

Does Ovarian Cancer Treatment and Survival Differ by the Specialty Providing Chemotherapy?

Jeffrey H. Silber, Paul R. Rosenbaum, Daniel Polsky, Richard N. Ross, Orit Even-Shoshan, J. Sanford Schwartz, Katrina A. Armstrong, and Thomas C. Randall

ABSTRACT

Purpose

Chemotherapy for ovarian cancer is usually administered by medical oncologists (MOs) or gynecologic oncologists (GOs). GOs perform a broad spectrum of surgical and medical activities while managing a limited number of diseases; MOs specialize in the administration of chemotherapy but manage a broad array of diseases. We asked whether survival, treatment, and toxicity differed according to the type of specialist providing the chemotherapy after surgery.

Patients and Methods

Using Surveillance, Epidemiology, and End Results (SEER) -Medicare data for patients ≥ 65 years old from 1991 through 2001 from eight SEER sites, we identified 344 patients with ovarian cancer who were treated with chemotherapy by a GO after surgery. Using optimal matching and propensity scores based on 36 characteristics, we matched these patients to 344 similar patients who were operated on and staged by the same type of surgeon but who received chemotherapy from an MO.

Results

MOs administered chemotherapy over more weeks than did the GOs (16.5 v 12.1 weeks, respectively; $P < .0023$), and MO patients had substantially more weeks that included chemotherapy-associated adverse events than GO patients (16.2 v 8.9 weeks, respectively; $P < .0001$). However, there was no difference in 5-year survival rate between the GO and MO groups (35% v 34%, respectively; $P = .45$).

Conclusion

GO- and MO-treated patients who were closely matched on prognostic characteristics experienced very different rates of chemotherapy-associated adverse events and very different chemotherapy treatment styles by specialty type; however, their survival was virtually identical.

J Clin Oncol 25:1169-1175. © 2007 by American Society of Clinical Oncology

INTRODUCTION

Several studies suggest that survival from ovarian cancer is improved if surgery is performed by a gynecologic oncologist (GO).¹⁻⁴ It is not known whether the specialty of the physician administering chemotherapy for ovarian cancer also affects toxicity and survival.

In ovarian cancer, because of the inherent differences in the training and clinical activities of GOs and medical oncologists (MOs), there is an a priori reason to believe that MOs and GOs administer chemotherapy to similar ovarian cancer patients in dissimilar ways. MOs receive 2 to 3 years of residency training in internal medicine before they enter a 3-year fellowship that teaches them how to administer chemotherapy and manage the adverse effects of cancer treatment.⁵ Much of their practice involves

administering chemotherapy and treating the subsequent, inevitable, adverse effects of such therapy. Although MOs often specialize in certain types of cancers, they generally care for a wide variety of cancer types.⁵ GOs, however, must complete a 4-year residency training in obstetrics and gynecology, followed by a 3- to 4-year fellowship in gynecologic oncology, where they learn specific operative techniques for the surgical management of gynecologic cancers.⁶ The majority of a GO's practice is devoted to the management of cancers of the ovary, uterus, and cervix. In this capacity, GOs divide their time between performing surgery and administering chemotherapy. Thus, the GO has a more limited exposure to the administration of chemotherapy, giving only those chemotherapy regimens that are used for gynecologic cancers. One might suppose that because GOs spend much of their time operating, they might be less equipped to manage the

From the Center for Outcomes Research, The Children's Hospital of Philadelphia; Department of Pediatrics, Division of Pediatric Oncology and Department of Anesthesiology and Critical Care, Division of General Internal Medicine, and Department of Obstetrics and Gynecology, Division of Gynecologic Oncology, University of Pennsylvania School of Medicine; The Leonard Davis Institute of Health Economics, the University of Pennsylvania; and the Department of Statistics, The Wharton School, Philadelphia, PA.

Submitted July 14, 2006; accepted January 4, 2007.

Supported by Grant No. R01-CA095664 (J.H.S.) from the National Cancer Institute and Grant No. SES-0345113 (P.R.R.) from the National Science Foundation.

Presented at the 42nd Annual Meeting of the American Society of Clinical Oncology, June 2-6, 2006, Atlanta, GA.

Authors' disclosures of potential conflicts of interest and author contributions are found at the end of this article.

