Doctor, How Am I Doing? Conditional Survival Analyses
Background

- Survival rates usually reported from time of diagnosis only
- Doesn't reflect changing hazard rates over time:
  - early: higher hazard rate
  - late: lower hazard rate
What is Conditional Survival?

The probability of survival given that the patient has already survived a certain period of time since diagnosis.
Scenarios

- A patient asks, "Doctor, now that I have survived 2 years, what are the chances I will survive another 5 years?
- As a physician, what is an appropriate schedule for follow-up surveillance, based on changing risk?
- As a researcher, when designing a clinical trial, what is a sufficient follow-up time for reporting end points?
Conditional Survival

Let $S(t)$ be Kaplan-Meier survival at time $t$.

Conditional Survival, $CS(y|x)$, is probability of surviving $y$ yrs, given already survived $x$ yrs.

\[
CS(y \mid x) = \frac{S(x + y)}{S(x)}
\]

e.g., $CS(5\mid2) = \frac{S(5+2)}{S(2)}$
Ten-Year Overall Survival

Years after Diagnosis

Overall Survival

Stage I
Stage II
Stage III
Stage IV

Example

\[ S(5) \quad \text{CS}(5|2) \]
As time since diagnosis passes, changes in conditional survival reflect changes in the instantaneous hazard rate ("slope" of K-M curve).
Conditional Survival for Patients with Colon Cancer:
An Analysis of NSABP C-03 to C-06
Conditional Survival and the Choice of Conditioning Set for Patients With Colon Cancer: An Analysis of NSABP Trials C-03 Through C-07

Beth A. Zamboni, Greg Yothers, Mehee Choi, Clifton D. Fuller, James J. Dignam, Peter C. Raich, Charles R. Thomas Jr, Michael J. O’Connell, Norman Wolmark, and Samuel J. Wang

See accompanying article on page 2520

ABSTRACT

Purpose
Colon cancer overall survival (OS) is usually computed from the time of diagnosis. Survival gives the initial prognosis but does not reflect how prognosis changes with changing hazard rates over time. Conditional survival (probability of surviving y additional years given they have survived x years [CS or OS/OS]) is an alternative measure that accounts for elapsed time since diagnosis, providing more relevant prognostic information. We extend the concept of CS to condition on the set of patients alive, recurrence-free, and second primary cancer-free (disease-free survival [OS/DFS]).

Patients and Methods
Using data from National Surgical Adjuvant Breast and Bowel Project trials C-03 through C-07, 5-year OS/DFS was calculated on patients who were disease-free up to 5 years after diagnosis, stratified by age, stage, nodal status, and performance status (PS).

Results
For stage II, OS/DFS improved from 87% to 92% at 5 years. For stage III, OS/DFS improved from 69% to 88%. Patients younger than 50 years showed OS/DFS improvement from 79% to 95%; those older than 70 years showed no sustained increase in OS/DFS. Node-negative patients with ≥12 nodes resected showed little change (89% to 94%); those with more than four positive nodes showed an improvement (57% to 86%). Patients with a PS of 0 or 1 demonstrated a small improvement; those with a PS of 2 did not (64% to 88%).

Conclusion
Prognosis improves over time for almost all groups of patients with colon cancer, especially those with positive nodes. OS/DFS is a more relevant measure of prognosis for those who have already survived disease free a period of time after diagnosis.

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Specific Aim

To examine Conditional Survival of patients enrolled in the NSABP C-03 to C-06 colon cancer trials
Methods

- NSABP C-03 to C-06
- Included all Fluorouracil-equivalent arms
- Retrospectively analyzed 10 years of disease-free (DFS) & overall survival (OS) data
- Subset by stage, # positive nodes, location, age, race, sex, performance status
## Included Study Arms

