Application of an Alternative Approach for Nonfatal Events in Survival Analysis

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Objectives

The objective of this study was to determine actual and actuarial approaches to survival analysis, especially for nonfatal events.

Methodology

Actual versus actuarial

In recent years, the new term actual is being used more commonly in cardiac surgery literature. This technique determines cumulative incidence or observable probability as estimated by the following formula:

$$\text{Estimation } S(t): \frac{\#\text{ of individuals with survival times}}{\#\text{ of individuls in the data set}}$$

S(t) is a step function: constant between two adjacent endpoint time

In contrast to actual analysis, the actuarial approach is simply the application of the life table method and its use is often extended to include the Kaplan-Meier method.

The Kaplan-Meier method estimates survival probability as in the following formula:

$$\text{Kaplan-Meier estimator of } S(t): \prod_{i=1}^{t} (1-p_i)$$

where,

$$p_i = \frac{d_i}{n_i}$$

d_i= # of deaths (endpoint) at time t_i
n_i= # of alive at time t_i
t_i= survival time (time intervals are independent)

Survival analysis

Survival analysis examines the time period needed for an individual to reach an endpoint of interest (e.g. death, the life span of a living organism or the time which elapses for remission from a disease) when some data are censored. Censored data are used in survival analysis when there is incomplete information about outcome. In the Kaplan-Meier method, patients who are still alive at the time of analysis are censored and it is assumed that they will eventually die. So the risk of the endpoint (dying) in the future for censored patients will be the same as that observed for patients who have already died.

Nonfatal events

When we speak about nonfatal events, these are events with outcomes other than death, like angina. In this case for example in patients who have had coronary artery bypass surgery, all patients are called censored if they have not yet experienced that event, including those who have died and will never have the event.

When the Kaplan-Meier method is applied to a nonfatal event , the question about risk becomes :"What is the risk of the event if no patient ever died?"
So the event-free estimate answers this question.

When the other alternative method which is called simply the actual method, is applied to a nonfatal event, the question about the risk turns to : "What is the probability that a particular patient will experience the event?".

Application of the method

Our study covers 212 patients who had coronary artery disease plus severe left ventricular dysfunction and who had undergone coronary artery bypass surgery at Maltepe University Hospital Cardiovascular Surgery Department between 1996-2000, performed by the same surgeon. Angina

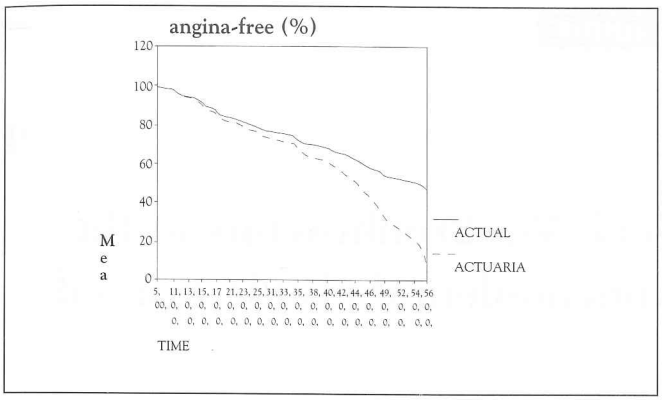

Figure 1. *Actual versus actuarial analyses of angina estimates.*

pectoris was the predominant symptom in all patients. Endpoints of the study other than mortality were recurrence of the angina and of the congestive heart failure. Thus angina pectoris is the nonfatal event for this study.

The Kaplan-Meier method estimates angina-free curves by censoring the patients who are still alive without angina or who have already died without angina. Thus the Kaplan-Meier method gives the probability of being angina-free if deaths were theoretically eliminated. In this method it is assumed that patients without angina, whether they are currently alive or dead (without angina) will have angina in the future.

In the actual analysis, only patients who are alive without angina are censored. This method estimates the percentage who will actually suffer from angina and in this case patients who have died are eliminated from the risk pool.

Results

Cumulative survival data on angina-free probability according to time (months) endpoints are listed below:

Time	% actuarial	% actual
5,00	99,4400	99,4700
9,00	98,2700	98,4300
11,00	97,6700	97,8600
12,00	95,2500	95,6800
13,00	93,9800	94,5700
14,00	93,3300	94,0200
15,00	90,7200	91,7500
16,00	87,4300	88,8400
17,00	86,1100	87,6500
18,00	82,7200	84,6200
21,00	81,2700	83,3900
22,00	80,5300	82,7600
23,00	79,0500	81,5000
24,00	76,8100	79,5800
25,00	75,9900	78,9300
29,00	73,4300	76,9500
31,00	72,5700	76,2900
32,00	71,7100	75,6100
33,00	70,8200	74,9400
34,00	69,8800	74,2600
35,00	65,9400	71,4900
36,00	63,9400	70,0800
38,00	62,9000	69,3600
39,00	61,7700	68,6400
40,00	60,5600	67,9200
41,00	56,8500	65,7100
42,00	55,5900	64,9700
43,00	53,0100	63,4600
44,00	50,3500	61,9200
45,00	45,4800	59,5800
46,00	42,1100	57,9900
48,00	38,1000	56,3700
49,00	31,3800	53,8900
51,00	29,1400	53,0000
52,00	26,9000	52,2000
53,00	24,2100	51,3000
54,00	21,1800	50,4800
55,00	18,1500	49,6000
56,00	7,2600	46,9600

The study results, estimated according to the Kaplan-Meier (actuarial) method at the end of 55 months (≈4.5 years) show that the percentage of patients who will experience angina is 81.75% if no patient dies. This percentage was estimated as 50.4% according to actual analysis in patients who have undergone coronary artery bypass surgery.

From a medical point of view, the actual angina-free percentage (49.6%) seems to be more reasonable than the actuarial angina-free percentage estimate (18.5%).

Conclusion

Actual and actuarial curves for percentages free from angina over time (event-free percentages) are quite different from one another. In this study these estimates were found as 49.6% and 18.15% respectively at 55 months. We believe that especially for nonfatal events such estimates need to be interpreted with caution and with consideration of the reason why the estimate was done.

References

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