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Surgical outcomes in women with ovarian cancer

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Objective: We sought to assess whether the specialty of the surgeon or the hospital involved in the initial management of women with ovarian cancer determined the likelihood of unnecessary repeated abdominal surgery and long-term patient survival. **Methods:** We conducted a population-based study involving women in Ontario, Canada, who had epithelial ovarian cancer treated initially with abdominal surgery between January 1996 and December 1998. We documented incident surgical cases using hospital contact data and the Ontario Cancer Registry. We obtained data on patient characteristics, clinical findings, surgical techniques and perioperative care from electronic administrative data records and patient charts. We performed regression analyses to assess the influence of surgeon and hospital specialization and of case volumes on the likelihood of repeat surgery and survival. We controlled for stage of disease and other factors associated with these outcomes. We also examined the relation between the adequacy of surgery and adjuvant chemotherapy with survival. **Results:** A total of 1341 women met our inclusion criteria. Our analysis showed that repeat surgery was associated with the surgeon's discipline, younger patient age, well-differentiated tumours and early stage of disease. However, survival was not associated with the surgeon's discipline; rather, it was associated with advanced patient age, increasing comorbidities, advanced stage of disease, poorly differentiated tumours, urgent surgery and adjuvant chemotherapy. We observed a trend between inadequate surgery and a decreased likelihood of survival. **Conclusion:** Further study is needed to understand patterns of repeat surgery for ovarian cancer. Improved quality of operative reporting is required to classify surgical adequacy.

Objectif : Nous avons voulu savoir si la spécialité du chirurgien ou de l'hôpital intervenant dans la prise en charge initiale des femmes atteintes d'un cancer de l'ovaire a un effet sur la probabilité de chirurgies abdominales répétées inutiles et sur la survie à long terme de la patiente. **Méthodes :** Nous avons effectué une étude représentative portant sur des femmes de l'Ontario, au Canada, atteintes d'un cancer de l'épithélium de l'ovaire traité initialement par chirurgie abdominale entre janvier 1996 et décembre 1998. Nous avons documenté les cas de chirurgie incidente à partir de données sur les contacts avec l'hôpital et du Registre du cancer de l'Ontario. Nous avons tiré de dossiers administratifs électroniques et des dossiers des patientes des données sur les caractéristiques des patientes, les constatations cliniques, les techniques chirurgicales et les soins périopératoires. Nous avons effectué des analyses de régression pour évaluer l'influence de la spécialisation du chirurgien et de l'hôpital et des volumes de cas sur la probabilité d'interventions chirurgicales répétées et de survie. Nous avons établi un contrôle en fonction du stade de la maladie et d'autres facteurs associés à ces résultats. Nous avons aussi examiné le lien entre la pertinence de l'intervention chirurgicale et la chimiothérapie adjuvante, d'une part, et la survie, de l'autre. **Résultats :** Au total, 1341 femmes ont satisfait à nos critères d'inclusion. Notre analyse a démontré qu'il y avait un lien entre les interventions chirurgicales répétées et la discipline du chirurgien,

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des patientes plus jeunes, des tumeurs bien différenciées et le stade précoce de la maladie. Il n'y avait toutefois pas de lien entre la survie et la discipline du chirurgien, mais il y en avait un avec l'âge avancé de la patiente, des comorbidités croissantes, le stade avancé de la maladie, des tumeurs mal différenciées, l'urgence de la chirurgie et la chimiothérapie adjuvante. Nous avons remarqué une tendance entre une intervention chirurgicale inadéquate et une diminution de la probabilité de survie. **Conclusion :** Une étude plus poussée s'impose pour comprendre les tendances de la chirurgie répétitive contre le cancer de l'ovaire. On souhaite améliorer la qualité des rapports opératoires pour déterminer si l'intervention chirurgicale est pertinente.

Ovarian cancer is the leading cause of death from gynecologic cancer in women. Surgery plays a key role in the management of this disease, and it is important for making the diagnosis, identifying prognostic factors, alleviating symptoms and extending survival. Unfortunately, there is evidence[1–14] that some women are not being appropriately staged or optimally debulked at the time of initial surgery. In addition to having a direct impact on survival, inadequate initial surgical management can result in greater morbidity because of a need for repeat abdominal surgery.

In 2002, we reported[15] marked differences in staging and debulking as a result of the surgical management of incident ovarian cancer in Ontario depending on the specialization of the surgeon and hospital. We also demonstrated a volume–outcomes effect in which repeat surgery was more common among patients who underwent initial surgery in institutions with low surgical volumes where no gynecologic oncologist (GO) was present or where the initial surgery was performed by someone other than a GO. We also found that patient survival varied depending on the discipline of the surgeon who performed the initial procedure.