Address reprint requests to Jeffrey H. Silber, MD, PhD, The Center for Outcomes Research, The Children's Hospital of Philadelphia, 3535 Market St, Ste 1029, Philadelphia, PA 19104; e-mail: silber@email.chop.edu.

© 2007 by American Society of Clinical Oncology

0732-183X/07/2510-1169/\$20.00

DOI: 10.1200/JCO.2006.08.2933

complications of chemotherapy. However, GOs are more focused on the management of gynecologic cancers than are most MOs. We hypothesized that survival after surgery would be better in patients receiving chemotherapy from an MO compared with patients receiving chemotherapy from a GO, after adjustment for the surgeon type and relevant patient characteristics.

The question is not an easy one to study. We must adequately account for differences in the surgical care of the patient (before chemotherapy) and differences in the selection of patients undergoing chemotherapy. Because it is well known that ovarian cancer surgical techniques may vary between a GO, a general surgeon, and even a gynecologist,³ it becomes clear that, before comparing survival after the start of chemotherapy, we will want to be sure that patient characteristics and their treatments before chemotherapy are nearly the same for both the GO and MO groups. However, even being sure that stage is comparable between MO and GO patients presents a challenge. Because GO surgeons may perform more extensive primary surgery, they may be more likely to assign a higher stage to their patients compared with patients operated on by general surgeons,^{1,7-9} who often perform less extensive initial surgery. Because GOs are more likely to administer chemotherapy for a patient on whom they performed surgery, any analysis comparing chemotherapy effectiveness must compare patients with the same surgeon type as well as the same stage. We addressed this problem by matching as closely as possible each patient of a GO to a patient of an MO who received surgery from the same category of surgeon (GO, general surgeon, or gynecologist) and who had the same stage. Even if staging by GOs is different from staging by general surgeons, this does not bias our comparison of chemotherapeutic treatment by GOs and MOs because both patients in each matched pair received the same stage from the same category of surgeon.

PATIENTS AND METHODS

Patient Population

We obtained linked Surveillance, Epidemiology, and End Results (SEER)-Medicare claims for the years 1991 through 2001. Medicare files linked to SEER patients with a 94% match rate.¹⁰ We then studied Medicare patients who were older than 65 years and had an ovarian cancer diagnosis between 1991 and 2001 in the SEER registries ($n = 11,680$). We excluded patients when the diagnosis of ovarian cancer was only made on death certificate, leaving 11,430 patients. Women enrolled in a Medicare-HMO at baseline were excluded because complete treatment information was unavailable, leaving 9,180 patients. Of these women, we excluded those without surgery, leaving 6,346 patients. We also excluded 12 patients with stage 0 disease, leaving 6,334 patients. We excluded the SEER sites of Utah and San Jose (because of too few GO physicians) and Hawaii (because MO patients were too few compared with GO patients), leaving 5,588 patients. Of these, there were 3,523 patients with evidence of chemotherapy, of whom 2,903 had chemotherapy administered between 30 and 90 days from diagnosis (a requirement for identifying a dominant provider of chemotherapy as defined below). Of these 2,903 patients, there were 2,369 with MO or GO claims. Of these, we could determine an unambiguous dominant provider in 2,355 patients. Of the 2,355 patients, there were 344 who were provided chemotherapy by a GO, and the remaining 2,011 patients were provided chemotherapy by an MO. The metropolitan regions included in this study were Atlanta, Detroit, Los Angeles, San Francisco/Oakland, and Seattle/Puget Sound. The states were Connecticut, Iowa, and New Mexico.

We modeled comorbidity and severity using a pool of potential variables.¹¹⁻¹³ We coded 36 patient characteristics for use in developing a propensity score using International Classification of Diseases, ninth revision

codes recorded 90 days before each patient's ovarian cancer diagnosis on the Medicare portion of the SEER-Medicare file. Stage and grade of each patient's tumor were defined through the SEER data set, as was date of diagnosis with resolution to the month.

Definitions

Chemotherapy. A patient was defined as having had chemotherapy if codes were present in the Medicare billing data that could identify this activity (Table 1).

Defining the specialty of the surgeon. We defined the following three groups of surgical specialists from billing data in Medicare Part B: (1) surgery performed by a GO; (2) surgery performed by a gynecologist; and (3) surgery performed by a general surgeon or other surgical specialist. When multiple surgical specialists were involved with a single operative procedure, we classified the patient in group 1 as having been treated by the GO if there was a bill from a GO for surgical care. Otherwise, if there was a bill for surgical care from a gynecology specialist, the patient was classified in group 2.

