economic terms are likely to be quite small. Thus, it often becomes difficult to justify costly treatment on the basis of economic benefits.

We shall now complicate the problem one step further. These curves tail off towards zero, but the values do not become negative. Here we enter a conflict between economist and lay reasoning. Economists distinguish between real economics and financial economics. Both are important, but must be kept separate and definitely should not be added together. *Real* economics deals with production of goods and services. When an old person needs care, he becomes a zero economic value, but not negative. *Financial* economics, however, relates to transfer of money, such as taxes, pensions and sickness benefits. In financial terms, therefore, an elderly person who needs care becomes a negative value, an expense. Lay experience, of course, confirms this reasoning, because taxes are used to support the elderly. For example, nearly half of all public expenses in Norway are used to cover pensions and social and health services. From the point of view of public economy, therefore, gained life years in the elderly become costly. Furthermore, pensions and services are covered out of the same budget and therefore compete: the more we spend on pensions, the less is left for health and other services. Thus, in financial economic terms, gained life years in the elderly are expensive.

Enthusiastic doctors often talk in terms of saved lives. However, a life is never saved for good, death is only postponed. Thus, if a life is prolonged by treatment, costs of terminal care will eventually be due. This complicates economic calculations, since these costs are unknown for the individual patient. This issue is particularly touchy in coronary disease, since as many as 40–50% of the coronary patients die suddenly, 44%, for example, in the Framingham study[4]. Treatment may change the course of the disease, and the patient may finally die of an unrelated disease which requires expensive services, such as cancer or senile dementia. Thus, there is an

unknown factor in these calculations, and it may be quite large.

To sum up this discussion on the value of life, we make two points:

(1) Such calculations are extremely difficult and uncertain.
(2) They do suggest, however, that it is difficult to argue for costly treatment by promising large economic gains.

Therefore, we prefer to argue in terms of fairness, decency and human values, rather than in money.

The marginal problem

To illustrate the marginal problem in medicine, we use secondary prevention of myocardial infarction as an example. Beta-blockers reduce mortality by about 25% in all mortality groups[5]. High-risk groups should obviously be treated, because the benefits are large. However, when the treatment is offered to groups with less and less mortality, the benefits decrease, and the total costs, including side effects, increase. Most people intuitively feel that there is a cut-off point somewhere along the line, because treatment no longer is worthwhile. To define the cut-off point is not an objective problem, since it depends on personal biases and on special features of the disease and the treatment. The problem is related to the so-called perceived risk in general risk analysis. Somehow, people calculate unconsciously a 'risk product' (= the importance of the event × the ·hance for it to happen) which guides them in their ·hoices and in their risk-taking. When the event is death, the cut-off point is of course set at a lower level of risk. In secondary prevention of myocardial infarction many doctors probably feel that an annual mortality risk of 4% may represent a reasonable cut-off point. At this risk, one has to treat 100 patients to benefit one, and all 100 are exposed to side effects. The patient's age is of course important. An annual mortality of 4% represents a considerable increase at 50 years, a moderate increase at 60 years, and no increase at 73 years.

There are four general characteristics of the marginal problem in medicine:

(a) It involves many patients, since there are always more patients with low risk than with high risk.
(b) Since the risk is small, the gain is also small.

(c) Since many patients are involved, the costs are high, in terms of accumulated side effects, costs and medical resources.
(d) Powerful interests are always involved, such as the drug industry, the research establishment and the medical profession.

As treatment in coronary disease is refined and expanded, it moves into the marginal problem and faces difficult decisions.

The opportunity cost

The concept of the opportunity cost is simple and obvious: the money we use for one project cannot be used for any other. Therefore, the real cost of a given project is the projects we cannot do, since the same sum of money can only be used once. Ideally, it should be used for *that* project which gives more benefits than any other.

This is another aspect of the marginal problem. The money we spend on marginal treatment cannot be used for care of the elderly, to provide jobs for the young, or to integrate the handicapped into the society. This is the situation we have to face and the responsibility we have to accept.