<table>
<thead>
<tr>
<th>Trial</th>
<th>Arm</th>
<th>Randomized</th>
<th>Ineligible</th>
<th>Consent Withdraw</th>
<th>No Follow-up</th>
<th>Included</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-03</td>
<td>LV + 5FU</td>
<td>539</td>
<td>19</td>
<td>1</td>
<td>1</td>
<td>518</td>
</tr>
<tr>
<td>C-04</td>
<td>LV + 5FU</td>
<td>719</td>
<td>26</td>
<td>0</td>
<td>2</td>
<td>691</td>
</tr>
<tr>
<td>C-04</td>
<td>LV + 5FU + LEV</td>
<td>717</td>
<td>20</td>
<td>0</td>
<td>2</td>
<td>695</td>
</tr>
<tr>
<td>C-05</td>
<td>LV + 5FU</td>
<td>1088</td>
<td>18</td>
<td>0</td>
<td>1</td>
<td>1069</td>
</tr>
<tr>
<td>C-05</td>
<td>LV + 5FU + IFN</td>
<td>1088</td>
<td>21</td>
<td>1</td>
<td>7</td>
<td>1059</td>
</tr>
<tr>
<td>C-06</td>
<td>LV + 5FU</td>
<td>803</td>
<td>25</td>
<td>0</td>
<td>6</td>
<td>772</td>
</tr>
<tr>
<td>C-06</td>
<td>LV + UFT</td>
<td>805</td>
<td>21</td>
<td>0</td>
<td>1</td>
<td>783</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>5759</strong></td>
<td><strong>150</strong></td>
<td><strong>2</strong></td>
<td><strong>20</strong></td>
<td><strong>5587</strong></td>
</tr>
</tbody>
</table>
Kaplan-Meier Overall Survival

All Patients

Survival Distribution Function

Years since Diagnosis

0.00
0.25
0.50
0.75
1.00
0.0  2.5  5.0  7.5  10.0  12.5  15.0  17.5
5-Yr Conditional OS

Years after Diagnosis

<table>
<thead>
<tr>
<th>Years after Diagnosis</th>
<th>OS</th>
<th>After Recurrence</th>
<th>DFS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>76%</td>
<td>76%</td>
<td>76%</td>
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<tr>
<td>1</td>
<td>75%</td>
<td>7%</td>
<td>79%</td>
</tr>
<tr>
<td>2</td>
<td>78%</td>
<td>11%</td>
<td>85%</td>
</tr>
<tr>
<td>3</td>
<td>81%</td>
<td>10%</td>
<td>89%</td>
</tr>
<tr>
<td>4</td>
<td>83%</td>
<td>19%</td>
<td>90%</td>
</tr>
<tr>
<td>5</td>
<td>85%</td>
<td>11%</td>
<td>90%</td>
</tr>
</tbody>
</table>
OS Conditional on DFS

- Pts with recurrence are known to have poorer prognosis
- After a pt has survived *without disease* for $x$ years, what is their 5-yr OS?
- Variation of "pure" Conditional Survival
- Better estimate of prognosis for pts who are disease-free after $x$ years
5-year overall Conditional Survival for all patients as a function of (1) the total number of years survived since diagnosis ("Alive") and (2) the # yrs survived without recurrence or second primary cancer.

Zamboni B A et al. JCO 2010;28:2544-2548
By Stage

5-Year Conditional Overall Survival

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dukes B</td>
<td>87%</td>
<td>87%</td>
<td>90%</td>
<td>92%</td>
<td>91%</td>
<td>92%</td>
</tr>
<tr>
<td>Dukes C</td>
<td>68%</td>
<td>72%</td>
<td>81%</td>
<td>87%</td>
<td>89%</td>
<td>88%</td>
</tr>
</tbody>
</table>

Disease-Free Years after Diagnosis
5-yr overall Conditional Survival stratified by stage, as a function of the number of disease-free years survived.
## Number of Positive Nodes

<table>
<thead>
<tr>
<th>Disease-Free Years after Diagnosis</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nodes 0</strong></td>
<td>87%</td>
<td>87%</td>
<td>90%</td>
<td>92%</td>
<td>91%</td>
<td>92%</td>
</tr>
<tr>
<td><strong>Nodes 1-3</strong></td>
<td>75%</td>
<td>77%</td>
<td>84%</td>
<td>88%</td>
<td>90%</td>
<td>89%</td>
</tr>
<tr>
<td><strong>Nodes 4-9</strong></td>
<td>58%</td>
<td>63%</td>
<td>74%</td>
<td>84%</td>
<td>87%</td>
<td>88%</td>
</tr>
<tr>
<td><strong>Nodes 10+</strong></td>
<td>37%</td>
<td>47%</td>
<td>67%</td>
<td>76%</td>
<td>78%</td>
<td>81%</td>
</tr>
</tbody>
</table>
5-yr overall Conditional Survival stratified by # positive nodes, as a function of the number of disease-free yrs survived.

