Predicting non-home discharge in epithelial ovarian cancer patients: External validation of a predictive model

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HIGHLIGHTS

Approximately 12% of women are not discharged home after CRS.
Non-home discharge after CRS for EOC can be accurately predicted.
Inclusion of preoperative variables allows for patient counseling and planning.
Use of this tool may streamline discharge planning and decrease length of stay.

ABSTRACT

Objective: To externally validate a model predicting non-home discharge in women undergoing primary cytoreductive surgery (CRS) for epithelial ovarian cancer (EOC).

Methods: Women undergoing primary CRS via laparotomy for EOC at three tertiary medical centers in an academic health system from January 2010 to December 2015 were included. Patients were excluded if they received neoadjuvant chemotherapy, had a non-epithelial malignancy, were not undergoing primary cytoreduction, or lacked documented model components. Non-home discharge included skilled nursing facility, acute rehabilitation facility, hospice, or inpatient death. The predicted probability of non-home discharge was calculated using age, pre-operative CA-125, American Society of Anesthesiologists (ASA) score and Eastern Cooperative Oncology Group (ECOG) performance status as described in the previously published predictive model. Model discrimination was calculated using a concordance index and calibration curves were plotted to characterize model performance across the cohort.

Results: A total of 204 admissions met inclusion criteria. The overall rate of non-home discharge was 12% (95% CI 8–18%). Mean age was 60.8 years (SD 11.0). Median length of stay (LOS) was significantly longer for patients with non-home discharge (8 vs. 5 days, P < 0.001). The predictive model had a concordance index of 0.86 (95% CI 0.76–0.93), which was similar to model performance in the original study (CI 0.88). The model provided accurate predictions across all probabilities (0 to 100%).

Conclusions: Non-home discharge can be accurately predicted using preoperative clinical variables. Use of this validated non-home discharge predictive model may facilitate preoperative patient counseling, early discharge planning, and potentially decrease cost of care.

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1. Introduction

Epithelial ovarian cancer (EOC) is diagnosed in over 22,000 women each year in the United States and causes over 15,000 deaths, making it the 5th leading cause of cancer-related deaths among U. S. women [1]. Surgery is the primary treatment approach in most patients for the purposes of diagnosis and staging, symptom relief, as well as cytoreduction to improve survival [2]. Half of patients diagnosed with ovarian cancer are >65 years old and older age has been associated with increased peri-operative morbidity and decreased overall survival [2–4]. Nonetheless, many women in this age group are able to tolerate aggressive primary cytoreductive surgery (CRS) and experience overall survival benefit similar to younger patients [4]. Taken together, the advanced age and surgical complexity of ovarian cancer patients means that many...
Recent economic pressures have promoted a focus on value-based care, which minimizes healthcare cost while maximizing patient benefit. In a recent Surveillance, Epidemiology, and End Results (SEER) database analysis that included 2902 women undergoing surgery and adjuvant chemotherapy for EOC, costs of treatment in the first year after diagnosis averaged $83,915 [5]. More than half (51%) of that cost was attributed to surgery and inpatient stay. After adjusting for year of treatment and geography, mean inpatient costs per patient were $24,653 with a striking standard deviation of $34,463. This high variability in cost implies that modification and improvement are possible. Ovarian cancer patients often pose medical and surgical challenges including postoperative complications, and disease-related morbidity. These patients often require individualized discharge planning, which can further prolong postoperative length of stay (LOS). Prediction models have been previously developed for patients undergoing cardiac, orthopedic, pancreatic, and colorectal surgery [6–9]. Importantly, prediction of non-home discharge may be associated with reduction in postoperative LOS and thus perioperative cost [7].

A nomogram was previously developed by AlHilli et al. for the prediction of non-home discharge in women undergoing primary surgical management of EOC [Fig. 1] [10]. This instrument is based on preoperative age, performance status, anesthesia risk score, and CA-125 level. However, this nomogram has yet to be externally validated. The objective of this study was to assess the external validity of the previously developed non-home discharge nomogram.

### Methods

After obtaining approval from the Institutional Review Board, retrospective chart review was performed to identify women undergoing primary CRS via laparotomy for EOC at three tertiary care hospitals within an academic health system from January 1, 2010 to December 31, 2015. Patients were excluded if they received neoadjuvant chemotherapy, had a nonepithelial malignancy or had prior surgery for EOC. Data including postoperative LOS, patient age at time of surgery, preoperative CA-125, Eastern Cooperative Oncology Group (ECOG) performance status, and American Society of Anesthesiologists (ASA) score assigned by anesthesia at time of surgery, and ultimate disposition were extracted from the electronic medical record [11,12]. If multiple preoperative CA-125 values were identified, the value closest to the surgery date was used. We preferentially included ECOG performance status documented at the time of the preoperative visit. In the event that preoperative ECOG performance status was not documented, we used ECOG status from a follow-up visit at least 1 month after surgery. ASA score was identified in the anesthesia perioperative care records. If an individual lacked any of the necessary nomogram variables they were excluded from analysis. Disposition was categorized as: 1) Home without home health care, 2) home with home health care services, 3) skilled nursing facility (SNF) or acute rehabilitation facility, 4) hospice, or 5) in-hospital death. Non-home discharge was defined as any discharge outside of the home and included discharge to SNF, hospice, or inpatient death.

