Graphical Presentation of Survival Analysis

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ABSTRACT

Survival analysis and graphical presentation of the survival analysis result are not uncommon in pharmaceutical industry. In this paper we use simulated survival data to demonstrate the graphical presentation of Kaplan-Meier survival analysis result by using Proc Lifetest, Proc Gplot and Proc Greplay.

SURVIVAL ANALYSIS AND PRESENTATION

Simulated Survival Data

Following is the code we used to generate the survival data. In these data, we assume there are 2 treatment groups, namely study drug and placebo. And there are 100 patients in each treatment group. The survival time is exponentially distributed and the treatment effect is 20 units for study drug and 10 units for placebo. The censoring indicator variable CENSOR is coded 1 for the patients who were censored and 0 for the patients who had event.

```
options nocenter;

proc format;
  value trt
    1 = 'Study Drug'
    2 = 'Placebo';
run;

data surv;
  do trt = 1 to 2;
    do pat = 1 to 100;
      if trt = 1 then do;
        surv = -log(ranuni(0))*20;
        if mod(pat, 5) then censor = 0;
        else censor = 1;
      end;
      else do;
```

```
        if mod(pat, 7) then censor = 0;
        else censor = 1;
        surv = -log(ranuni(0))*10;
      end;
      drop pat;
      patient = put(pat, z5.);
      output;
    end;
  end;
run;
```

Sample data:

patient	trt	surv	censor
00001	1	75.7023	0
00002	1	7.0416	0
00003	1	5.1007	0
00004	1	5.8182	0
00005	1	3.8551	1
00006	1	6.5943	0
00007	1	11.2427	0
00008	1	38.2103	0
00009	1	44.6357	0
00010	1	23.2238	1

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Survival Analysis

The Kaplan-Meier survival estimates were created by calling Proc Lifetest procedure.

```
ods listing close;
ods output  ProductLimitEstimates = s_est
            CensoredSummary = cen_sum
            HomTests = homtest
            Quartiles = quart;
  proc lifetest data = surv;
    time surv*censor(1);
    strata trt;
    id patient;
    format trt trt.;
  run;
```

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```
ods output close;
ods listing;
```

Extraction of Statistics

SAS ODS provides great convenience for extraction of Log-Rank p-value, median survival time and other statistics. Here we convert these statistics into macro variables so that we can annotate them onto the survival curves later on.

```
/***************************************
   Populate the censored patients
   with appropriate KM estimates.
***************************************/

data s_est;
  set s_est;
  retain pr_s;
  if censor = 0 then pr_s = survival;
  surviva = .;
  if censor = 1 then do;
    surviva = pr_s;
    survival = .;
  end;
run;


/***************************************
   Convert the total number of
   patients, number of patient with
   event, number of patients with
   censoring into macro variables.
***************************************/

proc sort data = cen_sum;
  by trt;
  where control_var is missing;
run;

data _null_;
  set cen_sum end = last;
  pctevt = 100 - pctcens;
  call symput('groupf'||compress(_n_),
              compress(put(trt, trt.)));
  call symput('ng'||compress(_n_),
              compress(put(total, 8.)));
  call symput('ngevt'||compress(_n_),
              compress(put(failed, 8.)));
  call symput('pgevt'||compress(_n_),
              compress(put(pctevt, 8.2)));
  call symput('ngcen'||compress(_n_),
              compress(put(censored, 8.)));
  call symput('pgcen'||compress(_n_),
              compress(put(pctcens, 8.2)));
```

```
run;


/***************************************
   Convert Log-Rank test p-value
   into macro variable.
***************************************/

proc sort data = homtest;
  where test = 'Log-Rank';
  by test;
run;

data _null_;
  set homtest;
  call symput('logrp', compress(put(probchisq,
              pvalue6.4)));
run;


/***************************************
   Convert median survival estimates
   and its 95% CI into variables.
***************************************/

proc sort data = quart;
  by trt;
  where percent = 50;
run;