Defining the dominant chemotherapy provider. We aimed to study a group of patients who unambiguously received chemotherapy by either an MO or GO specialist. We first identified all provider bills associated with a patient's care after diagnosis to a follow-up time of 3 months. We excluded all patients who did not have either a GO or MO administer chemotherapy in the second and third month after diagnosis. We used this time window because we wished to classify providers during a time when the initial and most important chemotherapy regimen was being established. We next determined the number of chemotherapy administrations by specialists for the first 3 chemotherapy administration days during the second and third months after diagnosis. We defined the dominant provider as that provider who was involved with administering all of the chemotherapy treatment that was delivered by either a GO or MO (note, > one provider could be associated with each treatment) and had the majority of chemotherapy bills among the GO and MO bills. Patients for whom the number of GO and MO administrations were tied (eg, if all chemotherapy was administered by both the GO and MO; $n = 2$) or for

Table 1. Coding Definitions of Chemotherapy and Chemotherapy Associated Adverse Events (from inpatient and outpatient bills)

Coding Definitions
Chemotherapy administration
ICD-9 procedure codes
99.25: Injection or infusion of cancer chemotherapeutic substance
HCPCS codes
964.xx: intravenous chemotherapy administration
965.xx: intravenous chemotherapy administration
CPT codes
36640: insertion catheter, artery
36260 insertion of infusion pump
Codes for ovarian cancer drugs
J8999-J9999; Q0163-Q0185
Chemotherapy-associated adverse events: ICD-9 diagnosis codes
Anemia
280.x; 281.x; 283.x; 284.8; 284.9; 285.xx
Neutropenia
288.0
Thrombocytopenia
287.5
Mucositis
528
Dehydration, dehydration, nausea, diarrhea
276.5; 787.01; 787.02; 787.91
Neuropathy (drug associated)
357.6
Abbreviations: ICD, International Classification of Diseases; HCPCS, Healthcare Common Procedure Coding System; CPT, Current Procedural Terminology.

whom there was no dominant provider (n = 12) were excluded from the analysis to avoid ambiguity in assignment. Once assigned by our algorithm, using information up to the end of the third month from diagnosis, we retained patients in these assignments, whether later treatment was continually provided by the same specialist or not.

Statistical Methods: The Matching Algorithm

We first identified all patients who had GOs as their primary chemotherapy provider, and we then identified all patients who had MOs as their primary chemotherapy provider. This resulted in 344 patients treated with chemotherapy by a GO, and 2,011 patients treated by an MO. Using an optimal matching algorithm,¹⁴⁻²⁰ we matched the 344 GO-treated patients to 344 MO-treated patients using 36 baseline variables or covariates, including those listed in Tables 2 and 3. The algorithm sought the closest possible matches on time interval, surgeon type, clinical stage, and black race; exact balance on SEER site within time interval (1991 to 1992, 1993 to 1996, or 1997 to 1999); and optimally close matches on key variables including tumor grade and an estimated propensity score¹⁶ for treatment by a GO. We controlled SEER site by optimal balanced matching^{14,20} within each time interval, so the same number of GO and MO patients came from each SEER site in each time interval. As seen in Tables 2 and 3, before matching, there were dramatic differences between GO and MO patients regarding surgeon type, SEER site, and year of diagnosis and noticeable differences in clinical stage, tumor grade, propensity score, and hypertension, but the matched groups are comparable.

Comparison of survival within matched pairs was based on the paired Prentice-Wilcoxon test,²¹ the standard method for censored pairs. Survival plots depict the Kaplan-Meier estimates.²² CIs and tests about the survival

Table 2. Distributions Before and After Matching*

Covariate	% of Patients		
	Patients of GOs (n = 344)	Matched Patients of MOs (n = 344)	All Patients of MOs (n = 2,011)
SEER site			
Connecticut	18	18	15
Detroit	26	26	12
Iowa	17	17	17
New Mexico	7	7	3
Seattle	9	9	16
Atlanta	9	9	7
Los Angeles	12	12	19
San Francisco	1	1	9
Year of diagnosis			
1991	4	4	9
1992	7	7	14
1993	10	9	14
1994	11	11	12
1995	11	13	12
1996	10	9	12
1997	16	15	10
1998	13	15	9
1999	18	17	9

NOTE. There were no statistically significant differences between the GO and matched MO groups.

