Clinical decision making in elderly with aortic stenosis
Bouma, B.J.

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Chapter 5

Variations in cardiologists' treatment advice for elderly patients with aortic stenosis: a nation-wide survey in the Netherlands

Abstract

The objective was to determine the influence of the patients' age, cardiac signs and symptoms, and co-morbidity on the cardiologists' decisions to advise surgery, as well as to identify groups of cardiologists who are influenced by these characteristics in a similar way.

We performed a Nation-wide postal survey among all 530 cardiologists in the Netherlands. With a questionnaire cardiologists were asked to indicate on a 6-point scale whether they would advise cardiac surgery for each of 32 case vignettes. The vignettes were designed in such a way that the influence of each of 10 clinical characteristics on the cardiologist's decision to advise surgery could be estimated independently of the 9 others.

Fifty-two percent of the cardiologists responded. There was marked variation in the cardiologists' treatment advice. We could explain 60% of the variance in the cardiologists' advice scores by distinguishing 6 groups. 41% of the cardiologists were predominantly influenced by the age of the patients, and 50% of them had a high and 50% a low inclination towards surgery. 24% were influenced equally by the patients' age as by the severity of the aortic stenosis and the left ventricular function, and 62% of them had a high and 38% a low inclination towards surgery. In addition to the influence of age, 23% of the cardiologists were mainly influenced by the left ventricular function, and 12% by the aortic valve area. The presence of co-morbidity always played a minor role.

Cardiologists varied systematically according to the extent they were inclined to advise surgery as well as the way they were influenced by clinical characteristics. These results indicate the need for prospective studies to identify the best treatment for elderly patients according to their clinical profile.
Introduction

There are clear clinical guidelines for the treatment of young and middle-aged patients with aortic stenosis. These guidelines point out that in general, patients with a symptomatic stenosis should undergo surgery and aortic valve replacement. However, treatment decisions for elderly patients are more difficult, since the patients' age and any concomitant diseases increases the harms and decrease the benefits of aortic valve replacement.

The dilemma for elderly patients may be illustrated by the following clinical example: A 72-year-old man is seen by a cardiologist at the outpatient clinic. The cardiologist rates the severity of his symptoms as functional class III according to the New York Heart Association. The patient is also known to have impaired renal function (serum creatinin concentration = 250 μmol/L), and to have had a stroke with moderate residual paresis. Pulmonary function is normal. On auscultation of the lungs, there are findings of left ventricular heart failure. Doppler echocardiography reveals an aortic valve area of 0.6 cm². Left ventricular ejection fraction is 20%. The coronary angiogram is normal. Should this patient undergo aortic valve replacement? The cardiologist has to balance the mortality and morbidity associated with the aortic valve replacement against the expected gain in the duration and quality of the patient's life.

There is a lack of information about the outcome of aortic valve replacement in elderly patients. Most studies were performed in selected young and middle-aged patients. Information about the outcome of medically treated patients mostly dates back to the pre-surgical and pre-catheterisation era, and relates almost exclusively to younger patients as well. More recent studies about the outcome of medical treatment also contained few elderly patients, and reported on rather ambiguous end-points (e.g. a combination of death and cardiac surgery), which makes also their results difficult to interpret. Furthermore, elderly patients frequently have concomitant diseases. The selective nature of the available epidemiological studies make it impossible however to untangle in every day clinical practice, the mixture of effects that age and comorbidity have on the variation in cardiologists' treatment
'vitality' of a patient in general, and the advisability of surgical treatment in particular.