Model and assumptions

The purpose of any intervention is to improve and prolong life. Quality of life is hard to measure, but we can calculate the number of life years gained from an intervention. Therefore, we have used 'gained life years' as a measure of effect. There are two types of effect:

(1) One from primary prevention, namely, prolongation of life for the normal population.
(2) One from secondary prevention or treatment, namely prolongation of life for patients with angina pectoris.

We calculate the differences in survival with and without intervention, i.e. the effect of the interventions expressed in gained life years. To use the model, we must make four assumptions.

(1) First, we assume that the total prevalence of coronary artery disease in the population, as manifest by chronic angina or treated myocardial infarction, is about 2·5% or 25 000 per million. This estimate is based on the Health Interview Survey of The National Center For
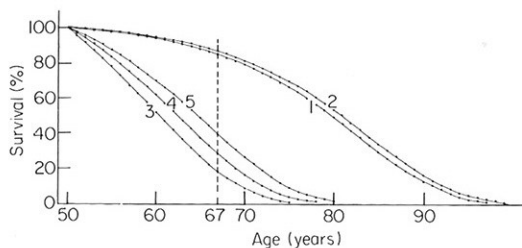
Figure 2 Survival curves for 50 year olds (men and women): curve 1, normal Norwegian population – no intervention; curve 2, normal Norwegian population – non-smoking; curve 3, patients with angina pectoris – untreated; curve 4, patients with angina pectoris – treated; curve 5, patients with angina pectoris – treated and non-smoking.

Figure 3 Survival curves for 60 year olds (men and women): curve 1, normal Norwegian population – no intervention; curve 2, normal Norwegian population – non smoking; curve 3, patients with angina pectoris – untreated; curve 4, patients with angina pectoris – treated; curve 5, patients with angina pectoris – treated and non-smoking.
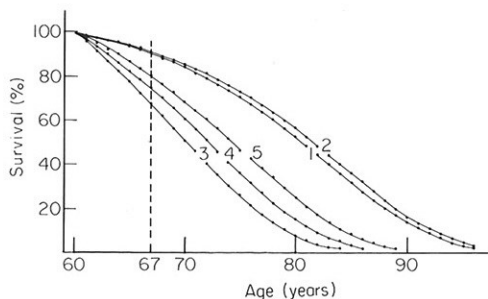
Health Statistics in the U.S.A.[6]. There are large variations, both within countries[7] and between countries. The American estimate may be high, but appears reasonable to us.

(2) Secondly, we assume that about half the patients with coronary artery disease have angina. This is in agreement with both Norwegian[7] and American[4] observations.

(3) Thirdly, we assume that all patients are the same age. Since age is so important, we have used two mean ages:

  (a) 50 years, which was the mean age of the patients included in the CASS study[6].

  (b) 60 years, which was the mean age of the patients included in the Norwegian study of secondary prevention of myocardial infarction by Timolol[8]. We believe that 60 years is fairly representative for *all* patients with angina pectoris.

(4) Fourthly, we assume that patients with untreated angina pectoris have an annual mortality of 4%. This figure agrees with older estimates[4]. More recent studies suggest a lower figure. In the CASS study, for example, the annual mortality of medically treated patients was 1·6%[6]. However, such studies are based on selected patients, and medical treatment does of course reduce mortality. Therefore, we believe the older figure of 4% is more representative of unselected and untreated patients with angina.

Obviously, these assumptions are rough estimates and therefore open to argument and criticism.

However, the prevalence varies so much between regions that we believe it is a waste of effort to attempt to refine the assumptions. For the same reason, we do not adjust gained life years for reduced quality of life, nor for discount. We have also not separated men and women in our calculations.

