

# Survival Analysis of Post-Myocardial Infarction Patients

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5/22/2020

## Abstract

### Background

The rates of myocardial infarction is becoming an increasing common occurrence in the United States. As medical knowledge and techniques improve to meet need of infarction episode, so does the need to understand the survivability of patients who have survived such episodes.

### Objectives

Our goal is to provide detailed survival statistics of post-myocardial infarction patients as well as provide an accurate regression model to best prediction of survival outcomes of a single year following an infarction episode.

### Methods

Data from 133 post-myocardial infarction patients measure the time in months until death in a one year monitoring period of follow-up. We use a combination of nonparametric (Kaplan-Meier) and parametric methods (Weibull/Cox PH) to determine estimates of survival among age, gender, and myocardial strata (contraction depth, muscular activity, ). We consider a slew of statistical and graphical results before determining the most appropriate method of modeling.

### Results

Out of all of our methods, we have determined that [] is the most appropriate model for prediction of patient survival. We have AIC values of. We have BIC values. Thus, this model is the best.

### Conclusion

[summary statistics] [review of our model + specific survival rates]

## Introduction

Myocardial infarctions are becoming largely common among U.S. populations. The number of myocardial infarctions are remarkably increased from [start date] to [end date] by [x] amount (add citation). In 2015, approximately 23% of all fatalities in the United States was related to some degree of heart disease (cdc. cite please). Unsurprisingly, clinical studies have shown harmful symptoms in post-infarction survival patients. Our obtained dataset to examine the tangible difference in survivability rates from the course of year following an infarction episode.

By applying survival analysis techniques to this data set, we seek to achieve improved understanding of the characteristics exhibited by patients in a one year post-infarction interval. We also propose a model to better predict the probability of a survival of patients based on these variable characteristics.

Table 1: Dataset Variable Labels

Variable	Label	Definition
Survival	Survival	The number of months the patients survived, post-myocardial infarction.
Alive at the end of Survival Period	Alive.E	Binary variable. 0 denotes that patient is alive at the end of the survival period.
Patient Age	Age	The age in years when a myocardial infarction occurs.
Pericardial Effusion	P.Effusion	Binary variable. Pericardial effusion is excess fluid surrounding the heart.
Fractional Shortening	F.Shortening	Fractional shortening is a measure of contractility around the heart.
E-Point Septal Separation	EPSS	E-point septal separation is an additional measure of heart contractility.
Left Ventricular End-Diastolic Dimension	LVDD	Left ventricular end-diastolic dimension is the measure of the left ventricle's size.
Wall Motion Score	WMS	Wall motion score is a measure of how the segments of the left ventricle move.
Wall Motion Index	WMI	Wall motion index is the wall motion score divided by the number of segments.

## Dataset

We have obtained our data set from Kaggle. The data set contains 131 observations and records 8 variables. It should be noted that two patients' data were removed as there was no recorded months survival date.

Below is a table summary of each table header variable label and a definition of that variable.

Since the time of infarction varies, some patients were followed for less than a year. This provides a clear censoring and truncation problem. We will address this concern in detail in the later in this section. It should be noted that we have a slew of missing values. Since a single patient has shown as missing, we have opted to impute the values for this data row. With this in mind, our predictive and summary models will have less than ideal accuracy.

The full dataset is available in the appendix of this paper.

## Methodology

### Censoring

Left Censored: Because all the patients had their heart attacks at different times, it is possible that some patients have survived less than one year but they are still alive. Check the second variable to confirm this. Such patients cannot be used for the prediction task mentioned above.

### Imputation

There are several missing values in the data set. The variables we chose to more `## Summary statistics ##`  
Kaplan-Meier We conduct nonparametric Kaplan-Meier fit on our data over multiple strata. We first conduct a fit over all patients in regards to censoring. Then we work on gender groups, age, and general ventricular condition.

### Weibull Fits

### Cox PH

## Results

### Table of Summary Statistics

```
##      speed      dist
##  Min.   : 4.0    Min.   : 2.00
##  1st Qu.:12.0    1st Qu.: 26.00
##  Median :15.0    Median : 36.00
```

##	Mean	:15.4	Mean	: 42.98
##	3rd Qu.:	19.0	3rd Qu.:	56.00
##	Max.	:25.0	Max.	:120.00

## KM Curve

KM Overall

##	speed		dist	
##	Min.	: 4.0	Min.	: 2.00
##	1st Qu.:	12.0	1st Qu.:	26.00
##	Median	:15.0	Median	: 36.00
##	Mean	:15.4	Mean	: 42.98
##	3rd Qu.:	19.0	3rd Qu.:	56.00
##	Max.	:25.0	Max.	:120.00

KM Age

##	speed		dist	
##	Min.	: 4.0	Min.	: 2.00
##	1st Qu.:	12.0	1st Qu.:	26.00
##	Median	:15.0	Median	: 36.00
##	Mean	:15.4	Mean	: 42.98
##	3rd Qu.:	19.0	3rd Qu.:	56.00
##	Max.	:25.0	Max.	:120.00

KM Gender

##	speed		dist	
##	Min.	: 4.0	Min.	: 2.00
##	1st Qu.:	12.0	1st Qu.:	26.00
##	Median	:15.0	Median	: 36.00
##	Mean	:15.4	Mean	: 42.98
##	3rd Qu.:	19.0	3rd Qu.:	56.00
##	Max.	:25.0	Max.	:120.00

KM Ventricular Activity

##	speed		dist	
##	Min.	: 4.0	Min.	: 2.00
##	1st Qu.:	12.0	1st Qu.:	26.00
##	Median	:15.0	Median	: 36.00
##	Mean	:15.4	Mean	: 42.98
##	3rd Qu.:	19.0	3rd Qu.:	56.00
##	Max.	:25.0	Max.	:120.00

