Systems dynamics as an interactive patient education tool for preventing coronary artery disease and myocardial infarction

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Introduction: Being able to predict when a person would have a myocardial infarction (MI) would have multiple implications: (1) that we understand what leads to MI's, (2) that we have a means to identify patien who are at risk for having immanent MI's and that we could help them to delay or avoid an MI, and (3) that could give patients accurate feedback about the results for them of risk factor modification. The goal of thi research was to develop a systems dynamics computer simulation model that would predict MI's.

Methods: A model created to simulate the course of patients' cardiovascular health and disease, begin at birth and predicting time in months at which eventual coronary artery occlusion and myocardial infarctio (MI) would occur. The model was developed on a cohort of patients with acute myocardial infarction using such variables as cholesterol; systolic and diastolic blood pressure; sex; menstrual status; triglyceride levels HDL and LDL cholesterol levels; glucose levels; family history of age at initial myocardial infarction; smoki status and amount; exercise frequency, duration, and intensity; activity level of the patient's lifestyle; amoun dietary fat consumed; weight and height; hostility; levels of psychosocial stress; and a number of other varia known to influence the rate of development of coronary artery disease. Psychosocial data was obtained ab stress, support and depression. Lifestyle data was obtained about exercise, activity levels, diet, alcohol, caffeine, cigarettes and drug consumption.

A second group of patients interacted with the model to study how patients would react to the feedback provided and whether or not they would change risk factors. Patients were given specific predictions with graphs about when they would be expected to have a heart attack and predictions of how much longer we would expect them to live with risk factor modification. They were permitted to query the computer regard how other changes they might make would affect their longevity. For example, patients could stop smoking begin exercising at the present time, re-run the simulation, and determine how this behavior change in the present would affect the time before they could expect to have a myocardial infarction (heart attack; crise cardiac). Patients could ÒbargainÓ with the simulation to determine what combination of risk factors they were willing to change to obtain specific lengthening of time before they could expect a myocardial infarctio

Results:
<u>Sample characteristics.</u> Of the 44 patients used for the initial validation testing, 14 were women and 11 we Hispanic. Systolic blood pressures ranged from 79 to 176 (mode = 130). Diastolic pressures ranged from 4 110 (mode = 80). Cholesterol ranged from 118 mgm/dl to 373 mgm/dl (mode = 222 mgm/dl). Triglycerides ranged from 56 mgm/dl to 710 mgm/dl (mode = 139 mgm/dl). Random blood glucoses ranges from 80 mgm to 724 mgm/dl (mode = 132 mgm/dl). Activity levels ranged from 0 to 6 (mode = 0). Total CK levels ranged from 102 to 6200 I.U. (mode = 712 I.U.). Time of initial myocardial infarction ranged from 432 months to 9 months (mode = 635 months). Pack years of smoking ranged from 0 to 210 (mode of 0). Body mass index ranged from 0.0127 to 0.0483 (mode = 0.0254). Table 2 shows the breakdown in MI Outcome Index by rac

<u>Comparisons to conventional statistics.</u>
1. <u>Cluster analysis.</u> Both the Joins and the K-means procedures were used. Despite attempting all possible permutations of variables, the best classification obtained was 13 correct assignments out of the 22 test cas

(59.1% accuracy). This was achieved by using all independent variables with the single linkage method (nea neighbor). The distance metric was the Pearson correlation coefficient. This compares to 88% correct classification with dynamic systems modeling.

2. Multiple regression analysis. A multiple regression model predicted 26.6% of the variance (p = 0.018). A borderline significant interaction of race and sex was noted with white males faring the worst. The most significant and best predictors were triglyceride and cholesterol levels.

Dynamic Systems Modeling. The model correctly classified 88% of patients. The false positive rate was 6% the false negative rate was 13%. The false positive patients included a 64 year old Hispanic female with a b glucose of 529 mgm/dl, cholesterol of 373 mgm/dl and triglycerides of 323 mgm/dl. The assumption of 20 y of chronicity may not have been accurate for this patient or she may have had an unmeasured protective fa operable. The first false negative was a 43 year old white, post-menopausal female with all normal indicato except for 25 pack-years of cigarette smoking. The second false negative was a 42 year old Hispanic male all normal indicators except for a blood pressure of 155/105 and a cholesterol level of 234 mgm/dl.