Our previous study was based exclusively on electronic administrative data. We could not be certain when repeat surgery was attributable to complications. We were also unable to adjust for potentially important clinical determinants of survival. Hence, we designed the present study to assess the roles that patient, disease and clinical care factors play in the outcomes of care by collecting data through extensive chart abstraction.

Methods

Data sources and study population

We conducted a population-based cohort study of all women in Ontario, Canada, with newly diagnosed ovarian cancer treated initially with abdominal surgery between Jan. 1, 1996, and Dec. 31, 1998. We obtained ethics approval from the Ontario Central Research Ethics Board and each hospital.

We used the databases of the Canadian Institute for Health Information (CIHI) and the Ontario Cancer Registry (OCR) to identify patients with ovarian cancer (diagnostic code 183). We excluded patients whose records could not be linked to a valid health number and patients whose charts we were not able to access for abstraction. We also excluded patients if they had received a prior diagnosis of ovarian cancer, patients with nonepithelial cancer (e.g., low malignant potential tumours, germ cell tumours, stromal cell tumours or other histologic findings), patients who had primary surgery outside the recruitment window or who had chemotherapy before index surgery, and patients for whom we found no operative records assigning disease stage. We removed duplicate records.

Chart abstraction

We designed and tested a data manual and a computerized data abstraction program. Six abstractors with nursing or data abstraction backgrounds trained to use these tools. We performed reliability testing after the abstraction of 10 and then 20 charts. The lead author (L.E.) reviewed surgical and pathology notes, blinded by outcome, to ensure reliable stage assignment.

Variable definition

Outcome

We defined repeat surgery as a second abdominal surgery unrelated to complications performed within 5 months of the index surgery. Mortality was documented in hospital admission and discharge data, and we linked vital statistics data to public health insurance data and the OCR. We calculated survival time from the pathologically confirmed diagnosis of ovarian cancer (initial date of surgery) and the date of death from any source. Follow-up ended with the latest available health insurance data.

Structure

We identified the most responsible surgeon from operative notes in patient charts. We then classified surgeons as general surgeon, gynecologist or other using the Canadian Medical Protective Association code from a provincial care provider database. We identified gynecologic oncologists within the gynecologist group using a previously established list of subspecialists.

We defined patient volumes for surgeons and facilities within the population-based cohort (annual number of incident ovarian cancer patients who had surgery during the study period). We classified surgical centres as hospitals with onsite access to a GO, university-affiliated teaching hospitals or affiliates of regional cancer centres without onsite access to a GO or all remaining (community) hospitals.

Covariates

Covariates included the patient's age at diagnosis, history of previous cancer (as indicated in the OCR), disease stage and histology at diagnosis (patient charts), and comorbidity at diagnosis using the Charlson index.[16] We calculated the comorbidity score based on medical conditions documented in patient charts and electronic hospital records that existed prior to the diagnosis of ovarian cancer. We linked the patients' postal codes to Canadian Census summary data on the size of the patients' communities and urban/rural classification, as well as an indicator of relative affluence of the small area of residence (quintiles of median household income).

Quality indicator

We derived a novel indicator of surgical adequacy. We deemed a woman to have had an adequate index surgery if she had stage 1 disease and was optimally staged based on European Organisation for Research and Treatment of Cancer criteria (optimal v. moderate or inadequate),[17] or if she had stage 2, 3 or 4 disease and was optimally debulked to 1 cm or less of residual disease.[18] We deemed surgery to be inadequate if these criteria were not met. Undefined surgery referred to procedures for which the quality could not be discerned from the surgical or pathology records.

Statistical analysis

We performed regression analyses to estimate the influence of patient characteristics, disease stage and histology, and surgeon and hospital characteristics on the outcomes of repeat surgery and mortality. For the outcome of repeat surgery, we used Poisson regression to obtain estimated relative risks (RRs) and associated confidence intervals (CIs). We performed survival time analysis using the Cox proportional hazards model (adjusting for patient age, stage of disease, comorbidity and grade). Model diagnostics included the evaluation of residuals and tests of model assumptions. For all models, robust variance estimates and CIs account for the fact that patients may have been seen by the same surgeon. We performed analyses using the SAS GENMOD procedure (with exchangeable covariance matrix) and comparable procedures in Stata software (StataCorp LP).

Funding

Our study was funded by the National Cancer Institute of Canada through a peer review granting process. They were not involved in the design or conduct of the study or the reporting of the findings.