Primary prevention

Primary prevention tries to reduce and retard the disease process which leads to angina pectoris. Many interventions have been discussed and tried. In general, mass interventions have been disappointing. However, we believe there are sufficient data for smoking to allow reasonable assumptions and calculations. About 50% of the patients who are hospitalized for myocardial infarction in Norway smoke[8], and it seems reasonable to conclude that their mortality would be reduced by about 50% if they stopped smoking[9,10]. Therefore, we have calculated the benefits to the population from less coronary disease if everybody stopped smoking. We assume that 50% of the population have coronary disease, since about 50% die of cardiovascular disease, mainly coronary artery disease. Furthermore, we assume that 50% smoke, that all of them stop smoking, and that this would reduce mortality by 50% in the smokers. This would result in a 12·5% overall improvement in survival. On an average, the 50 year olds would gain 1·2 life years, and the 60 year olds would gain 0·9 life years. This looks modest in Figs 2 and 3, but is substantial since

Table 2 Average remaining life years for the normal Norwegian population and for patients with angina pectoris, with and without intervention (see text for assumptions)

	Average remaining life years	
	50 year olds	60 year olds
National population		
No interventions	28·8	20·4
Non-smoking	30·0	21·3
Patients with angina pectoris		
Untreated	11·2	11·1
Treated	13·1	12·8
Treated and non-smoking	15·0	14·8

it involves so many people. Here, we have *only* considered death from coronary artery disease. In addition, of course, lives would be saved every year from reduced mortality of lung cancer, respiratory diseases etc.

We conclude that stopping smoking has a safe, cheap and significant primary preventive effect. The gained life years also have a high quality, since they are free of coronary disease. The only problem is that the intervention has no cost and therefore pays no dividend to anybody, except to the patients. Therefore, the drive towards a smoke-free society is half-hearted.

Treatment

The first step is to calculate the survival of untreated patients, assuming 4% annual mortality. This indicates an excess mortality among patients 'th angina pectoris of 9·5% at an average age of 50

years and 3·7% at an average age of 60 years. Assuming that medical and/or surgical treatment reduces the mortality by 25%, we calculate survival for the treated patients. We have not distinguished between surgical and medical treatment, since CASS did not find significant differences[6]. Larger series will probably demonstrate a significant difference in favour of surgical treatment, especially in patients with widespread and/or severe disease. However, such differences will not shift the survival curves dramatically. For our purpose, we have limited the calculations to a 25% reduction in mortality.

Stopping smoking will reduce mortality in patients with clinically significant coronary artery disease[9,10]. Assuming a 50% reduction in mortality by mechanisms which differ from those of medical and surgical treatment, we have calculated survival for patients who are treated and also stop smoking. We admit, of course, that these assumptions are uncertain.

Table 3 Economics of treatment for angina pectoris, calculated per million people per year (see text for assumptions)

	Million $ per year, assuming mean ages of	
	50 years	60 years
Costs of treatment		
Surgery	2·25	2·25
Medical treatment	1·11	1·09
Total	3·36	3·34
Increased old age pensions		
Treatment	1·1	2·7
Treatment plus non-smoking	2·8	5·8
Income from increased production		
Treatment	9·8	1·7
Treatment plus non-smoking	18·4	3·2

We have carried out these calculations both for 50-year-old patients (Fig. 2) and for 60-year-old patients (Fig. 3). The same data can be used to calculate the average remaining life years, which may produce more instructive curves than the survival ones (see Table 2). The calculation shows that treatment gives the average 50-year-old patient an extra 1·9 years and the average 60-year-old patient an extra 1·7 years of life.

Costs of treatment

We have calculated the costs per million population. We assume that the average cost of surgery is about $9000 and about 50% of the patients will have bypass surgery sooner or later. With an incidence of 500 patients per million per year, there will be 250 surgical operations for angina pectoris per year. The total number of bypass operations is nearly three times higher in the U.S.A. – 159 000 operations in 1981[6] – but our calculations are limited to angina pectoris, or roughly 50% of the patients with coronary artery disease. The average cost of medical treatment, including fees and drugs, we assume to be about $170 per year for each patient, whether operated on or not. On the basis of these assumptions the total treatment costs per million population is shown in Table 3.

The costs of the treatment programme per patient per year will be $6720, assuming an average age of 50 years, and $6680, assuming an average age of 60 years. The treatment costs per gained life year will be $3537, assuming an average age of 50 years, and $3929, assuming an average age of 60 years.

