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COVID-19 outcomes of patients with gynecologic cancer in New York City: An updated analysis from the initial surge of the pandemic

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HIGHLIGHTS

• Gynecologic cancer patients with COVID-19 had a case fatality rate of 17.6% during the initial surge of the COVID-19 pandemic.
• Hospitalization due to COVID-19 was associated with age ≥ 65 years, Black race, performance status ≥ 2 and ≥ 3 comorbidities.
• Only former or current history of smoking was associated with death due to COVID-19.
• Recent immunotherapy use was not associated with hospitalization or death due to COVID-19 infection.

ABSTRACT

Background. Despite significant increase in COVID-19 publications, characterization of COVID-19 infection in patients with gynecologic cancer remains limited. Here we present an update of COVID-19 outcomes among people with gynecologic cancer in New York City (NYC) during the initial surge of severe acute respiratory syndrome coronavirus 2 (coronavirus disease 2019 [COVID-19]).

Methods. Data were abstracted from gynecologic oncology patients with COVID-19 infection among 8 NYC area hospital systems between March and June 2020. Multivariable logistic regression was utilized to estimate associations between factors and COVID-19 related hospitalization and mortality.

Results. Of 193 patients with gynecologic cancer and COVID-19, the median age at diagnosis was 65.0 years (interquartile range (IQR), 53.0–73.0 years). One hundred six of the 193 patients (54.9%) required hospitalization; among the hospitalized patients, 13 (12.3%) required invasive mechanical ventilation, 39 (36.8%) required ICU admission. Half of the cohort (49.2%) had not received anti-cancer treatment prior to COVID-19 diagnosis. No patients requiring mechanical ventilation survived. Thirty-four of 193 (17.6%) patients died of COVID-19 complications. In multivariable analysis, hospitalization was associated with an age ≥ 65 years (odds ratio [OR] 2.12, 95% confidence interval [CI] 1.11, 4.07), Black race (OR 2.53, CI 1.24, 5.32) and ≥ 3 comorbidities (OR 2.00, CI 1.05, 3.84). Only former or current history of smoking (OR 2.75, CI 1.21, 6.22) was associated with death due to COVID-19 in multivariable analysis. Administration of cytotoxic chemotherapy within 90 days of COVID-19 diagnosis was not predictive of COVID-19 hospitalization (OR 0.83, CI 0.41, 1.68) or mortality (OR 1.56, CI 0.67, 3.53).
1. Introduction

New York City (NYC) has been a major epicenter of the pandemic caused by SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2 (coronavirus disease 2019 [COVID-19])). Since the onset of this public health crisis, patients with cancer have been assumed to be at higher risk for severe COVID-19 infection and related death. Early reports suggested increased risk of contracting the virus and developing COVID-19 related complications in patients with cancer [1–3]. However, these findings were limited by their heterogeneity, small sample size, lack of generalizability to all cancer types and limited comparisons to cohorts without cancer.

Multi-institutional studies published early in the pandemic showed case fatality rates from 11 to 28% in patients with cancer and 21% among the general population of patients with COVID-19 infection [4–7]. Subset analyses revealed varied mortality rates among cancer types, which is the highest mortality seen in patients with lung cancer (55%) [6]. More recent studies continue to show that the overall fatality rate of COVID-19 patients with cancer is higher than COVID-19 patients without cancer (22.4% vs 5.9%) [8]. While more in-depth analysis has shown patients with leukemia, non-Hodgkin lymphoma, and lung cancer have the highest risk of COVID-19 infection [9].

Notably, patients with gynecologic cancer are underrepresented in these larger studies. Our initial study of patients with gynecologic cancer and COVID-19 infection revealed a case fatality rate of 14%, and revealed no association between cytotoxic chemotherapy or cancer-directed surgery and COVID-19 severity or death. However, immunotherapy was noted to increase risk of mortality in our limited sample size of patients with gynecologic cancer and COVID-19 infection [10]. Given these initial observations of anti-cancer treatment use in patients with gynecologic cancer, specifically immunotherapy, the objective of this study is to provide additional insight into continued cancer-directed therapy in a larger cohort of patients. The primary objective of this multi-institutional study is to explore the relationship between COVID-19 severity in a cohort of patients with both gynecologic cancer and COVID-19. Furthermore, we provide updated clinical and cancer characteristics associated with hospitalization and mortality due to COVID-19.

2. Methods

2.1. Study population

We conducted a multi-institutional, retrospective, observational cohort study at 8 NYC area hospital systems. The study was approved by the institutional review board at each site. Patients 18 years or older with gynecologic malignancy and confirmed SARS-CoV-2 infection from March 1, 2020 and June 1, 2020 (initial surge in NYC) were included. SARS-CoV-2 infection was defined as: a positive result with a real-time reverse transcriptase–polymerase chain reaction assay on a nasopharyngeal swab; serologic confirmation of SARS-CoV-2; or a diagnosis based on radiologic imaging by chest radiograph or chest computed tomography [11]. All included subjects were de-identified prior to data review.

2.2. Data collection

Clinical data were abstracted from the electronic medical record (EMR) for all patients meeting inclusion criteria using Research Electronic Data Capture (REDCap) software (Vanderbilt University).

Conclusions. The case fatality rate among patients with gynecologic malignancy with COVID-19 infection was 17.6%. Cancer-directed therapy was not associated with an increased risk of mortality related to COVID-19 infection.
use required hospitalization compared to non-smokers (65.3% [32/49] vs 51.4% [74/144]).