No. of patients

<table>
<thead>
<tr>
<th>Category</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>N- ≥ 12 resected</td>
<td>1,323</td>
<td>1,268</td>
<td>1,181</td>
<td>1,128</td>
<td>1,040</td>
<td>926</td>
<td></td>
</tr>
<tr>
<td>N- &lt; 12 resected</td>
<td>1,378</td>
<td>1,298</td>
<td>1,191</td>
<td>1,101</td>
<td>1,009</td>
<td>929</td>
<td></td>
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<tr>
<td>1–3 N+</td>
<td>2,673</td>
<td>2,440</td>
<td>2,106</td>
<td>1,901</td>
<td>1,655</td>
<td>1,430</td>
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<tr>
<td>4 or more N+</td>
<td>1,333</td>
<td>1,074</td>
<td>824</td>
<td>686</td>
<td>566</td>
<td>488</td>
<td></td>
</tr>
</tbody>
</table>
By Age

Disease-Free Years after Diagnosis

Age <50
- 0%: 78%
- 1%: 82%
- 2%: 90%
- 3%: 95%
- 4%: 95%
- 5%: 95%

Age 50-60
- 0%: 77%
- 1%: 79%
- 2%: 86%
- 3%: 91%
- 4%: 92%
- 5%: 92%

Age 60-70
- 0%: 76%
- 1%: 78%
- 2%: 83%
- 3%: 86%
- 4%: 87%
- 5%: 88%

Age >70
- 0%: 71%
- 1%: 75%
- 2%: 80%
- 3%: 82%
- 4%: 76%
- 5%: 73%

5-Year Conditional Overall Survival

<table>
<thead>
<tr>
<th>Disease-Free Years after Diagnosis</th>
<th>Age &lt;50</th>
<th>Age 50-60</th>
<th>Age 60-70</th>
<th>Age &gt;70</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>78%</td>
<td>77%</td>
<td>76%</td>
<td>71%</td>
</tr>
<tr>
<td>1</td>
<td>82%</td>
<td>79%</td>
<td>78%</td>
<td>75%</td>
</tr>
<tr>
<td>2</td>
<td>90%</td>
<td>86%</td>
<td>83%</td>
<td>80%</td>
</tr>
<tr>
<td>3</td>
<td>95%</td>
<td>91%</td>
<td>86%</td>
<td>82%</td>
</tr>
<tr>
<td>4</td>
<td>95%</td>
<td>92%</td>
<td>87%</td>
<td>76%</td>
</tr>
<tr>
<td>5</td>
<td>95%</td>
<td>92%</td>
<td>88%</td>
<td>73%</td>
</tr>
</tbody>
</table>
5-yr overall Conditional Survival stratified by age, as a function of the number of disease-free years survived.

Zamboni B A et al. JCO 2010;28:2544-2548
By Sex

5-Year Conditional Overall Survival

<table>
<thead>
<tr>
<th>Disease-Free Years after Diagnosis</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>76%</td>
<td>77%</td>
</tr>
<tr>
<td>1</td>
<td>77%</td>
<td>81%</td>
</tr>
<tr>
<td>2</td>
<td>83%</td>
<td>88%</td>
</tr>
<tr>
<td>3</td>
<td>87%</td>
<td>92%</td>
</tr>
<tr>
<td>4</td>
<td>88%</td>
<td>92%</td>
</tr>
<tr>
<td>5</td>
<td>88%</td>
<td>93%</td>
</tr>
</tbody>
</table>
# of Resected Nodes

<table>
<thead>
<tr>
<th>Disease-Free Years after Diagnosis</th>
<th>Resected 0-7</th>
<th>Resected 8-11</th>
<th>Resected 12-17</th>
<th>Resected &gt;18</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>76%</td>
<td>74%</td>
<td>78%</td>
<td>79%</td>
</tr>
<tr>
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<td>92%</td>
</tr>
<tr>
<td>5</td>
<td>89%</td>
<td>88%</td>
<td>90%</td>
<td>93%</td>
</tr>
</tbody>
</table>

5-Year Conditional Overall Survival
Tumor Location

<table>
<thead>
<tr>
<th>Disease-Free Years after Diagnosis</th>
<th>Right Colon</th>
<th>Left Colon</th>
<th>Recto-Sigmoid</th>
<th>Multiple</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>75%</td>
<td>77%</td>
<td>79%</td>
<td>68%</td>
</tr>
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<td>80%</td>
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<td>91%</td>
</tr>
<tr>
<td>5</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
</tr>
</tbody>
</table>

