**Title: Estimation of survival function, cumulative survival function using Kaplan - Meier estimator, Comparison of survival function using log rank test.**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Q1)** Time in months to progression of patients with stages 2 or 3(a) ovarian carcoma by low grade or where differentiated cancer.

|  |  |  |  |
| --- | --- | --- | --- |
| Patient No. | Time(in month) | censored | cell grade |
| 1 | 0.92 | yes | low |
| 2 | 2.93 | yes | low |
| 3 | 5.76 | yes | low |
| 4 | 6.41 | yes | low |
| 5 | 10.16 | yes | low |
| 6 | 12.4 | No | low |
| 7 | 12.93 | No | low |
| 8 | 13.35 | No | low |
| 9 | 14.7 | No | low |
| 10 | 15.2 | yes | low |
| 11 | 23.32 | No | low |
| 12 | 24.27 | No | low |
| 13 | 25.33 | No | low |
| 14 | 36.38 | No | low |
| 15 | 39.67 | No | low |

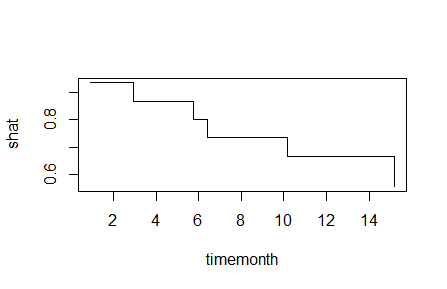
You can coded censored as Yes =1,No=0

Calculate survival probability for each distinct failure time using KM estimator. Also draw KM plot for survival probability

**#Solution:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Time in months | No. of events | No.of censored obs. | No.in risk set | sp | cp |
| 0.92 | 1 | 0 | 15 | 0.933333 | 0.933333 |
| 2.93 | 1 | 0 | 14 | 0.928571 | 0.866666 |
| 5.76 | 1 | 0 | 13 | 0.923077 | 0.8 |
| 6.41 | 1 | 0 | 12 | 0.916667 | 0.733333 |
| 10.16 | 1 | 4 | 11 | 0.909091 | 0.666666 |
| 15.2 | 1 | 1 | 6 | 0.833333 | 0.555555 |

**#KM Plot for survival function:**



**Q2)** To assess results and identify predictors of survival ,Martini et al. (A-1) reviewed their total experience with primary malignant tumors of the the sternum. They classified patients as having either low-grade(25 patients) or high grade(14 patients) tumors. The event(Status), time t event (months), and tumor grade for each patient are shown in table below. We wish to compare the 5-year survival experience of these two groups by mean of the K-M procedure.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| subject | Time(month) | Vital Status | Tumor grade | subject | Time(month) | Vital Status | Tumor grade |
| 1 | 29 | dod | L | 21 | 155 | ned | L |
| 2 | 129 | ned | L | 22 | 102 | dod | L |
| 3 | 79 | dod | L | 23 | 34 | ned | L |
| 4 | 138 | ned | L | 24 | 109 | ned | L |
| 5 | 21 | dod | L | 25 | 15 | dod | L |
| 6 | 95 | ned | L | 26 | 122 | ned | H |
| 7 | 137 | ned | L | 27 | 27 | dod | H |
| 8 | 6 | ned | L | 28 | 6 | dod | H |
| 9 | 212 | dod | L | 29 | 7 | dod | H |
| 10 | 11 | dod | L | 30 | 2 | dod | H |
| 11 | 15 | dod | L | 31 | 9 | dod | H |
| 12 | 337 | ned | L | 32 | 17 | dod | H |
| 13 | 82 | ned | L | 33 | 16 | dod | H |
| 14 | 33 | dod | L | 34 | 23 | dod | H |
| 15 | 75 | ned | L | 35 | 9 | dod | H |
| 16 | 109 | ned | L | 36 | 12 | dod | H |
| 17 | 26 | ned | L | 37 | 4 | dod | H |
| 18 | 117 | ned | L | 38 | 0 | dpo | H |
| 19 | 8 | ned | L | 39 | 3 | dod | H |
| 20 | 127 | ned | L |  |  |  |  |