Results

Study population

Our search on the CIHI database identified 3153 patients with ovarian cancer who had surgery during our study period. Of these, we excluded 558 patients because they had received a prior diagnosis of ovarian cancer between 1988 and Dec. 31, 1995. We found procedure codes for abdominal surgery for 2094 women aged 18 years and older. The OCR indicated that 2874 incident cases of ovarian cancer were identified from 1996 to 1998 by a process of case ascertainment consisting of deterministic linkage of records from the cancer centres, pathology reports from the Ontario hospitals, hospital discharge abstracts from CIHI and death certificates from the registrar general. The database comprised 2626 records, of which 48 could not be linked to a valid health number. We were unable to access 80 charts for abstraction. We excluded 723 patients who had nonepithelial cancer, 347 patients who had primary surgery outside the recruitment window and 61 patients who had chemotherapy before the index surgery. For 17 patients, we found no operative records assigning disease stage. After removing duplicate records, 1341 patients were eligible for inclusion in our study.

Characteristics of the patient cohort are presented in Table 1. The median patient age was 60.7 years. More than 90% had no history of cancer and 5% had a comorbidity score of 2 or more. Roughly 25% of the cohort had stage 1, 12% had stage 2, 56% had stage 3 and 7% had stage 4 disease at the time of initial surgery.

Repeat surgery

Eighty-four patients (6.3% of the cohort) experienced repeat abdominal surgery unrelated to complications within 5 months of the index surgery (Table 1). Twenty-two percent of these patients were upstaged. Patient-, disease- and care-related covariates (Table 1) that had associations with the likelihood of repeat surgery on univariate analysis are presented in Table 2. In addition, all other levels of surgeon training were significantly associated with an increased probability of repeat surgery relative to GOs in the unadjusted analysis. The relative risk (RR) (and 95% confidence intervals [CIs]) were 9.31 (3.81–22.78) for obstetrician/gynecologists and 16.11 (6.24–41.60) for general surgeons. Lower surgeon volume and hospital volume were significantly associated with repeated surgery (Table 2). The RRs (and 95% CIs) were 7.63 (3.29–17.69) for a surgeon volume of 3–9, 10.04 (4.44–22.71) for a surgeon volume of 1–2 and 5.70 (1.22–26.73) for a hospital volume of 1–15 procedures. Patients with a lower disease stage and well-differentiated tumours were more likely to have repeat surgery, as were those living in rural areas. In the multivariate model, surgical discipline was significantly associated with risk for repeat surgery (Table 3). The RR (and 95% CI) for other surgical disciplines was 12.42 (2.69–57.41). Patients who initially saw a general surgeon were 17 times more likely to undergo repeat

Table 1

Characteristics of all patients in Ontario, Canada, with nonepithelial cell ovarian cancer who had initial surgery between 1996 and 1998 (*n* = 1341)

Characteristic	No. (%) of patients*	Characteristic	No. (%) of patients*
Patient		**Surgical experience**	
Age, yr		Surgery	
18–44	158 (11.8)	Elective	1175 (87.6)
45–59	436 (32.6)	Urgent	117 (8.7)
60–69	363 (27.0)	Emergent	49 (3.7)
≥ 70	384 (28.6)	Discipline of primary surgeon	
Size of community		Obstetrician/gynecologist	664 (49.5)
≥ 1 250 000	483 (36.0)	Gynecologic oncologist	485 (36.2)
500 000 – 1 249 999	177 (13.2)	General surgeon	158 (11.8)
100 000 – 499 999	324 (24.2)	Other	15 (1.1)
10 000 – 99 999	139 (10.4)	Missing	19 (1.4)
< 10 000	178 (13.3)	Surgeon volume (ovarian cancer surgical volume)	
Missing	40 (3.0)	Mean (SD) (median)	14.5 (16.5) (4)
Income quintile		No. patients in 3 yr	
First quintile	258 (19.2)	1–2	425 (31.7)
Second quintile	245 (18.3)	3–9	403 (30.0)
Third quintile	239 (17.8)	≥ 10	496 (37.0)
Fourth quintile	272 (20.3)	Missing	17 (1.3)
Fifth quintile	251 (18.7)	Hospital type	
Missing	76 (5.7)	Gynecologic oncologist on staff	626 (46.7)
Prior diagnosis of cancer		Regional cancer or teaching centre	98 (7.3)
Yes	99 (7.4)	Community hospital	617 (46.0)
No	1209 (90.2)	Hospital volume	
Missing	33 (2.5)	Mean (SD) (median)	42.3 (36) (24)
Charlson comorbidity score		No. patients in 3 yr	
0–1	1279 (95.4)	1–15	515 (38.4)
≥ 2	62 (4.6)	16–99	721 (53.8)
Disease		≥ 100	104 (7.8)
Stage		Length of the operation, mean (SD) (median)	110.6 (52.8) (104)
1	330 (25.0)	Length of stay in hospital, mean (SD) (median)	9.7 (10.6) (7)
2	164 (12.2)	Quality indicator	
3	756 (56.0)	Inadequate	638 (47.6)
4	91 (6.8)	Adequate	177 (13.2)
Grade		Undefined	526 (39.2)
Undifferentiated	21 (1.6)	Days from admission to surgery, mean (SD) (median)	2.3 (3.1) (1)
Poor	570 (42.4)	**Postsurgical management**	
Moderate	323 (24.0)	Treatment	
Well	189 (14.3)	Surgery	506 (37.7)
NS	238 (17.8)	Surgery + CT	764 (57.0)
Histologic type		Surgery + RT	38 (2.8)
Serous	744 (55.4)	Surgery + RT + CT	33 (2.5)
Nonserous	596 (44.6)	**Outcomes under study**	
		Second operation unrelated to complications (< 5 mo)	84 (6.3)
		Total deaths documented (median survival time, d)†	893 (66.6)