5-Year Conditional Overall Survival

- Right Colon: 75%, 79%, 86%, 91%, 91%, 90%
- Left Colon: 77%, 79%, 85%, 89%, 90%, 90%
- Recto-Sigmoid: 79%, 80%, 84%, 88%, 89%, 90%
- Multiple: 68%, 71%, 80%, 83%, 91%, 90%
## Performance Status

<table>
<thead>
<tr>
<th>Disease-Free Years after Diagnosis</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-Year Conditional Overall Survival</td>
<td>PS 0</td>
<td>77%</td>
<td>80%</td>
<td>86%</td>
<td>90%</td>
<td>90%</td>
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<tr>
<td></td>
<td>PS 1</td>
<td>72%</td>
<td>74%</td>
<td>83%</td>
<td>87%</td>
<td>88%</td>
</tr>
<tr>
<td></td>
<td>PS 2</td>
<td>62%</td>
<td>65%</td>
<td>47%</td>
<td>52%</td>
<td>63%</td>
</tr>
</tbody>
</table>

Disease-Free Years after Diagnosis
5-yr overall Conditional Survival stratified by ECOG PS, as a function of the number of disease-free yrs survived.
Conditional Survival and the Choice of Conditioning Set for Patients With Colon Cancer: An Analysis of NSABP Trials C-03 Through C-07

Beth A. Zamboni, Greg Yotbers, Mehee Choi, Clifton D. Fuller, James J. Dignam, Peter C. Raich, Charles R. Thomas Jr, Michael J. O’Connell, Norman Wolmark, and Samuel J. Wang

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Conclusion
Prognosis improves over time for almost all groups of patients with colon cancer, especially those with positive nodes. OS|DFS is a more relevant measure of prognosis for those who have already survived disease free a period of time after diagnosis.

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**Limitations of CS Calculation**

- As more time elapses from Dx, # pts in each group decreases as pts recur, develop 2\textsuperscript{nd} cancer, or expire. Hence some of the trends may, in part, be due to smaller # of pts in the modal over time.
  - Wider C.I. may be noted over time

- Exploratory analyses over eras may not reflect current diagnostic & Rx approaches
Summary

- Conditional Survival for colon cancer patients changes over time
- Largest CS increases seen for advanced stage, more positive nodes, younger age, females
- CS decreases for older age, poor performance status
- Number of positive nodes is prognostic, but number resected is not
Summary

Known prognostic factors that are important at baseline (Stage, # positive nodes) appear to lose significance as disease-free period increases (CS curves converge)
Conditional survival in gastric cancer: a SEER database analysis

Samuel I. Wang,1,2 Rachel Emery,3 Clifton D. Fuller,4 Jong-Sung Kim,5 Dean F. Silver,6 and C. Thomas F. Jr.7

1 Department of Radiation Medicine, OHSU, Portland, OR, USA
2 Department of Nuclear Medicine and Clinical Epidemiology, OHSU, Portland, OR, USA
3 School of Medicine, OHSU, Portland, OR, USA
4 Department of Radiation Oncology, OHSU, Portland, OR, USA
5 Department of Radiation Oncology, OHSU, Portland, OR, USA
6 Department of Biostatistics and Epidemiology, OHSU, Portland, OR, USA
7 Department of Radiation Oncology, OHSU, Portland, OR, USA

Abstract

Background. Gastric cancer survival is typically reported in terms of survival from the time of diagnosis. Conditional survival is a more relevant measure of prognosis for patients who have already survived 1 or more years since diagnosis.

Methods. Using the Surveillance, Epidemiology, and End Results (SEER 17) database from the National Cancer Institute, we analyzed data from 20018 gastric cancer patients diagnosed between 1988 and 1998. Using the life-table method, we computed 5-year relative conditional survival, grouped by summary stage, age, sex, and ethnicity, for patients who had already survived up to 5 years from diagnosis.

Results. Relative conditional survival improves over time for all groups of gastric cancer patients who survive a period of time after diagnosis. The largest gains in conditional survival were seen in patients with advanced stage disease. In general, females showed better survival than males. When grouped by ethnicity, Asians continued to have improved survival compared to other ethnic categories, even at 5 years out from diagnosis.