The prevalence of aortic stenosis (≤ 1.2 cm²) increases with age from 2.5% at the age of 75 to 8.1% at 85 years in the general population.¹² This implies that with the ageing of the population cardiologists are increasingly being faced with this problem. We performed a nation-wide survey to investigate the advice that Dutch cardiologists give to elderly patients with an aortic stenosis. We sent a questionnaire to all 530 Dutch cardiologists that contained a series of 32 case vignettes describing patients of 72 years and older with various clinical profiles. The cardiologists were asked to indicate for each of these 'paper patients' whether they would advise aortic valve replacement or not, given the patients' clinical profile. We used an experimental design and recently developed advanced statistical techniques that are mostly applied to investigate consumers' decisions in marketing research. In this way, we were able to estimate the relative influence of age, cardiac signs and symptoms, and comorbid conditions on the cardiologists' decision to advise aortic valve replacement as well as to identify groups of cardiologist who made their decisions in a similar way.¹³

Methods

Survey
We sent a questionnaire containing 32 case vignettes to all 530 cardiologists in the Netherlands who were member of the Dutch Association for Cardiology in 1995. The case vignettes described clinical profiles according to 10 characteristics, which were considered to be important on the basis of an analysis of a cohort of patients with aortic stenosis of 70 years and older,¹⁴ and interviews with 5 senior cardiologists in the Netherlands. The characteristics were age (72, 77, 82 and 87 years), sex, NYHA classification (III or IV), heart failure on physical examination (none, left sided, and left and right sided heart failure), aortic valve area (0.6, 0.8, 1.0 and 1.2 cm²), left ventricular ejection fraction (60, 40 and 20%), concomitant coronary artery disease (none or 2 vessel disease), neurological disease (none or history of stroke with moderate paresis), pulmonary disease
(none or first second forced expired ventilation below 60% of predicted), and renal disease (none or serum creatinin concentration = 250 μmol/L).

**Experimental design**
We designed the 32 case vignettes varying the levels of these 10 clinical characteristics following a fractional factorial design\(^\text{15}\). Such a design makes it possible to estimate the influence of each clinical characteristic on the cardiologist's decision to advise valve replacement or not independently of the 9 other characteristics. The cases were described on separate sheets of paper and presented to each cardiologist in one of 8 different random orders. For each case, the cardiologist was asked to indicate whether he/she would advise surgery on a 6-point scale ranging from 'certainly no' to 'certainly yes' (see appendix I). We added 4 case vignettes ('hold-out profiles') to the questionnaire that were used to evaluate whether the observed advice given for these 4 cases could be predicted using the statistical model derived from the other 32.

**Statistical model**
Latent class metric conjoint analysis was used to analyse the responses of the cardiologists to the 32 case vignettes. This is a technique developed in marketing research. Using latent class analysis, we clustered cardiologists into separate groups with homogeneous decision behaviour on the basis of their average inclination to advise surgery for these 32 cases as well as on the basis of the extent to which their advice for each individual case was influenced by the 10 clinical characteristics. These parameters were determined by regression analysis with the cardiologists' responses on the 6-point scale as dependent variable, and the clinical characteristics as independent variables. The merit of latent class metric conjoint analysis is that it performs the regression analysis and the cluster procedure simultaneously, employing a stochastic framework involving mixtures of multivariate conditional normal distributions.\(^{16-18}\) The number of groups of cardiologists that optimally explained the heterogeneity in the cardiologists' decisions was determined by a statistical criterion (the minimisation of the variation in cardiologists' treatment)
Consistent Akaike's Information Criterion). The Glimmix program was used to perform these analyses.

Results

Of the 530 Dutch cardiologists who were sent a questionnaire, 275 (52%) responded. Baseline characteristics of all responding and non-responding cardiologists are presented in Table 1. There was a tendency for responding cardiologists to be younger, to be more frequently working in a university hospital and to be responsible for smaller wards than non-responding cardiologists.

Variation among cardiologists

Figure 1 shows the marked variations in the advice scores of all 275 responding cardiologists for the 32 case vignettes. This is illustrated by the distribution of the advice scores given for the clinical example presented in the Introduction (case number 25). It was found that 24 cardiologists (9% of the 275 responding cardiologists) indicated that they certainly would advise surgery (advice score of 6), whereas 39 (14%) indicated that they certainly would not (advice score of 1). The
### Figure 1.