Abbreviations: GO, gynecologic oncologist; MO, medical oncologist; SEER, Surveillance, Epidemiology, and End Results.

*Matching algorithm used a propensity score with the following variables (or categories of variables): SEER sites; year of diagnosis; stage; grade; race; age; and the comorbidities of anemia, angina, arrhythmia, asthma, chronic obstructive pulmonary disease, coagulation disorder, diabetes, electrolyte abnormality, hepatic dysfunction, hypertension, hyperthyroidism, peripheral vascular disease, and rheumatoid arthritis. Variables used in the optimal matching procedure were stage, grade, race, year of diagnosis, propensity score, congestive heart failure, diabetes, weight loss, and specialty of surgeon.

Table 3. Balance Before and After Matching for Selected Covariates

Covariate	% of Patients		
	Patients of GOs (n = 344)	Matched Patients of MOs (n = 344)	All Patients of MOs (n = 2,011)
Surgeon type			
GO	76	75	33
Gynecologist	15	16	39
General surgeon	8	8	28
Stage			
I	9	9	9
II	11	9	9
III	51	53	47
IV	26	26	31
Missing	3	2	3
Tumor grade			
1	5	4	4
2	16	13	17
3	52	55	47
4	9	8	11
Missing	18	20	21
Patient characteristic			
White	91	94	94
Black	8	5	3
COPD	15	12	13
Hypertension	48	46	42
Diabetes	11	8	8
Congestive heart failure	2	2	4
Mean age, years	72.2	72.2	72.8
Mean propensity score to get a GO	0.23	0.21	0.14

NOTE. There were no statistically significant differences between the GO and matched MO groups.

Abbreviations: GO, gynecologic oncologist; MO, medical oncologist; COPD, chronic obstructive pulmonary disease.

curves at individual years 1, 2, and 5 make use of the unpaired Kaplan-Meier curves. Weeks of chemotherapy and adverse events, in various time intervals, were compared using the Wilcoxon rank sum test, ignoring the pairing, which is known to be slightly conservative.²¹ We also performed, but do not report here, analogous tests with broadly similar results, which retained the pairing using Wilcoxon's signed rank test; however, these have the awkward feature that they discard an entire pair when either patient in the pair is censored or dies. With binary responses, we report the χ^2 test for a 2×2 table.

RESULTS

Results of Matching

Table 2 displays the balance of patients over time and across SEER site. Of interest, it seems that GOs are not equally distributed geographically. However, the matching algorithm has balanced these factors quite closely. Although not displayed in Table 2, the SEER sites are not only balanced overall as seen in the table, but they are also balanced within each time interval.

Table 3 describes how well the groups were balanced by provider and patient characteristics. Although very different before matching, the type of surgeon was almost exactly matched between GO and MO groups. There was one GO patient who received surgery from a GO who was matched to an MO patient who was operated on by a

gynecology surgeon. Otherwise, all matched pairs had identical types of surgical providers. This matching was essential because staging has been known to vary by surgical specialty, with GO and gynecology surgeons staging similarly and general surgeons having been reported to perform less extensive node sampling.³ Because we matched on the specialty of the surgeon, we knew that the stages we also matched on were determined by a surgeon with the same specialty. Although stage III may have a different meaning if staged by a GO rather than a general surgeon, within all but one matched pair, the stage for the GO patient and the matched MO patient came from the same type of surgeon, so differences in staging style across surgical specialty did not bias the comparison of GO versus MO chemotherapy treatment. There were 36 variables used in the propensity score and 30 variables used in the matching algorithms; some of these are listed in Table 3. For each variable, we provide the rate in the GO group ($n = 344$), the rate in the matched MO group ($n = 344$), and the rate in the complete MO group ($n = 2,011$), reflecting the initial pool of MO patients from which the MO patients were drawn. Before matching, the patients of GOs, compared with patients of MOs, were more likely to have stage II or III disease rather than stage IV, were more likely to have grade 3 tumors, were substantially more likely to be black, and had more hypertension and diabetes at diagnosis but less congestive heart failure. In contrast, the matched samples look quite similar. In particular, the substantial difference in the propensity score (reflecting the propensity to be a GO-treated patient as a function of all 36 variables) before matching is greatly reduced.