CT = chemotherapy; NS = not stated; RPDB = Ontario Registered Persons Database; RT = radiotherapy; SD = standard deviation.
*Unless otherwise indicated.
†Mortality defined from chart abstraction and RPDB.

surgery than those who saw GOs (RR 16.97, 95% CI 6.35–45.32). Those whose surgeries were performed by obstetricians were 6 times more likely than those who saw GOs to undergo repeat surgery (RR 6.54, 95% CI 2.53–16.93). Younger age, earlier stage of disease and lower grade continued to have an influence on this outcome.

We found that surgeon and hospital specialization were strongly correlated (model not shown). Hospital type did not make a significant contribution to the fit of the model; however, adding hospital type caused a marked reduction in the size of the effect associated with surgeon discipline. After adjustment for hospital effects, patients of a general surgeon continued to have an estimated likelihood of repeated surgery that was 6 times greater than that of patients who saw GOs (RR 5.7, 95% CI 1.17–28.46).

Survival

The results of the unadjusted Cox regression models of mortality are presented in Table 4. As expected, advanced patient age, comorbidity and advanced disease were all associated with higher mortality. Before consideration of confounding by case-mix and other factors, patients whose index surgeries were

Table 2

Unadjusted associations among patient, disease and care covariates with likelihood of patient receiving second surgery* (*n* = 1341)

Characteristic	RR† (95% CI)	Characteristic	RR† (95% CI)
Surgical experience		**Patient (continued)**	
Discipline of initial surgeon		Rural residence	1.00 (ref)
Gynecologic oncologist	1.00 (ref)	No‡	2.00 (1.19–3.38)
Obstetrician/ gynecologist‡	9.31 (3.81–22.78)	Yes	
General surgeon‡	16.11 (6.24–41.60)	Income quintile	
Other‡	16.16 (3.49–74.88)	First quintile	1.00 (ref)
Surgeon procedure volume		Second quintile	1.14 (0.53–2.47)
≥ 10	1.00 (ref)	Third quintile	1.89 (0.94–3.80)
3–9‡	7.63 (3.29–17.69)	Fourth quintile	1.74 (0.87–3.47)
1–2‡	10.04 (4.44–22.71)	Fifth quintile	1.20 (0.56–2.56)
Hospital procedure volume		Cancer history	
≥ 100	1.00 (ref)	No	1.00 (ref)
16–99‡	1.89 (0.39–9.23)	Yes	0.97 (0.43–2.18)
1–15‡	5.70 (1.22–26.73)	Charlson comorbidity score	
Hospital type		0–1	1.00 (ref)
Centres with gynecologic oncologist	1.00 (ref)	≥ 2	0.25 (0.03–1.77)
Other regional cancer centre‡	3.19 (1.14–8.94)	**Disease**	
Remaining centres‡	4.57 (2.26–9.20)	Tumour grade	
Quality indicator		Poor/undifferentiated	1.00 (ref)
Adequate	1.00 (ref)	Well v. poor/undifferentiated‡	3.57 (1.99–6.42)
Inadequate	1.28 (0.06–2.74)	Moderate v. poor/undifferentiated	1.31 (0.68–2.50)
Undefined	1.64 (0.76–3.54)	NS v. poor/undifferentiated‡	2.01 (1.00–4.02)
Patient		Stage at initial surgery	
Patient age, yr		1	1.00 (ref)
≥ 70	1.00 (ref)	2 v. 1	0.83 (0.47–1.44)
60–69	1.19 (0.58–2.43)	3 v. 1‡	0.28 (0.16–0.48)
18–59‡	2.69 (1.54–4.68)	4 v. 1‡	0.37 (0.14–0.99)

CI = confidence interval; NS = not stated; RR = relative risk.
*Poisson regression models with robust variance estimates accounting for correlated error within surgeon performing initial surgery.
†RR > 1.00 means a higher rate of repeat surgery compared with the reference group; RR < 1.0 means a lower rate of repeat surgery.
‡Results of the Cox proportional hazards model were statistically significant.