data _null_;
  set quart;
  call symput('gmed'||compress(_n_),
              compress(put(estimate, 8.2)));
  call symput('llmit'||compress(_n_),
              compress(put(lowerlimit, 8.2)));
  call symput('ulmit'||compress(_n_),
              compress(put(upperlimit, 8.2)));
run;
```

Plot the Kaplan-Meier Estimates

Proc Gplot is used to plot the survival estimates against the observed survival time. Notice that we call the Proc Gplot twice. One is for the event curve and the other for the censored curve. The survival statistics including log-rank p-value are put on the graph by note statements. In addition, the name statement is used to create two different graphs in order to replay the two graphs onto one graph which will have both event and censored curves.

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```
/********
   Gplot
********/

title1 h = 3 "Kaplan-Meier Survival Estimate";

filename event "c:/survival/lifetest_event.cgm";
filename censor "c:/survival/lifetest_censo.cgm";

axis1  c = black value = (h = 2.2) minor = none
       order = (0 to 1 by 0.1) width = 2
       label=(angle=90 h = 2.4 'Kaplan-Meier
Estimate');

axis2  c = black value = (h = 2.2)
       order = (0 to 80 by 10) width = 2
         minor = none label= ( h = 2.4 "Survival
Time (Months)");

legend value = (height = 1.8) cborder  = black
         label    = none
         position = (TOP inside RIGHT)
         mode     = share;

goptions reset = symbol rotate = landscape
         device  = cgmmwwc gsfname = event
         ctext = black cback = white
         gsfmode = replace ftext=swissb
         gsflen=80 display autofeed
         gunit   = pct;

proc gplot data = s_est gout = work.mygraf;
  note height = 1.3 j = left font = swissbu
  move = (62,  74) "&groupf1"
  move = (48,  71) "No of Patients"
  move = (48,  69) "Death"
  move = (48,  67) "Censored"
  move = (48,  65) "Median Survival"
  move = (48,  63) "95% CI"
  move = (48,  60) "Log Rank P-Value : &logrp"
  move = (64,  71) "&ng1"
  move = (64,  69) "&ngevt1 (&pgevt1.%)"
  move = (64,  67) "&ngcen1 (&pgcen1.%)"
  move = (64,  65) "&gmed1 Mos."
  move = (64,  63)  "[&llmit1, &ulmit1]"
  move = (76, 74)  "&groupf2"
  move = (78, 71)  "&ng2"
  move = (78, 69)  "&ngevt2 (&pgevt2..%)"
  move = (78, 67)  "&ngcen2 (&pgcen2..%)"
  move = (78, 65)  "&gmed2 Mos."
  move = (78, 63)  "[&llmit2, &ulmit2]" ;

symbol1 V = none I = steplj L = 1 c = black
        H = 1.5 W = 3.5;
symbol2 V = none I = steplj L = 2 c = black
        H = 1.5 W = 3.5;
```

```
    plot survival*surv = trt
          / name = 'g1'
            haxis=axis2
            vaxis=axis1
            legend = legend ;
        format survival 8.1 surv 8.;
run;


goptions reset = symbol gsfname = censor
       gsfmode = replace;

proc gplot data = s_est gout = work.mygraf;
    symbol1 V = dot I = none c = black
          H = 1.5 W = 3.5;
    symbol2 V = circle I = none c = black
          H = 1.5 W = 3.5;
     plot surviva*surv = trt
         / name = 'g2'
           haxis=axis2
           vaxis=axis1
           legend = legend;
          format surviva 8.1 surv 8.;
run;
```

Overlay the Survival Curves

In order to show both the event patients and the censored patients on the survival curves, the Proc Greplay is used to overlay the two survival curves.

```
filename wordfile "c:/survival/lifetest.cgm";

goptions reset = symbol gsfname = wordfile
       gsfmode = replace;

proc greplay  igout = work.mygraf
               tc  = work.newtwo nofs;
  tdef newtwo  des = 'Survival Curves'
     1/llx =  0    lly = 0
       ulx =  0    uly = 100
       urx = 100   ury = 100
       lrx = 100   lry = 0;
       template newtwo;
       treplay
         1:g1
         1:g2;
     quit;
run;

proc catalog cat = work.mygraf;
  delete g1 g2/entrytype = grseg;
run;
```
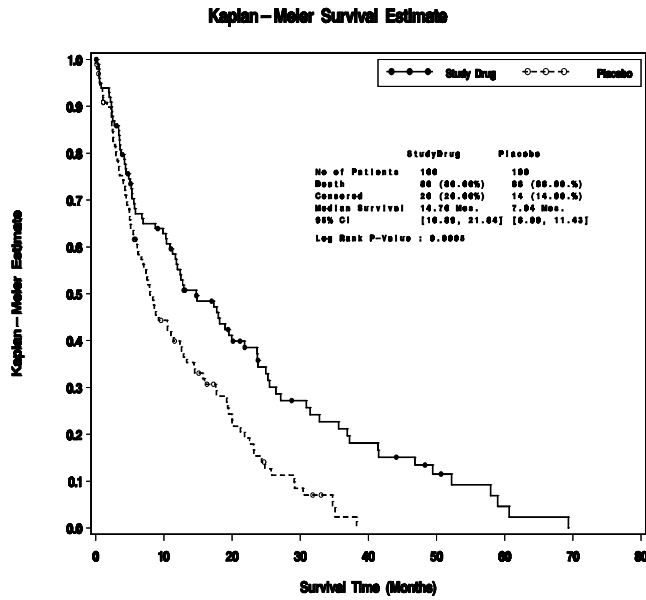
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Kaplan–Meier Survival Estimate

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CONCLUSIONS

Gplot, Greplay and annotation techniques are powerful tools in presenting the survival analysis results graphically. We can not only show the survival curves, but also the survival statistics on one graph. In addition, with different devices and colors specified in Goptions, we can convert the regular survival analysis results into colorful slides for example.

REFERENCES

SAS Institute Inc. (1990), SAS/GRAPH Software: Reference, Version 6, First Edition, Volume 1, Volume 2, Cary, NC: SAS Institute Inc.

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