Conclusion. For gastric cancer patients who survive a period of time after diagnosis, the largest increases in conditional survival are seen for patients with advanced stage disease and for those less than 65 years old. Conditional survival can provide more relevant prognostic information than survival from the time of diagnosis for gastric cancer patients who survive a period of time after diagnosis.

Key words Survival analysis • Epidemiological methods • Stomach neoplasms
Overall Survival

0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

0 1 2 3 4 5 6 7 8 9 10
Years after Diagnosis

Overall Survival (Relative)

Localized
Regional-
Direct Ext
Regional-
Nodes
Regional-
Both
Distant
Mets
Figure 2

All Patients By SEER Summary Stage

<table>
<thead>
<tr>
<th>Years after Diagnosis</th>
<th>Localized</th>
<th>Regional-Direct Extension</th>
<th>Regional-Lymph Nodes</th>
<th>Regional-Both</th>
<th>Distant Mets</th>
</tr>
</thead>
<tbody>
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<td>71%</td>
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<td>85%</td>
<td>79%</td>
<td>79%</td>
<td>67%</td>
<td>64%</td>
</tr>
</tbody>
</table>
Figure 3

All Patients By Race

5-Year Relative Conditional Survival

<table>
<thead>
<tr>
<th>Years after Diagnosis</th>
<th>White</th>
<th>Black</th>
<th>Am Indian/Alaskan</th>
<th>Asian/Pacific Islander</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>20%</td>
<td>22%</td>
<td>16%</td>
<td>31%</td>
</tr>
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Conditional survival in ovarian cancer: Results from the SEER dataset 1988–2001

Mehee Choi, Clifton D. Fuller, Charles R. Thomas Jr., Samuel J. Wang

* Department of Radiation Oncology, The University of Texas Health Science Center at San Antonio, San Antonio, TX, USA
* Graduate Division of Radiological Sciences, Department of Radiology, The University of Texas Health Science Center at San Antonio, San Antonio, TX, USA
* Department of Radiation Oncology, Oregon Health & Science University, Portland, OR, USA

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Fig. 2. Five-year relative conditional survival for ovarian cancer patients, by AJCC stage, as a function of elapsed time since diagnosis. Each bar represents the probability of surviving an additional 5 years, after having already survived the given number of years since diagnosis. Error bars indicate the standard error for each measurement.
Ovarian Cancer Conditional Survival

Fig. 3. Five-year relative conditional survival for patients with ovarian cancer, by histological type. Each point represents the probability of surviving an additional 5 years, after having already survived for 0 to 5 years since diagnosis.
Conditional Survival in Head and Neck Squamous Cell Carcinoma

Results From the SEER Dataset 1973–1998

Clifton D. Fuller, MD
Samuel J. Wang, MD
Charles R. Thomas, Jr., MD
Henry T. Hoffman, MD
Randal S. Weber, MD
David I. Rosenthal, MD

1 Department of Radiation Oncology and Graduate Division of Radiological Sciences, University of Texas Health Science Center at San Antonio, San Antonio, Texas.
2 Department of Radiation Medicine, Oregon Health and Science University Cancer Institute, Portland, Oregon.
3 Department of Otolaryngology—Head and Neck Surgery, University of Iowa, Iowa City, Iowa.
4 Department of Head and Neck Surgery, University of Texas M. D. Anderson Cancer Center, Houston, Texas.
5 Department of Radiation Oncology, University of Texas M. D. Anderson Cancer Center, Houston, Texas.

BACKGROUND. Survival statistics for patients with head and neck squamous cell carcinomas (HNSCC) are commonly calculated from the time of diagnosis. The less commonly employed conditional survival (CS) analyzes survival for patients who have survived a period of time after diagnosis. Useful prognostic information for cancer survivors is provided by CS analysis. Estimated baseline CS parameters for HNSCC were sought using large-scale cancer registry data.

METHODS. HNSCC cases identified from the Surveillance, Epidemiology, and End Results (SEER) Program were accessed to identify those diagnosed between 1973 and 1998. Five-year observed, relative, and cumulative CS calculations were performed, with secondary stratification by site, extent of disease, and age.