Table 3

Adjusted associations between discipline of the surgeon and other covariates with likelihood of repeat surgery* (*n* = 1341)

Characteristic	RR† (95% CI)
Surgical experience	
Discipline of surgeon	
Gynecologic oncologist	1.00 (ref)
Obstetrician/ gynecologist‡	6.54 (2.52–16.93)
General surgeon‡	16.97 (6.35–45.32)
Other‡	12.42 (2.69–57.41)
Patient	
Patient age, yr	
≥ 70	1.00 (ref)
60–69	1.29 (0.55–3.02)
18–59‡	2.88 (1.52–5.47)
Residence	
Urban	1.00 (ref)
Rural	1.38 (0.78–2.45)
Disease	
Tumour grade	
Poor/ undifferentiated	1.00 (ref)
Well differentiated‡	2.36 (1.26–4.42)
Moderately differentiated	1.08 (0.57–2.06)
Not stated	1.39 (0.70–2.77)
Stage of disease at initial surgery	
1	1.00 (ref)
2	1.07 (0.59–1.94)
3‡	0.37 (0.20–0.67)
4	0.44 (0.13–1.48)

CI = confidence interval; RR = relative risk.
*Adjusted for age, comorbidity, residence location, stage of disease and tumour grade.
†RR > 1.00 means a higher rate of repeat surgery compared with the reference group; RR < 1.0 means a lower rate of repeat surgery.
‡Results of the Cox proportional hazards model were statistically significant.

performed by GOs had shorter survival than the patients of gynecologists. Similarly, before adjustment, patients seen at centres with a GO on staff had poorer survival. Neither hospital volume nor patient residence was associated with survival.

In the multivariate model, after adjustment for age and disease severity (Table 5), the previous pattern in which survival was shortened for patients of GOs disappeared, with patients of GOs and gynecologists having the lowest mortality. This association was not statistically significant (hazard ratio [HR] 1.00, 95% CI 0.86–1.16). The survival for patients of general surgeons was not significantly different from that of patients of GOs or gynecologists (HR 1.19, 95% CI 0.94–1.50). Mortality was significantly increased for the category of "other" physicians, a small patient group for which we had no a priori expectation (HR 1.52, 95% CI 1.18–1.95). Advanced patient age, higher grade and stage of disease, and urgent index surgery were all significantly associated with mortality. The HRs (and 95% CIs) were 2.31 (1.71–3.12) for stage 2, 6.33 (4.87–8.20) for stage 3, 11.33 (7.98–16.10) for stage 4 and 1.47 (1.20–1.82) for urgent index surgery. We used multivariate models to detect whether the surgeon's discipline affected mortality among patients with stage 1 disease and among patients with stage 2, 3 or 4 disease. We detected no relation between surgical discipline and mortality within the stage groupings.

Quality indicator

We considered several indicators of quality of care in the univariate survival model for repeat surgery and survival. These included the delay

Table 4

Unadjusted associations between care, patient characteristics and patient survival time from initial surgery (*n* = 1341)

Characteristic	HR* (95% CI)	Characteristic	HR* (95% CI)
Surgical experience		**Postsurgical management (continued)**	
Discipline of Initial surgeon		Treatment subsequent to surgery (continued)	
Gynecologic oncologist	1.00 (ref)	Surgery + CT†	1.41 (1.21–1.66)
Obstetrician/gynecologist†	0.73 (0.64–0.83)	Surgery + RT†	0.37 (0.21–0.69)
General surgeon†	1.26 (1.03–1.54)	Surgery + CT + RT†	0.46 (0.29–0.76)
Other	0.90 (0.51–1.59)	**Patient**	
Surgeon procedure volume		Patient age, yr	
≥ 10	1.00 (ref)	≥ 70	1.00 (ref)
3–9†	0.73 (0.62–0.86)	60–69†	0.75 (0.63–0.90)
1–2	0.92 (0.79–1.06)	18–59†	0.54 (0.46–0.65)
Hospital procedure volume		Charlson comorbidity score ≥ 2 v. 0–1†	1.95 (1.42–2.58)
≥ 100	1.00 (ref)	Cancer history, yes v. no	1.00 (0.78–1.29)
16–99	1.05 (0.84–1.31)	Rural residence, yes v. no	0.93 (0.78–1.11)
1–15	0.91 (0.72–1.15)	Income quintile	
Hospital type		First quintile	1.00 (ref)
Centre with gynecologic oncologist	1.00 (ref)	Second quintile	0.99 (0.80–1.23)
Other regional cancer or teaching centre	0.74 (0.55–1.00)	Third quintile	0.89 (0.69–1.13)
Remaining centres†	0.87 (0.75–0.99)	Fourth quintile	0.95 (0.77–1.17)
Quality indicator		Fifth quintile	0.93 (0.75–1.16)
Adequate	1.00 (ref)	**Disease**	
Inadequate	1.16 (0.89–1.52)	Stage at initial surgery	
Undefined†	1.87 (1.48–2.37)	1	1.00 (ref)
Surgery type		2†	2.48 (1.85–3.33)
Elective	1.00 (ref)	3†	7.62 (6.06–9.58)
Emergency v. elective	0.85 (0.59–1.24)	4†	12.72 (9.21–17.62)
Urgent v. elective†	1.40 (1.12–1.75)	Tumour grade	
Days from admission to surgery (continuous variable)†	1.06 (1.04–1.08)	Poor/undifferentiated	1.00 (ref)
Postsurgical management		Well differentiated†	0.25 (0.19–0.32)
Treatment subsequent to surgery		Moderately differentiated†	0.68 (0.57–0.79)
Surgery alone	1.00 (ref)	Not stated†	0.76 (0.63–0.92)