We also asked whether time delay from surgery to initiation of first postoperative chemotherapy was different between the GO and MO groups. The mean time from surgery to postoperative chemotherapy was 30.7 days for the MO group and 25.8 days for the GO group; this difference of 4.9 days was statistically significant ($P < .0001$). This may reflect the fact that a GO who provides chemotherapy may also have been the patient's surgeon.

Comparing Survival Across Chemotherapy Providers

Figure 1 displays the Kaplan-Meier survival plot for the GO and MO groups. As can be seen, survival is almost identical across groups.

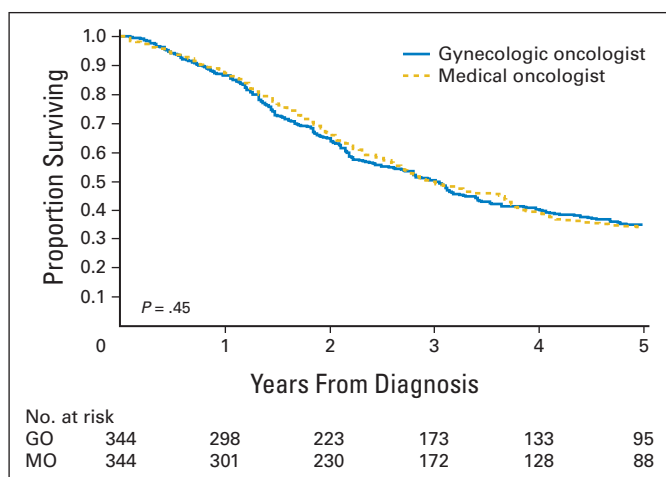


Fig 1. Kaplan-Meier survival plot comparing 344 patients administered postoperative chemotherapy for ovarian cancer by a gynecologic oncologist (GO) and a matched set of 344 patients administered postoperative chemotherapy for ovarian cancer by a medical oncologist (MO).

Table 4 compares survival statistics between groups. The median overall survival time was 3.04 years for the GO group and 2.98 years for the MO group ($P = .45$). The 2-year survival rate was 65% for the GO group and 67% for the MO group ($P = .27$). The 5-year survival rate was 35% for the GO group and 34% for the MO group ($P = .38$).

Comparing Treatment Style

We first studied the number of weeks over which chemotherapy was administered (Table 4). Over the first 5 years, MO patients received more weeks with chemotherapy than GO patients (patient mean, 16.5 v 12.1 weeks, respectively; $P < .0023$). This increased treatment was true for the first year and for years 2 to 5. We further asked how many weeks each group experienced some chemotherapy-associated adverse events. These events are defined in Table 1. Again, GO patients had fewer weeks that included chemotherapy-associated adverse events than MO patients (patient mean, 8.9 v 16.2 weeks, respectively; $P < .0001$). This was also true for year 1 and for years 2 to 5 analyzed separately.

MO patients received chemotherapy in years 2 to 5 at approximately the same rate as GO patients (56.4% v 52.9%, respectively; $P = .36$). Of patients who received chemotherapy in years 2 to 5, MO patients had more weeks of chemotherapy than GO patients (mean weeks, 15.5 v 10.3 weeks, respectively; $P = .001$). Of patients who received chemotherapy in years 2 to 5, MO patients also tended to develop adverse events at a higher rate than GO patients (64.2% v 58.7%, respectively; $P = .14$), and of patients who received chemotherapy in postsurgical years 2 to 5, MO patients had more weeks with adverse events than GO patients (mean weeks, 14.9 v 9.0 weeks, respectively; $P = .001$).

We asked whether MO or GO patients differed by the number of subsequent surgical procedures they underwent, after the initial surgery required to be eligible for analysis. There was no difference.

Finally, we re-estimated results in a subset of matched pairs with only stage III or IV disease (Table 5). The results were very similar to those in Table 4. We also studied patients with only stage I or II disease and found that the 5-year survival rate was nearly identical between the GO- and MO-treated groups (61.0% v 62.7%, respectively; $P = .85$), and treatment differences showed similar trends but did not reach statistical significance (results not shown).