RESULTS. The overall 5-year observed survival for all sites increased from 47.8% for 76,181 included patients from the time of diagnosis to 64.4% for those 43,985 patients alive at 3 years, and thereafter plateaus. The greatest increase in CS was for oropharyngeal cancers, which more than doubled over the first decade of surveillance (26.5%–60%). Distant disease showed a 10-year increase in CS (17.4%–60.4%), whereas localized disease CS was essentially static, ranging from 66.1% to 68.5% for those over 65 at diagnosis it ranged from 39.9–52.9%, whereas patients <65 years at diagnosis ranged from 53.8–73.5%.

CONCLUSIONS. Benchmark CS estimates for domestic HNSCC cohorts were developed from the SEER database. CS is a useful tool to assist clinicians in predicting the probability of demise from HNSCC for patients surviving 1 or more year after diagnosis. Cancer 2007;109:000–000. © 2007 American Cancer Society.
Conditional Survival in Rectal Cancer: A SEER Database Analysis

Samuel J. Wang, Clifton D. Fuller, Rachel Emery, Charles R. Thomas, Jr.

Abstract

Purpose: To provide an analysis of conditional survival (CS) in rectal cancer patients. Cancer survival is typically reported in terms of survival from time of diagnosis. CS can provide improved prognostic information for patients surviving a given period after diagnosis.

Methods: Data from 36,321 rectal cancer patients diagnosed between 1988 and 1998 were analyzed using the Surveillance, Epidemiology, and End Results (SEER 17) database. Observed 5-year CS rates according to disease stage, age, sex, and race were calculated using the life-table method.

Results: As survival from diagnosis increased from 0 to 5 years, the 5-year observed CS changed from 73% to 74% for stage I disease, 56% to 66% for stage II, 47% to 65% for stage III, and 6% to 48% for stage IV. Patients aged 65 years and over at diagnosis had lower CS than those under 65 years, both at diagnosis (45% vs. 61%) and at 5 years from diagnosis (59% vs. 81%). Men had slightly lower 5-year survival than women, both at diagnosis (50% vs. 53%) and after 5 years (68% vs. 71%). Black patients had slightly lower survival than white patients for nearly all time points and stages.

Conclusion: For rectal cancer patients who survive a given period of time after diagnosis, the largest increases in CS are in patients with advanced stage disease and for those under 65 years of age. CS can provide more accurate prognostic information for rectal cancer patients who survive a given period after diagnosis.

Gastrointest Cancer Res 1:84-99. ©2007 by International Society of Gastrointestinal Oncology

Table 1. Patient characteristics, by stage. (N=36,321)

<table>
<thead>
<tr>
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<th>Stage I</th>
<th>Stage II</th>
<th>Stage III</th>
<th>Stage IV</th>
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<tbody>
<tr>
<td>Age &lt; 65</td>
<td>4,843 (38)</td>
<td>3,153 (35)</td>
<td>3,778 (44)</td>
<td>2,527 (41)</td>
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<tr>
<td>Age ≥ 65</td>
<td>7,765 (62)</td>
<td>5,856 (65)</td>
<td>4,783 (56)</td>
<td>3,616 (59)</td>
</tr>
<tr>
<td>Men</td>
<td>6,866 (54)</td>
<td>5,177 (57)</td>
<td>4,871 (57)</td>
<td>3,625 (59)</td>
</tr>
<tr>
<td>Women</td>
<td>5,742 (46)</td>
<td>3,832 (43)</td>
<td>3,690 (43)</td>
<td>2,518 (41)</td>
</tr>
<tr>
<td>White</td>
<td>10,475 (83)</td>
<td>7,613 (85)</td>
<td>7,026 (82)</td>
<td>5,084 (83)</td>
</tr>
<tr>
<td>Black</td>
<td>900 (7)</td>
<td>638 (7)</td>
<td>611 (7)</td>
<td>547 (9)</td>
</tr>
<tr>
<td>Other</td>
<td>1,233 (10)</td>
<td>758 (8)</td>
<td>924 (11)</td>
<td>512 (8)</td>
</tr>
<tr>
<td>Totals</td>
<td>12,608 (100)</td>
<td>9,009 (100)</td>
<td>8,561 (100)</td>
<td>6,143 (100)</td>
</tr>
</tbody>
</table>

Figure 1. Ten-year Kaplan-Meier overall survival curves by disease stage. These data were used to calculate the 5-year observed conditional survival probabilities.
Figure 2. Five-year observed conditional survival (CS) by disease stage at diagnosis in all patients. Error bars show standard error.
Figure 3. Five-year observed conditional survival (CS) by age < 65 and age ≥ 65 years according to disease stage. Error bars show standard error.
Figure 5. Five-year observed conditional survival (CS) by race according to disease stage. Error bars show standard error.
Nomogram for Conditional Survival

http://skynet.ohsu.edu/nomograms/

Rectal Cancer

After your patient has already survived X months, what is their updated prognosis?