CI = confidence interval; CT = chemotherapy; HR = hazard ratio; RT = radiotherapy.
*HR > 1.00 means a worse survival rate compared with the reference group; HR < 1.0 means a better survival rate.
†Results of the Cox proportional hazards model were statistically significant.

from admission to surgery, whether the surgery was emergent or elective (both indicators of complex clinical conditions), adequacy of surgery and adjuvant therapy. Surgical adequacy was not associated with repeat surgery in either the univariate or multivariate model (Table 2). Those patients whose surgical records did not show complete staging or debulking at index surgery had poorer survival time in the univariate model. Table 6 shows the effect of adding treatment modifiers to the multivariate model. Surgical adequacy improved the fit of the model; however, the highest risk of death was associated with incomplete operative data (undefined category) compared with adequate

Table 5

Adjusted associations between care, patient characteristics and patient survival time from initial surgery*

Characteristic	HR† (95% CI)
Surgical experience	
Discipline of initial surgeon	
Gynecologic oncologist	1.00 (ref)
Obstetrician/gynecologist	1.00 (0.86–1.16)
General surgeon	1.19 (0.94–1.50)
Other‡	1.52 (1.18–1.95)
Surgery type	
Elective	1.00 (ref)
Emergency	0.83 (0.59–1.16)
Urgent‡	1.47 (1.20–1.82)
Patient	
Patient age, yr	
≥ 70	1.00 (ref)
60–69‡	0.68 (0.56–0.84)
18–59‡	0.58 (0.48–0.71)
Charlson comorbidity score	
0–1	1.00 (ref)
≥ 2‡	1.62 (1.20–2.11)
Disease	
Tumour grade	
Poor/undifferentiated	1.00 (ref)
Well differentiated‡	0.51 (0.40–0.66)
Moderately differentiated	0.87 (0.72–1.04)
Not stated	0.98 (0.80–1.20)
Stage at initial surgery	
1	1.00 (ref)
2‡	2.31 (1.71–3.12)
3‡	6.33 (4.87–8.20)
4‡	11.33 (7.98–16.10)

CI = confidence interval; HR = hazard ratio
*Adjusted for age, comorbidity, residence location, stage of disease and tumour grade.
†HR > 1.00 means a worse survival rate compared with the reference group; HR < 1.00 means a better survival rate.
‡Results of the Cox proportional hazards model were statistically significant.

Table 6

Adjusted associations between care and quality indicators, patient characteristics and patient survival time from initial surgery*