Old age pensions must also be considered. The total number of life years can be calculated from the areas under the survival curves. Age at pension is 67 years in Norway, and the pension is (at least) $3500 per year. Assuming an average age of 50 years, treatment will result in about 328 extra life years over 67 years per million people per year. With treatment plus non-smoking there will be about 796 extra life years over 67 years per million people per year. Assuming an average age of 60 years, the corresponding numbers of gained life years over 67 years will be 771 and 1662, respectively. Table 3 gives the costs per million population per year for pensions during these gained life years over 67 years.

Those who are under 67 years will to some extent be able to work and thus increase production. We have calculated gained life years under 67 years per million per year and assume an average production value of about $22 500 per year. Not all patients will be able to work full time, and we estimate that about 75% of them will do so. Table 3 gives the value of the resulting increased production.

Our calculations can obviously be refined and extended. For example, we have not included sickness benefits and disability pensions. Treatment will decrease these expenses in some patients and increase them in others, and we lack empirical data to judge the net effect. We have not adjusted gained life years for reduced quality of life, nor for discount. Finally, we have not attempted to calculate costs for terminal care. Thus, our calculated economic gains are undoubtedly too high.

The overall conclusion is that treatment is cost-effective in terms of money for the 50-year-old patients, but not for the 60-year-old patients. We believe that this conclusion will not be changed by refined calculations, nor by adjustments, within reason, of our assumptions.

Discussion

Firstly, there are obvious and important benefits that can hardly be calculated in terms of money. For example, what is the value of a grandfather to his grandchild, or the value of experienced and seasoned elderly people in family and society? In fact, we think that the main value of our calculations is to demonstrate the difficulties of cost-benefit analyses in decisions involving human values. This does not mean that money should be disregarded, but economic calculations should be tempered by human, moral and political considerations. It is important to carry out the calculations, but results must be used with care.

Secondly, treatment of angina pectoris takes us right into the marginal problem of medicine. As indications are widened, treatment is offered to large groups of low-risk and, therefore, also low-benefit patients. Thus, expenses and side effects will outgrow benefits. This requires honesty and discipline of the medical profession. As indications are widened, there is a cut-off point somewhere, and it must be defined by the medical profession. Already, bypass surgery has become the most frequent operation in some university clinics.

Thirdly, treatment of angina takes us into the problem of opportunity costs. Our calculations showed that the modern treatment of angina pectoris leads to an economic profit for the 50-year-old patients, but not for the 60-year-old patients.

For all patients the treatment costs less than $4000 per gained life year. This is a small cost, and a rich society can afford to do many things that are not economically profitable, because we value life itself higher than the economic productivity. Thus, treatment may be justified if it works and is well organized (i.e. is cost-effective), even if it is not economically profitable.

However, at this point we are up against the concept of opportunity cost. This concept says that money should be used for *that* project which gives more benefits than any other. Thus, a project may not be justified even if it is profitable, because there ̄e alternative projects that are more profitable. It becomes very complicated when treatment of angina has to be compared with, say, industrial or educational projects. Let us therefore stay in the health sector and look at alternative projects. We have selected suicide for the comparison. Victims of suicide are very much younger than patients with angina. Therefore, suicide in Norway comes second, both for men and women, when we calculate lost life years from the various causes of death. Suicide is also increasing quite markedly. The causes of suicide are complex, but money might do a great deal to prevent it, for example, by providing work, adequate housing, social support etc. However, prevention is not backed up by powerful interests such as the medical profession and the drug industry. Social workers wringing their hands in despair are no match for powerful surgeons who pile up deaths on their waiting lists. There is, of course, no easy answer to this problem, but we hope that it will stick in your mind and in your conscience.

The fourth comment deals with prevention. Prevention is obviously a better solution for coronary artery disease than treatment. But prevention is not backed up by strong interests. In fact, the strong interests are found on the other side in the battle of prevention. This is obviously true for the tobacco industry and for parts of the food industry. But it is also true for large groups of the medical profession. There is a paradox here: the better and more interesting the treatment is, the weaker becomes prevention. Thus, treatment corrupts prevention. We hope that this idea will also stick in your mind, as well as in your conscience.

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