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hf=heart failure, l=left sided, rsl=right and left sided; ava=aortic valve area in cm²; lvef=left ventricular ejection fraction; cad=coronary artery disease; two=two vessel disease; stroke=cerebrovascular accident in the history with limited paralyse; renal=creatinine 250 micromol/L; pulm=FEV1 60% of expected.
interquartile range (i.e. the difference between the 75th and 25th percentile) was 4 points on the 6-point scale. A similarly large interquartile range could be observed in advice scores for 8 other vignettes (case numbers 5, 6, 10, 13, 14, 18, 26 and 27).

Table 1. Background characteristics* of cardiologists according to response status

<table>
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<th>Non responders</th>
<th>p-value</th>
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<td>45.5 (7.7)</td>
<td>48 (6.4)†</td>
<td>0.0</td>
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<tr>
<td>Men</td>
<td>92%</td>
<td>92%</td>
<td></td>
<td>0.9</td>
</tr>
<tr>
<td>Year of accreditation*</td>
<td>'82 (6.8)</td>
<td>'82 (6.4)</td>
<td>'82 (7.0)‡</td>
<td>0.7</td>
</tr>
<tr>
<td>University hospital</td>
<td>20%</td>
<td>23%</td>
<td>17%</td>
<td>0.09</td>
</tr>
<tr>
<td>Hospital with cardiac surgery</td>
<td>28%</td>
<td>30%</td>
<td>25%</td>
<td>0.19</td>
</tr>
<tr>
<td>Ward size &gt; 40 beds</td>
<td>37%</td>
<td>33%</td>
<td>43%§</td>
<td>0.02</td>
</tr>
</tbody>
</table>

* given as mean and standard deviation. † t-test or $x^2$-test for 2x2 table, ‡ 52 missing, §13 missing

The advice for some of the other case vignettes was less heterogeneous. For example, most cardiologists (more than 90% responded with an advice score of 1, 2 or 3) would not advise surgery for the three 87-year-old cases who had an impaired left ventricular function with at least one comorbid condition (case numbers 1, 2 and 3), or for the 77-year-old woman with an impaired left ventricular function, a moderate aortic stenosis, and three comorbid conditions (case number 17). Also, most cardiologists agreed (more than 90% responded with an advice score of 4, 5 or 6) that surgery should be advised for those cases who had a severe aortic stenosis (aortic valve area $\leq 1.0 \text{ cm}^2$) with a good left ventricular function and no co-morbid conditions (case numbers 16, 31 and 32).
Figure 2. Mean advice score for 6 groups of cardiologists according to clinical characteristics. See text for explanation.
Groups with homogeneous decision making behaviour

The latent class metric conjoint analysis identified 6 different groups of cardiologists made their decisions in a similar way, which explained 60% of the variance in the cardiologists' advice scores. Figure 2 shows the overall mean of advice scores for the 32 case vignettes (which represents the average inclination of the cardiologists in each of the six groups to advise surgery), as well as the mean advice score for each level of the 10 clinical characteristics (which represents to what extent the advice of the cardiologists was influenced by the clinical characteristics). It shows that the 57 cardiologists in group 1 and 56 in group 2 (together 41% of all cardiologists) were predominantly influenced by the age of the cases, whereas other clinical variables played a less important role. These groups of 'age oriented decision makers' differed with respect to their inclination to advise surgery. The cardiologists in group 1 had a higher inclination to advise surgery than those in group 2. This is also illustrated by the observation that cardiologists in group 1 advised on average surgery (advice scores ranging from 4 to 6) for 65% and those in group 2 for 46% of the 32 cases.

The 41 cardiologists in group 3 and 25 in group 4 (together 24%) were influenced to the same extent by the age of the cases, the aortic valve area, and the ejection fraction, and also, but much less strongly, by the presence of renal, neurological and pulmonary comorbidity. Again, these groups of 'holistic decision makers' differed strongly with respect to their inclination to advise surgery. The cardiologist in group 3 advised surgery for 32% and those in group 4 for 86% of the 32 cases.