Characteristic	HR† (95% CI)
Surgical experience	
Discipline of initial surgeon	
Gynecologic oncologist	1.00 (ref)
Obstetrician/gynecologist	1.02 (0.81–1.30)
General surgeon	1.19 (0.90–1.58)
Other‡	1.38 (1.01–1.88)
Hospital type	
Centre with gynecologic oncologist	1.00 (ref)
Other regional cancer centre	0.81 (0.56–1.17)
Remaining centres	0.93 (0.74–1.16)
Surgery type	
Elective	1.00 (ref)
Emergency	0.86 (0.60–1.22)
Urgent‡	1.52 (1.24–1.86)
Quality indicator	
Adequate	1.00 (ref)
Inadequate	1.24 (0.99–1.53)
Undefined‡	1.28 (1.03–1.58)
Postsurgical management	
Treatment subsequent to surgery	
Surgery alone	1.00 (ref)
Surgery + CT‡	0.72 (0.61–0.85)
Surgery + RT	0.63 (0.37–1.07)
Surgery + CT + RT	0.86 (0.55–1.35)
Patient	
Patient age, yr	
≥ 70	1.00 (ref)
60–69‡	0.60 (0.49–0.73)
18–59‡	0.71 (0.58–0.87)
Charlson comorbidity score	
0–1	1.00 (ref)
≥ 2‡	1.55 (1.17–2.07)
Disease	
Tumour grade	
Poor/undifferentiated	1.00 (ref)
Well differentiated‡	0.49 (0.38–0.64)
Moderately differentiated	0.88 (0.73–1.05)
Not stated	0.97 (0.80–1.22)
Stage at initial surgery	
1	1.00 (ref)
2‡	2.46 (1.72–3.19)
3‡	7.18 (5.09–9.07)
4‡	12.81 (8.16–17.75)

CI = confidence interval; CT = chemotherapy; HR = hazard ratio; RT = radiotherapy.
*Adjusted for age, comorbidity, residence location, stage of disease and tumour grade.
†HR > 1.00 means a worse survival rate compared with the reference group; HR < 1.00 means a better survival rate.
‡Results of the Cox proportional hazards model were statistically significant.

staging or cytoreduction. Postsurgical treatment also improved the fit of the model, with superior survival being associated with the use of multimodality therapy involving surgery and chemotherapy compared with surgery alone (HR 0.72; 95% CI 0.62–0.87).

Discussion

Findings regarding repeat surgery

Repeat invasive surgery for staging or debulking represents an important increase in patient morbidity and mortality. We confirmed that patients whose index surgeries were performed by a general surgeon were nearly 6 times more likely to have repeat surgery than patients of GOs, after adjustment for patient characteristics and the nature of the centre in which the initial surgery took place.

We looked at several clinical and structural predictors of repeat surgery. Our data showed that repeat surgeries tended to be performed in younger women and in women with early-stage disease that was well differentiated. This finding is in keeping with a treatment philosophy of adequate surgical staging (as opposed to adjuvant chemotherapy) for stage 1 moderate to well-differentiated ovarian cancer. These younger, healthier women are more likely to tolerate a second surgery without major sequelae. Even after adjusting for these patient factors, different rates of repeat surgery by discipline remained.

We also set out to confirm or refute the specific hypothesis that repeat surgery was necessitated by inadequate index surgery performed by nonexpert surgeons. Although we demonstrated that repeat surgery was associated with surgical specialty, our findings failed to support the hypothesis that surgical adequacy was the explanation. However, this could have been a result of poor documentation. The reasons for the observed effects by specialization are not clear. The decision to repeat a surgery is partially subjective, and the answer may lie in clinical decision-making. Factors that contribute to the decision to perform repeat surgery include the patient's age, other comorbidities, opportunity to avoid adjuvant therapy because of the information from a subsequent staging surgery, the strength of the conviction that optimal debulking improves survival, physician bias based on who performed the initial surgery and patient preference.[19]

Observations on patient survival

For cancer patients, the overall length of survival or the potential disease-free interval are important factors in making a treatment decision. We did not find a significant relation between surgical discipline and survival. This is in contrast to our previous study[15] and the work of others.[1–3] The difference between our 2 reports is that, in the present study, we were able to adjust the analysis for potentially important confounders in a particular stage. It is very likely that women with ovarian cancer whose surgeries were performed by general surgeons had very advanced disease. We did show a survival benefit related to the use of adjuvant therapy. This is in keeping with randomized studies of early-stage disease and meta-analyses of advanced-stage disease.[20] Although we identified a relation between survival and the quality indicator for surgical adequacy, this finding was specific to the subgroup of "undefined" surgical adequacy. Our present study differs from the previous studies in that we failed to show a simple survival benefit associated with maximal surgical staging and cytoreduction.[1,3] The difference likely lies with the quality of the data available to us, with respect to how well residual disease and surgical procedures were documented (a more detailed assessment of what information is available in the Ontario system will be the subject of a parallel report from our cohort). In fact, we found that missing information on cytoreduction and staging was associated with poorer survival — most likely reflecting unmeasured prognostic or quality of care factors correlated with data quality and the extent of information provided in the medical records. We suspect that patients whose medical records lack specific evidence of extensive debulking are more likely to have had inadequate surgical management; however, we cannot confirm this hypothesis.

Our present study shows a potential limitation of outcomes research using administrative databases in which stage and other patient factors cannot be measured. When we adjusted for stage of disease and other prognostic factors, we observed a meaningful reduction in the magnitude of differences in survival among surgeons' practices. Caution is still warranted because not all clinically relevant prognostic factors can be assessed through patient records, and we have identified incomplete clinical information as a potential source of error that can result in residual confounding of case severity on observed patient outcomes associated with setting and specialty.