Data was collected and stored using REDCap™, a secure online database, to protect patient confidentiality [13]. Patients were divided into those with and without the outcome and data were summarized using descriptive statistics. Age was compared using Student’s t-test and all other predictors were compared using the Wilcoxon rank-sum test. Model accuracy was measured by ranking an individual’s risk among all subjects in the cohort using the concordance index. Confidence intervals for the concordance index were generated using 1000 bootstrapped samples with replacement. The concordance index, or C-statistic, is a measure of goodness of fit and describes the probability that a patient who experiences non-home discharge would have a higher risk score than a patient who is discharged home. Calibration

![Fig. 1. Nomogram for the prediction of non-home discharge.](image-url)
There were 332 surgical admissions for patients with ovarian cancer during the study period. Patients that received neoadjuvant chemotherapy ($n = 47$), had non-epithelial ovarian cancer ($n = 16$), underwent secondary or later cytoreduction ($n = 18$), had no documented performance status ($n = 35$), or a combination of these factors ($n = 12$) were excluded. A total of 204 women met inclusion criteria (Table 1). Mean age was 60.8 years (SD 11.0). The majority (89%) of patients had ECOG performance status ≤1. The majority of patients (68%) had an ASA score ≥3. The median preoperative CA-125 was 334.4 U/mL (range 1.3 U/mL–34,320 U/mL). Median postoperative LOS for the cohort was 6 days (range 1-45 days). Overall, 25 patients (12%) were not discharged home. Twenty-two patients (11%) were discharged to SNF or acute rehabilitation facility, 3 patients (1.5%) expired during the postoperative course, and no patients were discharged to hospice. Of the 179 patients discharged home, 34 (19%) required home health during the postoperative course, and no patients were discharged to hospice.

Importantly, this analysis included admissions to the preoperative setting and do not require a physician for assessment. The patients in this validation cohort had similar age, performance status, and almost identical rate of non-home discharge as the cohort described by AlHilli et al. However, patients in the validation cohort with non-home discharge were significantly older, had poorer ECOG performance status, higher ASA score, and longer LOS. The validation cohort also demonstrated a wide variation in preoperative CA125 values, and although patients with non-home discharge tended to have higher CA125 values, this did not differ significantly from the home discharge group. This may account for underprediction of the model in patients with probability of non-home discharge between 20 and 60%. The model demonstrated a concordance index of 0.86 in this study compared to a concordance index of 0.88 in the development study [10]. The model was effective for prediction of non-home discharge across all probabilities from 0 to 100%, as it remained within 95% confidence intervals. Thus, application of this nomogram is suitable for all patients undergoing primary CRS for EOC, whether or not they are suspected to be at high risk of non-home discharge. The practicality and ease of use of this risk assessment tool allows it to be easily applied in preoperative patient counseling and discharge planning.

In this study, we were able to validate a previously published model for the prediction of non-home discharge in patients undergoing CRS for ovarian cancer. The non-home discharge nomogram is a simple, easy-to-use means of discussing postoperative recovery course in the preoperative time period and may enable patients and families to plan accordingly for recovery. Additionally, all variables are easily obtained in the preoperative setting and do not require a physician for assessment.

### 3. Results

3. The median preoperative CA-125 was 334.4 U/mL (range 1.3 U/mL–34,320 U/mL). Median postoperative LOS for the cohort was 6 days (range 1-45 days). Overall, 25 patients (12%) were not discharged home. Twenty-two patients (11%) were discharged to SNF or acute rehabilitation facility, 3 patients (1.5%) expired during the postoperative course, and no patients were discharged to hospice. Of the 179 patients discharged home, 34 (19%) required home health services. Patients not discharged home were significantly older, had higher mean CA-125, were more likely to have ASA score ≥3 and more likely to have ECOG performance status ≥2 (Table 2).

Table 3 demonstrates how probabilities may be calculated from a series of sample patients in our cohort. Using the nomogram, points are added accordingly to each weighted preoperative variable and the point total corresponds to a predicted probability of non-home discharge [10]. For example, a 50-year-old woman with a preoperative CA-125 of 1024, ASA score of 2, and ECOG performance status of 0 has a probability of non-home discharge of <1%. By contrast, an 80-year-old patient with preoperative CA-125 of 256, ASA score of 3, and ECOG performance status of 2 has a 70% probability of non-home discharge.