The 64 cardiologists in group 5 (23%) based their advice on the left ventricular function and to some extent also on the age of the cases. These 'left ventricular function oriented decision makers' advised surgery in 58% of the 32 cases. The cardiologists in group 6 (12%) were most strongly influenced by the aortic valve area, but age and left ventricular function also played a role. These 'valve area oriented decision makers' recommended surgery in 61% of the cases.
Relation with background characteristics

Small differences in background characteristics among the 6 identified groups of cardiologists were detected. The age and year of graduation of the cardiologists as well as the presence of facilities for cardiac surgery differed significantly (Table 2). The ‘age-oriented’ cardiologists (group 1 and 2) seemed to be slightly younger and to have been accredited as cardiologists more recently and the ‘left ventricular function oriented’ cardiologists (group 5) seemed to be older and to have been accredited longer ago than the others.

Table 2. Background characteristics* of the cardiologist according to decision making behaviour

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<th>Inclination towards surgery group</th>
<th>High age oriented</th>
<th>Low age oriented</th>
<th>High holistic</th>
<th>Low holistic</th>
<th>IV age oriented</th>
<th>AV age oriented</th>
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<td>86%</td>
<td>100%</td>
<td>90%</td>
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<td>91%</td>
<td>92%</td>
<td>0.33</td>
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<tr>
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<td>75%</td>
<td>71%</td>
<td>88%</td>
<td>80%</td>
<td>88%</td>
<td>77%</td>
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<tr>
<td>4 (n=25)</td>
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<td>'84</td>
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<tr>
<td>5 (n=64)</td>
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<td>6 (n=32)</td>
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<td>17%</td>
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given as proportions or means and standard deviation, † analysis of variance or χ² test for contingency table

variation in cardiologists' treatment
The ‘holistic’ cardiologists with a low inclination to surgery (group 4) as well the ‘valve area oriented’ cardiologists (group 6) seemed to be more often affiliated to university hospitals and less often to hospitals without facilities for cardiac surgery, whereas the opposite seemed to be the case for the ‘left ventricular function oriented’ cardiologists (group 5).

Model evaluation
We compared for each cardiologist the observed advice scores for the 4 additional case vignettes ('hold out profiles') with the advice score predicted by the latent class model based on the original 32 cases. The actual and predicted advice scores corresponded rather well, and there was a difference of less than one point on the 6-point scale in 88% of the cases. If, for each case, the advice was dichotomised into an advice for or against surgery (advice score of 4 or more or 3 or less, respectively), the observed and predicted advice agreed also in 88% of the cases.

Discussion
Our nation-wide survey, to which about half of all cardiologists in the Netherlands responded, revealed marked variations in the treatment advice given as a response to written descriptions of elderly patients with aortic stenosis. The heterogeneity could largely be explained by distinguishing 6 groups of cardiologists who differed with respect to their average inclination to advise surgery as well as the way their advice was influenced by the patient's age, the left ventricular function, and the severity of the aortic stenosis. We detected four main ‘schools’: 41% of the cardiologists were ‘age oriented decision makers’, 24% were ‘holistic decision makers’ (influenced equally by age as by the severity of the stenosis and left ventricular function), 23% ‘left ventricular function oriented decision makers’, and 12% ‘valve area oriented decision makers’. The groups of ‘age oriented decision makers’ and ‘holistic decision makers’ were both dichotomised according to the cardiologists' average inclinations to advise surgery. A comparison of the background characteristics among these 6 identified
groups of cardiologists showed small differences in age and time since accreditation, and hospital type among these 6 groups of cardiologists.

'Schools' of cardiologists
Uncertainty associated with diagnostic or therapeutic decisions has been proposed as a source of variation in clinical practice. We found, however, that 60% of the variance in the treatment advice could be explained by identifying 6 groups of cardiologists according to their average inclination to advise surgical treatment as well as the extent that their advice was influenced by the patients' age, severity of aortic stenosis, cardiac signs and symptoms, and non-cardiac morbidity conditions.