An unidentified risk factor was isolated in the learning sample and on closer inspection was found to be fam history of early MI. It became prominent when age was greater than 57 years, blood pressure normal, smo less than 2 packs per day, body mass index greater than 0.0177 and cholesterol levels between 166 and 239 mgm/dl, with glucose levels between 100 and 210 mgm/dl and triglycerides between 105 and 185 mgm/dl fo men. When these parameters were exceeded, the genetic effects appeared to be sufficiently overshadowed a be rendered non-operable. It was operable in women with a positive history when age was greater than 5o, blood pressure normal, non-smoking was true, race was white and cholesterol was greater than 200 mgm/d with all other indices normal.

Results of Interaction with the Model: 21 patients who interacted with the model were followed for an aver of 5.9 mos. (range 5 to 20 mo). The patients were seen at 4-8 week intervals to update data and to interact the model. Nineteen reduced some aspect of risk behavior; 19 increased exercise and/or activity (90%); 4 increased HDL cholesterol (21%); 8 decreased LDL cholesterol (38%); 12 decreased BP (58%). Patients' acceptance of the systems dynamics model was high. They preferred what they learned from the model to t standard of medical care, which consists of lectures from the physician to change behavior (Òstop smoking, weight, exercise) or else. In the standard medical approach, Òor elseÓ is poorly specified and patients can question whether or not the information presented applies to them or not. Patients being able to use the systems dynamics model to evaluate their own personal risks and benefits and make choices based upon da presented rather than the usual lecture approach of their physician.

Sample Output. Figure 1 shows the prediction for a patient with many risk factors. The time (in months) at which line 1 (Time of MI) changes slope represents the time at which an MI is predicted to occur (about 520 months or age 43 and 4 months).

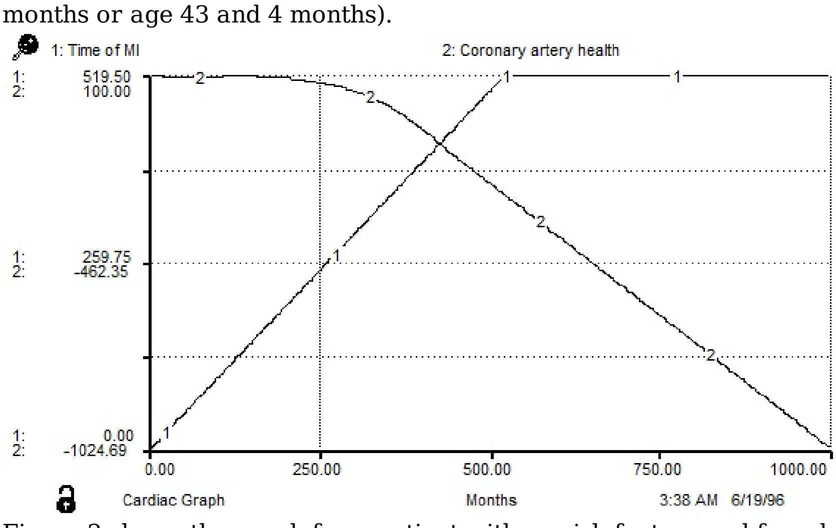
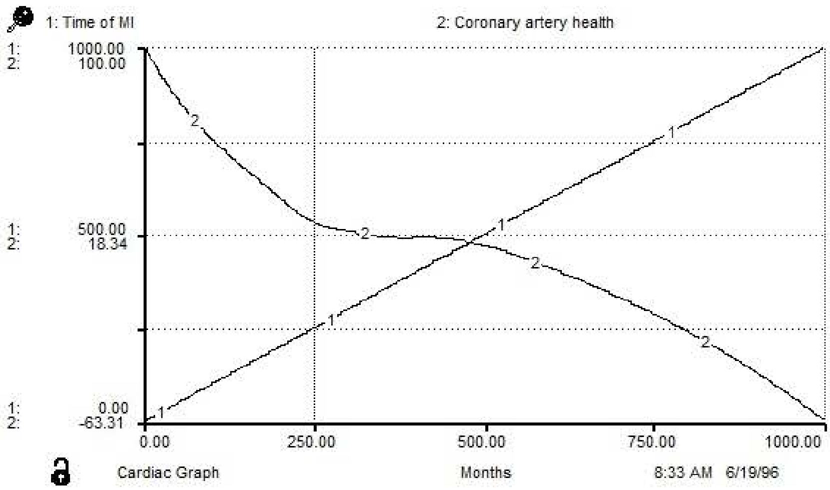


Figure 2 shows the graph for a patient with no risk factors and for whom no MI is predicted at even 1,000 months (age 83).


1: Time of MI
2: Coronary artery health
1: 1000.00
2: 100.00
1: 500.00
2: 18.34
1: 0.00
2: -63.31
0.00
250.00
500.00
750.00
1000.00
Cardiac Graph
Months
8:33 AM 6/19/96