### 4. Discussion

In this study, we were able to validate a previously published model for the prediction of non-home discharge in patients undergoing CRS for ovarian cancer. The non-home discharge nomogram is a simple, easy-to-use means of discussing postoperative recovery course in the preoperative time period and may enable patients and families to plan accordingly for recovery. Additionally, all variables are easily obtained in the preoperative setting and do not require a physician for assessment.
Even with enhanced recovery initiatives, many patients undergoing CRS for EOC will experience prolonged hospital stays and will require complex discharge planning. A significant fraction (11% in the original cohort and 12% in the validation cohort) of women undergoing CRS will require discharge to a rehabilitation facility or SNF. Several groups have reported the application of pre-operative variables to predict risk of non-home discharge in surgical patients. Similar predictive models have been developed and subsequently validated for use in patients undergoing joint arthroplasty, cardiac surgery, and surgery for pancreatic and colorectal cancers [6–9]. In an orthopedic population, it has been reported that prospective application of a predictive nomogram decreased length of stay [7]. However, there are currently no studies reporting the impact of prospective application of these models. While ERAS implementation has expedited physical recovery from surgery and in many cases decreased length of stay, early identification of patients with complex discharge needs would allow for early assessment by care management and avoidance of discharge delays attributed to late planning.

Additionally, implementation of such a tool has the potential to identify patients at risk of prolonged recovery after primary CRS who may benefit instead from neoadjuvant chemotherapy. There is no current consensus on which EOC patients gain the most benefit from neoadjuvant therapy over primary CRS, and prospective randomized trials have supported both primary surgery and neoadjuvant chemotherapy as reasonable treatment standards [17,18]. One strength of this model is its exclusive use of preoperative variables, which would allow for application at initial preoperative consultation. If non-home discharge or prolonged recovery is predicted, this may facilitate discussion regarding

primary surgical management versus neoadjuvant chemotherapy. Furthermore, it is currently unknown whether non-home discharge correlates with delays in adjuvant chemotherapy. Delay in initiation of chemotherapy after CRS for EOC is associated with poorer survival [19–21]. Even delay of chemotherapy initiation just 5 weeks after surgery has been associated with a 7% increase risk of death at 5 years [21]. In this vein, implementation of this model may not only be helpful for counseling patients regarding recovery expectations, but may better inform treatment decisions.

This study has limitations. Due to the retrospective nature of the study, only patients with a documented ECOG performance status were included. In some cases, only postoperative ECOG performance status was available. In order to take into account alterations in performance status due to recovery from surgery, we did not include any ECOG score within 1 month of surgery. This may be associated with inherent selection bias, as patients with poorer ECOG performance status may be more likely to have this documented. However, due to the fact that all included patients underwent surgical intervention, few patients were included with ECOG performance status of 2 or greater. A comparison of our validation cohort with the original cohort demonstrated very similar distribution of performance status as noted in Table 1. Furthermore, the original and validation patient samples are from high-volume academic centers in the Midwest. As such, these data may not represent the full geographic and population diversity of the country.

If applied prospectively, this predictive model has the potential to improve the efficiency of discharge planning for women requiring non-home discharge after surgery for ovarian cancer. Additionally, it may facilitate preoperative discussions with patients and family members to better prepare for recovery from surgery or better inform the decision to proceed with neoadjuvant chemotherapy. Prospective implementation of this risk prediction model may result in a significant decrease in LOS, and subsequent decrease in cost of care.

Conflict of interest statement
The authors have no conflicts of interest to disclose.

Author contributions
The first author EVC developed the research question, obtained IRB approval, participated in data collection, performed statistics, wrote the manuscript and participated in editing and submission. EMN participated in development of the research question, data collection, and manuscript editing. JEJ aided in development of the research question, performed statistical modeling, and participated in editing of the manuscript. MMA assisted in development of the research question, review of IRB proposal, and participated in manuscript editing.

References

Table 3
Sample patients for application of prediction model.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Sample patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>50 60 65 70 80</td>
</tr>
<tr>
<td>CA-125</td>
<td>1024 64 10,500 1024 256</td>
</tr>
<tr>
<td>ASA</td>
<td>2 1 3 2 3</td>
</tr>
<tr>
<td>ECOG</td>
<td>0 1 2 1 2</td>
</tr>
<tr>
<td>Predicted probability</td>
<td>&lt;1% &lt;1% 50% 10% 70%</td>
</tr>
</tbody>
</table>

ECOG = Eastern Cooperative Oncology Group, ASA = American Society of Anesthesiologists.

Fig. 2. Calibration plot of the predictive model in the validation cohort. The dashed line representing ideal or perfect concordance, and dotted line demonstrating model performance across the cohort.
to predict non-home discharge following pancreaticoduodenectomy in a national cohort of patients, HPB 19 (12) (2017) 1037–1045.