Age was for 41% of the cardiologists the main clinical variable upon which they based their decisions. The epidemiological evidence to support this dominant influence of age is rather poor. Studies among patients of 70 years and older showed that the increasing effect of age on surgical mortality could be explained for the greater part by other clinical characteristic and comorbid conditions. The patients included in these prognostic studies however were highly selected and the validity of these results for unselected patients is therefore debatable.

The 23% of the cardiologists who were in addition to age mainly influence by the left ventricular function advised strongly against surgery in patients with a left ventricular ejection fraction of 20%. This behaviour fits with observations that an impaired left ventricular function is associated with an increased surgical mortality and morbidity although it is also associated with a very poor prognosis after conservative treatment. On the other hand, there is also evidence that the left ventricular function can improve considerably after surgical therapy, and that particularly the prognosis of patients with an impaired left ventricular function gains most from aortic valve replacement.

The 12% of the cardiologists who were in addition to age mainly influenced by the aortic valve area advised against surgery for patients with a valve area of 1.2 cm², whether severe cardiac symptoms were present or not. This attitude is debatable as a study examining the outcome of patients with moderate aortic stenosis demonstrated that the overall mortality rate in these
patients who already have symptoms approaches the outcome of patients with a severe aortic stenosis.\textsuperscript{8}

The cardiologists’ advice scores were hardly affected by whether there was coronary artery disease or not, although a surgical procedure allows replacement of the aortic valve as well as coronary artery bypass grafting. This suggests that the cardiologist believe that the increased benefits of such a combined surgical procedure do not outweigh the twofold rise in surgical mortality that has been shown to be associated with it.\textsuperscript{27}

The average inclination towards surgical treatment varied considerably among the cardiologists. One group of the cardiologists who were influenced equally by the patients’ age as by the severity of the aortic stenosis and the left ventricular function advised surgery on average in 32% (group 3 in table 2), whereas the other group advised surgery in 86% of the 32 cases (group 4). As this variation can not be explained by the clinical characteristics of the patients (‘case mix’), this reflects a true difference in the attitude of the cardiologists. A comparison of the background characteristics of the conservative and aggressive cardiologists suggests that the conservative cardiologists more often work in university hospitals and in hospitals with facilities for cardiac surgery. This implies that the aggressive cardiologists more frequently have to refer patients with an aortic stenosis to a tertiary centre, where further evaluation of these patients is performed and subsequently the final decision to operate or not is made. It is therefore not unlikely that the aggressive cardiologists advise surgical treatment more frequently, because of their experience with this extra tier in the decision making process.

Comorbidity
Comorbidity always played a minor role. There is hardly any evidence of the impact of co-morbid conditions on the outcome of surgical treatment, because most studies of surgically treated patients excluded those with severe concomitant conditions. It is however likely that their impact might be considerable. A study of patients who underwent a coronary artery bypass procedure, for example, found that patients who had had a previous stroke had a
9-fold higher risk to have a stroke after surgery than patients who had not. A study of patients who were older than 80 years indicated that mortality in the first 5 years after cardiac surgery was 2.6 times higher in patients with an impaired renal function and 1.9 times in patients with chronic lung disease.

The ACC/AHA guidelines for the management of patients with valvular heart disease, which were published in 1998 after we had finished our survey, only indicate that valve replacement is technically possible at any age, but that severe comorbid conditions make cardiac surgery inappropriate. In other words, they indicate that the "biological age" of the patient rather than the "chronological age" should play an important role in the decision making process concerning valve surgery in elderly patients without giving clear guidance on how to implement this in practice.

In our series of 32 case vignettes, the prevalence of comorbidity was independent of age, whereas concomitant morbidity is indisputably more frequent and on average more severe in elderly patients in actual clinical practice. One possible explanation for the importance of age in our study is that it is difficult, if not impossible, for cardiologists to distinguish the effects of age and comorbidity on the condition of a patient. The cardiologists might therefore use age as the sole measure of a patient's prognosis that also incorporates the age-related frequency and severity of comorbid conditions. Although this strategy might be legitimate in general, it denies older patients without comorbid conditions access to beneficial surgical treatment.