Enter the patient details below and the number of months since diagnosis, and this tool will calculate the patient’s conditional survival, i.e., the likelihood of surviving additional years given that they have already survived a period of time.

Age: 55
Sex: Male
Race: White
Stage: Stage III

Probability of surviving additional years given 24 months already survived:

- 0 yr: 100%
- 1 yr: 92%
- 2 yrs: 84%
- 3 yrs: 78%
- 4 yrs: 72%
- 5 yrs: 68%
Nomogram for Conditional Survival

Practical Application of a Calculator for Conditional Survival in Colon Cancer

George J. Chang, Chung-Yuan Hu, Cathy Eng, John M. Skibber, and Miguel A. Rodriguez-Bigas

ABSTRACT

Purpose
Conditional survival (CS) estimates provide important prognostic information for clinicians and patients who have survived a period after diagnosis. In this study we performed a contemporary evaluation of conditional survival among colon cancer patients and created a browser-based tool for real-time determination of conditional survival expectancies.

Patients and Methods
Patients with colon adenocarcinoma diagnosed between 1988 and 2000 were identified from the Surveillance Epidemiology End Results (SEER) registry. Conditional survival estimates were calculated by using the multiplicative law of probability after adjustment for age; sex; ethnicity; grade; and American Joint Commission on Cancer, sixth edition stage. A browser-based calculator was constructed.

Results
A total of 83,419 patients were analyzed. As the time alive after initial treatment increased from 0 to 5 years, significant improvements in CS were observed for patients in all stages except stage I, which was associated with good CS even at diagnosis and which reflected the high likelihood of cure. Notably, adjusted 5-year CS rates improved from 42% to 80% for stage IIIC cancers and from 5% to 48% for stage IV cancers during the first 5 years. Differences in cancer-related CS at diagnosis were identified on the basis of age, ethnicity, and grade, but these differences decreased over time. A browser-based CS calculator was implemented by using the multivariate survival model (concordance index, 0.81).

Conclusion
For patients with colon cancer who survive over time, 5-year, cancer-specific CS improved dramatically, and the greatest improvements were among patients with poorer initial prognoses. These prognostic data are critical to inform patients for non-treatment-related life decisions and to inform treating physicians for planning of follow-up and surveillance strategies.

J Clin Oncol 27. © 2009 by American Society of Clinical Oncology
Additional Demographic & Tumor-related Variables for Conditional Survival Nomogram Calculations

http://skynet.ohsu.edu/nomograms/
**Limitations of CS Calculation**

- As more time elapses from Dx, # pts in each group decreases as pts recur, develop 2\(^{nd}\) cancer, or expire. Hence some of the trends may, in part, be due to smaller # of pts in the modal over time.
  - Wider C.I. may be noted over time

- Exploratory analyses over eras may not reflect current diagnostic & Rx approaches
Recent Conditional Survival Analyses

**Gastric**
Dikken, van de Velde et al, 2011 GI Cancers Symposium

**HNSCC**
Van der Schroeff et al, Erasmus Med Ctr, Rotterdam, *Head & Neck* 32:1613, 2010

**NSCLC Stage I s/p Lobectomy**

**Liver mets**
Nathan et al, JACS 210:755, 2010

**Melanoma**
Rueth et al, Uminn, Ann Surg Oncol 17:1668, 2010

**European database analysis**
Janssen-Heijnen et al, JCO 28:2520, 2010

**Review**
Merrill et al, The Oncologist 15:873, 2010

**NHL Diffuse-large cell**
Moller et al, Odense Univ, Dennmark Cancer 106:2165, 2006
Conditional Survival Applications

- At annual follow-ups, patients can be given more accurate survival estimates.
- Clinicians can use to plan more appropriate follow-up surveillance.
- Researchers can use to determine follow-up time in clinical trial design.
Conclusions

- Conditional Survival quantifies changing risk profile over time
- CS is a useful adjunct to traditional survival statistics
- CS has practical relevance to patients, clinicians, & researchers
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Randal Weber & David Rosenthal