DISCUSSION

We found no difference in survival between patients receiving chemotherapy administered by a GO or an MO. Once matched for surgeon type and stage and numerous other initial factors, survival in both groups was virtually indistinguishable. Furthermore, we observed that MOs seem to treat patients more intensively than GOs. We found that the MO patients received more weeks of chemotherapy and had more weeks with chemotherapy-associated adverse events.

There were important limitations of this analysis. We did not have exact data on the extent of cytoreductive surgery performed by each surgeon, and although we did match on surgeon type, there may have been differences in surgical approach inside of surgeon type. Furthermore, we assigned chemotherapy provider (GO v MO) based on the billing at 3 months. Some patients initially treated by GOs may have switched care to MOs later in the course of their disease and, thus, may have been more intensely treated by MO providers than they

Ovarian Cancer Outcomes

Table 4. Comparing the Outcomes of the GO and MO Groups (N = 344)

Outcome Measure	GO Group		MO Group		P
	Mean	Median	Mean	Median	
Weeks with some chemotherapy					
Over first 5 years	12.1	9.0	16.5	11.0	.0023
For year 1	6.6	6.0	7.7	6.0	.0106
For years 2 to 5	6.3	2.5	10.0	4.0	.0167
Weeks with chemotherapy-associated adverse events*					
Over first 5 years	8.9	5.0	16.2	7.0	.0001
For year 1	3.6	2.0	6.6	3.0	.0001
For years 2 to 5	6.1	2.0	11.0	4.0	.0001
No. of operative procedures after first staging surgery					
Over first 5 years	0.244	0	0.28	0	.62
For year 1	0.209	0	0.24	0	.44
For years 2 to 5	0.04	0	0.04	0	.98
Survival, years					.45
Median	3.04		2.98		
95% CI	2.50 to 3.40		2.69 to 3.67		
1-year survival, %					.57
Median	86.6		87.5		
95% CI	83.0 to 90.2		84.0 to 90.1		
2-year survival, %					.57
Median	64.8		66.9		
95% CI	59.8 to 69.9		61.9 to 71.8		
5-year survival, %					.81
Median	35.1		34.2		
95% CI	30.0 to 40.2		29.2 to 39.3		

Abbreviations: GO, gynecologic oncologist; MO, medical oncologist.

*Weeks with chemotherapy-associated adverse events was defined as any week that included the following diagnoses occurring as an inpatient or outpatient: anemia, neutropenia, thrombocytopenia, diarrhea, dehydration or mucositis, and neuropathy.

would have had they stayed with their initial GO provider; however, our measure would retain assignment to the GO group and assign all such treatment to the GO group. Despite this, we still found that GO patients received less treatment than MO patients. Other limitations may also stem from the use of billing data. It was possible that our measure of weeks of chemotherapy may not be a marker of treatment intensity if the weekly treatments used by one provider type consisted of less dosage or fewer agents per week than treatments used by another provider. Such a problem seems unlikely given the association between weeks of chemotherapy and chemotherapy-associated adverse events (Tables 4 and 5).

In light of our observations, one might argue that optimal care was observed when a patient received chemotherapy from a physician who specializes in the management of the patient's specific disease, rather than from a physician who concentrates on a particular clinical technique. In the case of ovarian cancer management, one could argue that the GOs may have better understood the course of a patient's disease and were, therefore, more able to treat women without undue morbidity or excess treatment. From the patient's perspective, these results raise the question of whether patients should choose physicians that train and practice in a more technique-specific or a more disease-specific paradigm.

Armstrong et al²³ have recently shown promising results with intraperitoneal cisplatin and paclitaxel in stage III patients with no residual mass greater than 1 cm. Although the intraperitoneal treatment had more chemotherapy-associated adverse events than con-

ventional intravenous treatment, there was a 15-month improvement in median overall survival time. In the future, there is no doubt that both MO and GO physicians will use this modality for some of their patients. There is also little doubt that variation in dose-intensity will also occur across providers. How this future variation will influence survival and quality of life remains to be seen.

During the era of treatment for our present analysis, there were equally important advances in chemotherapy treatment, such as the introduction of intravenous paclitaxel and platinum-based regimens, which improved median survival time in some trials by 14 months.²⁴ Nevertheless, we found that the extra training and experience in chemotherapy administration by MOs did not translate into improvements in survival. The combined mission of GO physicians, providing surgical and medical care, did not prove detrimental to the survival of their patients undergoing chemotherapy. Given the almost identical survival curves over the time period of this study, it would seem that approaches that minimized adverse effects may have been more desirable.