## Weibull Curve

##	speed		dist	
##	Min.	: 4.0	Min.	: 2.00
##	1st Qu.:	12.0	1st Qu.:	26.00
##	Median	:15.0	Median	: 36.00
##	Mean	:15.4	Mean	: 42.98
##	3rd Qu.:	19.0	3rd Qu.:	56.00
##	Max.	:25.0	Max.	:120.00

## Cox Proportional Hazard

```
##      speed      dist
## Min.   : 4.0   Min.   : 2.00
## 1st Qu.:12.0   1st Qu.: 26.00
## Median :15.0   Median : 36.00
## Mean   :15.4   Mean    : 42.98
## 3rd Qu.:19.0   3rd Qu.: 56.00
## Max.   :25.0   Max.    :120.00
```

## Model Diagnostics

### AIC, BIC, and Confidence Intervals

```
##      speed      dist
## Min.   : 4.0   Min.   : 2.00
## 1st Qu.:12.0   1st Qu.: 26.00
## Median :15.0   Median : 36.00
## Mean   :15.4   Mean    : 42.98
## 3rd Qu.:19.0   3rd Qu.: 56.00
## Max.   :25.0   Max.    :120.00
```

### Residual Analysis/QQ Plot

```
##      speed      dist
## Min.   : 4.0   Min.   : 2.00
## 1st Qu.:12.0   1st Qu.: 26.00
## Median :15.0   Median : 36.00
## Mean   :15.4   Mean    : 42.98
## 3rd Qu.:19.0   3rd Qu.: 56.00
## Max.   :25.0   Max.    :120.00

##      speed      dist
## Min.   : 4.0   Min.   : 2.00
## 1st Qu.:12.0   1st Qu.: 26.00
## Median :15.0   Median : 36.00
## Mean   :15.4   Mean    : 42.98
## 3rd Qu.:19.0   3rd Qu.: 56.00
## Max.   :25.0   Max.    :120.00
```

## Discussion

## References

[<https://www.cdc.gov/heartdisease/facts.htm>]

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## Appendix

Table 2: Dataset

Survival	Alive.E	Age	P.Effusion	F.Shortening	EPSS	LVDD	WMS
11.00	0	71	0	0.26	9	4.5999999999999996	14
19.00	0	72	0	0.38	6	4.0999999999999996	14
16.00	0	55	0	0.26	4	3.42	14
57.00	0	60	0	0.253	12.061999999999999	4.6029999999999998	16
19.00	1	57	0	0.16	22	5.75	18
26.00	0	68	0	0.26	5	4.3099999999999996	12
13.00	0	62	0	0.23	31	5.43	22.5
50.00	0	60	0	0.33	8	5.25	14
19.00	0	46	0	0.34	0	5.09	16
25.00	0	54	0	0.14000000000000001	13	4.49	15.5
10.00	1	77	0	0.13	16	4.2300000000000004	18
52.00	0	62	1	0.45	9	3.6	16
52.00	0	73	0	0.33	6	4	14
44.00	0	60	0	0.15	10	3.73	14
0.50	1	62	0	0.12	23	5.8	11.67
24.00	0	55	1	0.25	12.063000000000001	4.29	14
0.50	1	69	1	0.26	11	4.6500000000000004	18
0.50	1	62.53	1	7.0000000000000007E-2	20	5.2	24
22.00	1	66	0	0.09	17	5.819	8
1.00	1	66	1	0.22	15	5.4	27
0.75	1	69	0	0.15	12	5.39	19.5
0.75	1	85	1	0.18	19	5.46	13.83
0.50	1	73	0	0.23	12.733000000000001	6.06	7.5
5.00	1	71	0	0.17	0	4.6500000000000004	8
48.00	0	64	0	0.19	5.9	3.48	10
29.00	0	54	0	0.3	7	3.85	10
29.00	0	35	0	0.3	5	4.17	14
29.00	0	55	0	?	7	?	2
0.25	1	75	0	?	?	?	?
36.00	0	55	1	0.21	4.2	4.16	14
1.00	1	65	0	0.15	?	5.05	10
1.00	1	52	1	0.17	17.2	5.32	14
3.00	1	?	0	?	12	?	6
27.00	0	47	0	0.4	5.12	3.1	12
35.00	0	63	0	?	10	?	14
26.00	0	61	0	0.61	13.1	4.07	13
16.00	0	63	1	?	?	5.31	5
1.00	1	65	0	0.06	23.6	?	21.5
19.00	0	68	0	0.51	?	3.88	15
31.00	0	80	0	0.41	5.4	4.3600000000000003	?
32.00	0	54	0	0.35	9.3000000000000007	3.63	11
16.00	0	70	1	0.27	4.7	4.49	22
40.00	0	79	0	0.15	17.5	4.2699999999999996	13
46.00	0	56	0	0.33	?	3.59	14
2.00	1	67	1	0.44	9	3.96	17.5
37.00	0	64	0	0.09	?	?	12
19.50	1	81	0	0.12	?	?	9
20.00	1	59	0	0.03	21.3	6.29	17
0.25	1	63	1	?	?	?	23
2.00	1	56	1	0.04	14	5	?
7.00	1	61	1	0.27	?	?	9
10.00	0	57	0	0.24	14.8	5.26	18
12.00	0	58	0	0.3	9.4	3.49	14
1.00	1	60	0	0.01	24.6	5.65	39
10.00	0	66	0	0.28999999999999998	15.6	6.15	14