We have shown that the risk of repeat surgery is increased when a physician who is not specialized in ovarian cancer performs the index surgery. A repeat surgery is synonymous with increased morbidity and a delay in instituting adjuvant therapy. We have also shown that adjuvant therapy is associated with a survival advantage, thus supporting the role of chemotherapy in this disease. A standardized format for ensuring this information is captured will help us to better define the role of surgical adequacy as a quality indicator for the treatment of ovarian cancer[21] and possibly trigger a more careful conduct of the surgery and decision-making around who should perform the surgery.

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References

1. Giede KC, Keiser K, Dodge J, et al. Who should operate on patients with ovarian cancer? An evidence-based review. *Gynecol Oncol* 2005;99:447-61.
2. Junor E. The impact of specialist training for surgery in ovarian cancer. *Int J Gynecol Cancer* 2000;10:16-8.
3. Eisenkop SM, Spirtos NM, Montag TW, et al. The impact of subspecialty training on the management of advanced ovarian cancer. *Gynecol Oncol* 1992;47:203-9.
4. Kehoe S, Powell J, Wilson S, et al. The influence of the operating surgeon's specialization on patient survival in ovarian carcinoma. *Br J Cancer* 1994;70:1014-7.
5. Junor EJ, Hole DJ, Gillis CR. Management of ovarian cancer: referral to a multidisciplinary team matters. *Br J Cancer* 1994;70:363-70.
6. Hole DJ, Gillis CR. Use of cancer registry data to evaluate the treatment of ovarian cancer on a hospital basis. *Health Rep* 1993;5:117-9.
7. Nguyen HN, Averette HE, Hoskins W, et al. National survey of ovarian carcinoma. VI. Critical assessment of current International Federation of Gynecology and Obstetrics staging system. *Cancer* 1993;72:3007-11.
8. Mayer AR, Chambers SK, Graves E, et al. Ovarian cancer staging: Does it require a gynecologic oncologist? *Gynecol Oncol* 1992;47:223-7.
9. Munoz KA, Harlan LC, Trimble EL. Patterns of care for women with ovarian cancer in the United States. *J Clin Oncol* 1997;15:3408-15.
10. Puls LE, Carrasco R, Morrow MS, et al. Stage 1 ovarian carcinoma: specialty-related differences in survival and management. *South Med J* 1997;90:1097-100.
11. Piver MS. Systematic surgical saging: stage I ovarian cancer. *J Clin Oncol* 1997;15: 864-5.
12. Grant PT, Beischer NA, Planner RS. The treatment of gynaecological malignancy in a general public hospital. *Med J Aust* 1992; 157:378-80.
13. Young RC, Decker DG, Wharton JT, et al. Staging laparotomy in early ovarian cancer. *JAMA* 1983;250:3072-6.
14. Piver MS. Specialized surgery in ovarian cancer. *Eur J Cancer Clin Oncol* 1987;23: 123-5.
15. Elit L, Bondy SJ, Paszat L, et al. Outcomes in surgery for ovarian cancer. *Gynecol Oncol* 2002;87:260-7.
16. Charlson ME, Pompei P, Ales KL, et al. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987; 40:373-83.
17. Trimbos JB, Vergote IB, Bolis G, et al. Impact of adjuvant chemotherapy and surgical staging in early stage ovarian carcinoma: European Organisation for Research and Treatment of Cancer-Adjuvant Chemotherapy in Ovarian Neoplasm trial. *J Natl Cancer Inst* 2003;95:113-25.
18. Bristow RE, Tomacruz RS, Armstrong DK, et al. Survival effect of maximal cytoreductive surgery for advanced ovarian carcinoma during the platinum era: a meta-analysis. *J Clin Oncol* 2002;20: 1248-59.
19. Trimbos JB, Schueler JA, van Lent M, et al. Reasons for incomplete surgical staging in early ovarian carcinoma. *Gynecol Oncol* 1990;37:374-7.
20. Trimbos JB, Parmar M, Vergote IB, et al. International Collaborative Ovarian Neoplasm trial 1 and Adjuvant ChemoTherapy In Ovarian Neoplasm trial: two parallel randomized phase III trials of adjuvant chemotherapy in patients with early-stage ovarian carcinoma. *J Natl Cancer Inst* 2003;95:105-12.
21. Gagliardi AR, Fung MGK, Langer B, et al. Development of ovarian cancer surgery quality indicators using a modified Delphi approach. *Gynecol Oncol* 2005;97:446-56.