In the case of ovarian cancer, we studied variations in practice style that reflected the different training of physicians, GOs and MOs, while controlling for the prognostic category of their patients. In a closely matched group of patients, we observed substantial differences in treatment intensity and toxicity, with no difference in survival. Our study would suggest that the more intense use of chemotherapy by MOs did not yield improvement in survival. The reasons for this more intense treatment may be quite complex. It is possible that MOs, who are usually the providers of chemotherapy after surgery to patients

Table 5. Comparing the Outcomes of the GO and MO Groups in Patients With Stage III and IV Disease (n = 263 pairs)

Outcome Measure	GO Group		MO Group		P
	Mean	Median	Mean	Median	
Weeks with some chemotherapy					
Over first 5 years	13.1	10.0	18.5	13.0	.0005
For year 1	6.9	6.0	8.2	7.0	.0038
For years 2 to 5	7.3	4.0	11.9	7.0	.0038
Weeks with chemotherapy-associated adverse events*					
Over first 5 years	9.2	5.0	17.9	9.0	.0001
For year 1	3.6	2.0	7.1	4.0	.0001
For years 2 to 5	6.6	2.0	12.5	4.5	.0001
No. of operative procedures after first staging surgery					
Over first 5 years	0.27	0	0.32	0	.48
For year 1	0.24	0	0.28	0	.47
For years 2 to 5	0.04	0	0.05	0	.38
Survival, years					.17
Median	2.38		2.77		
95% CI	2.12 to 2.96		2.46 to 3.21		
1-year survival, %					.31
Median	84.4		85.9		
95% CI	80.0 to 88.8		81.7 to 90.1		
2-year survival, %					.18
Median	58.3		65.0		
95% CI	53.4 to 65.3		59.3 to 70.8		
5-year survival, %					.81
Median	26.8		27.8		
95% CI	21.4 to 32.3		22.3 to 33.4		

Abbreviations: GO, gynecologic oncologist; MO, medical oncologist.

*Weeks with chemotherapy-associated adverse events was defined as any week that included the following diagnoses occurring as an inpatient or outpatient: anemia, neutropenia, thrombocytopenia, diarrhea, dehydration or mucositis, and neuropathy.

operated on by a general surgeon, may have been overcompensating with chemotherapy on all their patients, even those operated on by surgeons who did more extensive staging surgery, such as GOs. Possibly, MOs believed in treatment intensity more than GOs. Alternatively, it may have been the case that GOs had better intuition regarding when to reduce intensity in favor of quality of life. As we move into another new era of ovarian cancer therapy using intraperitoneal chemotherapy, an awareness of each specialty's biases, beliefs, and understandings will be essential for maximizing quality of care and patient satisfaction.

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

The authors indicated no potential conflicts of interest.

REFERENCES

1. Kehoe S, Powell J, Wilson S, et al: The influence of the operating surgeon's specialisation on patient survival in ovarian carcinoma. *Br J Cancer* 70:1014-1017, 1994
2. Eisenkop SM, Spirtos MD, Montag TW, et al: The impact of subspecialty training on the management of advanced ovarian cancer. *Gynecol Oncol* 47:203-209, 1992

3. Earle CC, Schrag D, Neville BA, et al: Effect of surgeon specialty on processes of care and outcomes for ovarian cancer patients. *J Natl Cancer Inst* 98:172-180, 2006
4. Giede KC, Kieser K, Dodge J, et al: Who should operate on patients with ovarian cancer? An evidence-based review. *Gynecol Oncol* 99:447-461, 2005
5. American Board of Internal Medicine: Medical oncology exam. <http://www.abim.org/cert/ssmedon.shtm>

AUTHOR CONTRIBUTIONS

Conception and design: Jeffrey H. Silber, Paul R. Rosenbaum, Orit Even-Shoshan, J. Sanford Schwartz, Katrina A. Armstrong, Thomas C. Randall