Methodological considerations
We used the cardiologists' responses to a series of carefully designed case vignettes. Major advantages of this approach were, apart from its low costs, that it allowed us to study the treatment advice of every cardiologist for the same series of cases. The fractional factorial design of this series made it furthermore possible to estimate independently the influence of age and a number of other clinical characteristics. The very recent introduction of a user-friendly software package that we used to perform the latent class metric conjoint analysis, which simultaneously estimates the influence of clinical characteristics as well clusters
clinicians into groups with similar decision making behaviour, might further stimulate the application of techniques, primarily developed for marketing research, in clinical medicine.\footnote{20}

One might question the validity of the use of ‘paper cases’, firstly because of the simplified description of the patients’ clinical profile, and secondly because of the cardiologists’ knowledge that their advice would have no actual consequences. However, we found that the observed advice scores for 4 additional case vignettes (‘hold-out profiles’) were in close agreement with scores predicted by the latent class model based on the original 32 cases, which shows the internal consistency of the cardiologists’ decision making behaviour. Furthermore, we also compared the response to the case vignettes given by cardiologists from three university hospitals with observed practice in a consecutive series of 138 actual cases in these hospitals.\footnote{21} Both approaches, the responses to the case vignettes and the observations in actual clinical practice, produced remarkably similar results with respect to the influence of the clinical characteristics on the decision making process. Studies of clinical judgement in rheumatoid arthritis\footnote{22} and management decisions for unstable angina\footnote{23} also support the validity of policy analyses using written case descriptions.

The survey was sent to all cardiologists who were member of the Dutch Society of Cardiology. The membership list includes more than 95% of all Dutch cardiologists. The non responding cardiologists appeared to be slightly older, less often working in university hospitals, and more often responsible for larger wards. Because these differences were small, we feel that our results are representative for all cardiologists in the Netherlands.

**Conclusions**

Our study showed that groups of cardiologists varied systematically according to their inclination to advise surgery for elderly patients with symptomatic aortic stenosis and the extent that their advice is influenced by the patient’s age, and cardiac signs and symptoms. Given that randomised controlled trials of the effectiveness of surgical treatment among elderly patients with aortic stenosis are

\begin{footnotesize}
\footnote{variation in cardiologists' treatment}
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unlikely to happen in the near future, there is a clear need for observational prospective studies that include medically and surgically treated elderly patients, who are followed up immediately after the identification of the aortic stenosis, to elucidate which management strategy provides the best treatment in elderly patients with aortic stenosis. These studies should use accurate measures of cardiac signs and symptoms and especially of comorbid conditions to provide more insight in the harms and benefits of surgery for patients with comorbid conditions.
References


Appendix I

Example of a case description used in the questionnaire (case number 25 in figure 1)

You see a 72 year old man at the outpatient clinic. The medical history shows that he has cardiac symptoms of class III according to the New York Heart Association criteria.

The medical history also shows the following. The patient has had a stroke and a slight remaining paresis. The renal function is impaired (serum creatinin concentration is 250 μmol/L). The pulmonary function is normal.

On physical examination, you find a normal blood pressure and pulse. On auscultation of the heart, you detect a murmur with a maximum at 2R, radiating to the carotid arteries. On auscultation of the lungs, you detect crepitations.

Doppler echocardiography reveals an important aortic stenosis. The aortic valve area is estimated to be 0.6 cm². The left ventricular function ejection fraction is 20%.

Afterwards the patient undergoes a heart catheterization. Coronary angiography shows no coronary artery disease.

Question

Would you advise this patient surgical treatment?

certainly yes (6)  
probably yes (5)  
possibly yes (4)  
possibly no (3)  
probably no (2)  
certainly no (1)  

variation in cardiologists' treatment