**#Solution:**

**Dod=dead of disease; ned=no evidence of disease; dpo=dead post operation; L- low grade,H-high grade**

**Vital status (censored=0(ned), event=1(dod))**

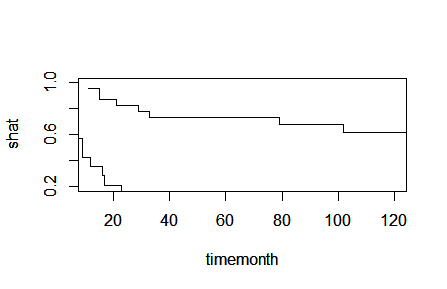
**# For low grade tumour:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Time | Vital status | Tumor grade | no.of censored | in risk | sp | cp |
| 11 | 1 | L | 0 | 23 | 0.956522 | 0.956522 |
| 15 | 1 | L | 0 | 22 | 0.909091 | 0.869565 |
| 15 | 1 | L | 0 |  |  |  |
| 21 | 1 | L | 0 | 20 | 0.95 | 0.826087 |
| 29 | 1 | L | 1 | 18 | 0.944444 | 0.780193 |
| 33 | 1 | L | 0 | 17 | 0.941176 | 0.7343 |
| 79 | 1 | L | 2 | 14 | 0.928571 | 0.68185 |
| 102 | 1 | L | 2 | 11 | 0.909091 | 0.619863 |
| 212 | 1 | L | 8 | 2 | 0.5 | 0.309932 |

**#For high grade tumour:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Time | Vital status | Tumor grade | censored | in risk | sp | cp |
| 0 | 1 | H | 0 | 14 | 0.928571 | 0.928571 |
| 2 | 1 | H | 0 | 13 | 0.923077 | 0.857142 |
| 3 | 1 | H | 0 | 12 | 0.916667 | 0.785714 |
| 4 | 1 | H | 0 | 11 | 0.909091 | 0.714285 |
| 6 | 1 | H | 0 | 10 | 0.9 | 0.642857 |
| 7 | 1 | H | 0 | 9 | 0.888889 | 0.571428 |
| 9 | 1 | H | 0 | 8 | 0.75 | 0.428571 |
| 9 | 1 | H | 0 |  |  |  |
| 12 | 1 | H | 0 | 6 | 0.833333 | 0.357143 |
| 16 | 1 | H | 0 | 5 | 0.8 | 0.285714 |
| 17 | 1 | H | 0 | 4 | 0.75 | 0.214286 |
| 23 | 1 | H | 0 | 3 | 0.666667 | 0.142857 |
| 27 | 1 | H | 0 | 2 | 0.5 | 0.071429 |

**#KM plot for low grade tumour:**



**Q3)** Data given below for Log Rank Test to compare survival curve. Group 1 represents the chemotherapy before surgery group and group 2 represents the chemotherapy after surgery group.

Compare two survival function using Log Rank Test.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time in months | Number at risk in group 1(N1t) | Number at risk in group 2 (N2t) | Number of events (deaths) in group 1(O1t) | Number of events (deaths) in group 2(O2t) |
| 8 | 10 | 10 | 1 | 0 |
| 12 | 8 | 10 | 1 | 0 |
| 14 | 7 | 10 | 1 | 0 |
| 21 | 5 | 10 | 1 | 0 |
| 26 | 4 | 8 | 1 | 0 |
| 27 | 3 | 8 | 1 | 0 |
| 28 | 2 | 8 | 0 | 1 |
| 33 | 1 | 7 | 0 | 1 |
| 41 | 0 | 5 | 0 | 1 |

**#Solution:**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Time(months) | No. at risk in group1 (N1t) | No. at risk in group2 N2t | Nt | O1t | O2t | Ot | E1t | E2t |
| 8 | 10 | 10 | 20 | 1 | 0 | 1 | 0.5 | 0.5 |
| 12 | 8 | 10 | 18 | 1 | 0 | 1 | 0.444444 | 0.555556 |
| 14 | 7 | 10 | 17 | 1 | 0 | 1 | 0.411765 | 0.588235 |
| 21 | 5 | 10 | 15 | 1 | 0 | 1 | 0.333333 | 0.666667 |
| 26 | 4 | 8 | 12 | 1 | 0 | 1 | 0.333333 | 0.666667 |
| 27 | 3 | 8 | 11 | 1 | 0 | 1 | 0.272727 | 0.727273 |
| 28 | 2 | 8 | 10 | 0 | 1 | 1 | 0.2 | 0.8 |
| 33 | 1 | 7 | 8 | 0 | 1 | 1 | 0.125 | 0.875 |
| 41 | 0 | 5 | 5 | 0 | 1 | 1 | 0 | 1 |
| Total= |  |  |  | 6 | 3 |  | 2.620603 | 6.379397 |

#For comparison of survival function :

**#Hypothesis:**

**H0: S1(y) =S2(y)**

**V/s H1: S1(y) ≠S2(y)**

**#Log rank test statistic:**

**χ LR**2 = ∑ (∑Ojt -∑ Ejt)2 = (6 - 2.62)^2/2.62 +(3 – 6.38)^/6.38 = **6.1511**

∑ Ejt

**χ21  = 3.84**

**#Decision Rule:**

Reject Ho if **χ LR2 >χ21** .

**Here, χ LR2 >χ21** **.**

**#Decision: Reject Ho.**

**#Conclusion: The survival function of chemotherapy before surgery is different than the survival function of chemotherapy after surgery.**