Financial support: Jeffrey H. Silber, Katrina A. Armstrong

Administrative support: Jeffrey H. Silber, Orit Even-Shoshan

Provision of study materials or patients: Jeffrey H. Silber

Collection and assembly of data: Jeffrey H. Silber, Paul R. Rosenbaum
Data analysis and interpretation: Jeffrey H. Silber, Paul R. Rosenbaum, Daniel Polsky, Richard N. Ross, Orit Even-Shoshan, J. Sanford Schwartz, Katrina A. Armstrong

Manuscript writing: Jeffrey H. Silber, Paul R. Rosenbaum, Daniel Polsky, Orit Even-Shoshan, J. Sanford Schwartz, Katrina A. Armstrong

Final approval of manuscript: Jeffrey H. Silber, Paul R. Rosenbaum, Daniel Polsky, Orit Even-Shoshan, J. Sanford Schwartz, Katrina A. Armstrong

6. American Board of Obstetrics and Gynecology: Resources for the public. <http://www.abog.org/women/defs.html#subs>

7. Mayer AR, Chambers SK, Graves E, et al: Ovarian cancer staging: Does it require a gynecologic oncologist? *Gynecol Oncol* 47:223-227, 1992

8. Nguyen HN, Averette HE, Hoskins W, et al: National survey of ovarian carcinoma: Part V. The impact of physician's specialty on patients' survival. *Cancer* 72:3663-3670, 1993

Ovarian Cancer Outcomes

9. Junor EJ, Hole DJ, McNulty L, et al: Specialist gynaecologists and survival outcome in ovarian cancer: A Scottish national study of 1866 patients. *Br J Obstet Gynaecol* 106:1130-1136, 1999
10. Potosky AL, Riley GF, Lubitz JD, et al: Potential for cancer related health services research using a linked Medicare-tumor registry database. *Med Care* 31:732-748, 1993
11. Elixhauser A, Steiner C, Harris DR, et al: Comorbidity measures for use with administrative data. *Med Care* 36:8-27, 1998
12. Silber JH, Rosenbaum PR, Trudeau ME, et al: Multivariate matching and bias reduction in the surgical outcomes study. *Med Care* 39:1048-1064, 2001
13. Polsky D, Armstrong KA, Randall TC, et al: Variation in chemotherapy utilization in ovarian cancer: The relative contribution of geography. *Health Serv Res* 41:2201-2218, 2006
14. Rosenbaum P: Optimal matching for observational studies. *J Am Stat Assoc* 84:1024-1032, 1989
15. Rosenbaum PR, Silber JH: Matching and thick description in observational study of mortality after surgery. *Biostatistics* 2:217-232, 2001
16. Rosenbaum P, Rubin D: The central role of the propensity score in observational studies for causal effects. *Biometrika* 70:41-55, 1983
17. Rosenbaum PR, Rubin DB: Constructing a control group using multivariate matched sampling methods that incorporate the propensity score. *Am Stat* 39:33-38, 1985
18. Rubin DB: Bias reduction using Mahalanobis metric matching. *Biometrics* 36:293-298, 1980
19. Rubin DB: Using multivariate matched sampling and regression adjustment to control bias in observational studies. *J Am Stat Assoc* 74:318-328, 1979
20. Rosenbaum PR, Ross RN, Silber JH: Minimum distance matched sampling with fine balance in an observational study of treatment for ovarian cancer. *J Am Stat Assoc* 102:175-183, 2007
21. Hollander M, Pledger G, Lin P-E: Robustness of the Wilcoxon test to a certain dependency between samples. *Ann Stat* 2:177-181, 1974
22. Kaplan EL, Meier P: Nonparametric estimation from incomplete observations. *J Am Stat Assoc* 53:457-481, 1958
23. Armstrong DK, Bundy B, Wenzel L, et al: Intraperitoneal cisplatin and paclitaxel in ovarian cancer. *N Engl J Med* 354:34-43, 2006
24. McGuire WP, Hoskins WJ, Brady MF, et al: Cyclophosphamide and cisplatin compared with paclitaxel and cisplatin in patients with stage III and stage IV ovarian cancer. *N Engl J Med* 334:1-6, 1996

Acknowledgment

We thank the late Dr Wendy Kahn for inspiring us to conduct this study. We thank the Applied Research Program, National Cancer Institute; the Office of Research, Development and Information, Centers for Medicare and Medicaid Services; Information Management Services, Inc; and the Surveillance, Epidemiology, and End Results (SEER) Program tumor registry participants who created the SEER-Medicare database.