There were 86 (44.6%) patients with three or more comorbidities. Patients with three or more coexisting illnesses were more likely to require hospitalization (55.7% [59/106] vs 44.3% [47 of 106]; P = 0.002). The most common comorbidity was hypertension (115, 59.6%), followed by diabetes mellitus (70, 36.3%), coexisting malignancies (21, 10.9%), asthma (21, 10.9%) and chronic kidney disease (21, 10.9%). The majority of patients had an ECOG performance status of 0 to 1 (76.7%). Twenty-seven patients had an ECOG performance status of 2 or greater, of which 24 (88.9%) required hospitalization. The most common presenting symptoms of fever (99, 51.3%), cough (94, 48.7%) and shortness of breath (73, 37.8%) were all associated with COVID-19 severity and risk of hospitalization (P values <0.05).

3.2. Cancer characteristics of patients

A wide distribution of gynecologic cancer types was seen in the cohort (Table 2). The most commonly represented cancer types were uterine (87, 45.1%), epithelial ovarian (62, 32.1%), and cervical carcinoma (24, 12.4%). One hundred of 193 (51.8%) patients presented with advanced stage disease. In the group, 50.8% (98 of 193) patients had received cancer directed therapy within 90 days of COVID-19 diagnosis. The most common therapy received was chemotherapy (57, 29.5%) followed by targeted therapy (19, 9.8%) and cancer-directed surgery (12, 6.2%). Of patients who were hospitalized 28.3% [30 of 106] received chemotherapy, 4.7% [5 of 106] underwent surgery and 5.6% [6 of 106] received either immunotherapy, targeted therapy or hormonal therapy in ninety days preceding COVID-19 diagnosis.

3.3. Factors associated with COVID-19 hospitalization and mortality

106 out of 193 patients (54.9%) required hospitalization (Table 3). Among hospitalized patients 90 (84.9%) presented from home. Upon hospitalization, 72.6% (77 of 106) of patients required respiratory intervention. The majority of patients required oxygen via nasal cannula (30, 28.3%), non-rebreather (17, 16.0%) or high flow nasal cannula (17, 16.0%). Invasive mechanical ventilation was required in 12.3% (13 of 106) of patients. No patient requiring invasive ventilation survived. The most common complications secondary to COVID-19 infection were pulmonary, cardiovascular and renal. Table 4 shows the distribution of demographic and cancer characteristics among hospitalized and non-hospitalized patients along with the between group differences and 95% CIs. Hospitalized patients were older (66 years for hospitalized vs 59.1 years for non-hospitalized), more often of Black race, and more commonly had three or more comorbidities with a performance status greater than 2 (55.7% vs 31.0%, difference 24.6% [38.9, 10.3]). Among hospitalized patients, no differences were seen in distribution of patients with respect to cancer status (5.7 [−8.9, 20.2]) or types of cancer-directed therapy.

There were a total of 39 patients who developed severe COVID-19 infections of which 34 (87.2%) died. The case fatality rate among patients with gynecologic cancer with COVID-19 was 17.6%. Of patients who died, 13 (38.2% [13 of 34]) had received chemotherapy while 4 (11.8% [4 of 34]) had received immunotherapy within ninety days of COVID-19 diagnosis. (Fig. 1). Group differences among survivors and non-survivors can be seen in Table 4. Patients who died were more likely to be older, Black, former or current smokers, have 3 or more comorbidities, and have recently received chemotherapy.

Multivariable analyses were performed to account for the associations between factors and risk of hospitalization or COVID-19-related death (Table 5). Patient who were 65 years or older had 2.12 fold greater risk (OR) of hospitalization (95% CI, 1.11, 4.07). Similarly Black race (2.53, 95%CI [1.24, 5.32]), performance status ≥2 (3.67, 95%CI [1.25, 13.51]), and ≥3 comorbidities (2.00, 95%CI [1.05, 3.84]) were all associated with increased risk of hospitalization.

In multivariable analysis specific to COVID-19-related mortality, only former or current smoking use increased the risk of death over 2-fold (2.75, 95%CI [1.21, 6.22]). Age, race, comorbidities, chemotherapy use, and performance status were not associated with death in the multivariable model.

4. Discussion

In our updated analysis of 193 patients with gynecologic malignancy and COVID-19, we examined the baseline demographics, cancer characteristics and determinants of COVID-19 severity and mortality. Over 50% of patients with gynecologic malignancy and COVID-19 required hospitalization. Similar to what has been described in the literature, age, Black race, poorer performance status and presence of three or more comorbidities was associated with increased need for hospitalization due to COVID-19 [4,15–17].

The overall mortality among our cohort of COVID-19 infected patients was 17.6%. In the multivariable analysis, only smoking habits maintained a significant association with death. Thirty nine of 193
(20%) of patients developed severe COVID-19 infection requiring ICU admission. Of these patients, 13 required intubation. Similar to our previous report, no patients requiring intubation survived, which could be informative when counseling patients with severe COVID-19 infection.

Our data shows that while 50% of patients that required hospitalization were receiving cancer-directed therapy, even the most common therapy (cytotoxic chemotherapy), did not affect hospitalization or mortality in patients with COVID-19 on multivariable analysis. Despite initial report of increased mortality for patient with gynecologic cancer and COVID-19 who were receiving immunotherapy, immunotherapy was not associated with an increased risk of death due to COVID-19 in this expanded cohort. However, we do acknowledge our small study cohort, and the need for large scale registries to define risk of cancer disease status and recent therapeutics in greater detail. This is particularly important because recent immunotherapy use has been linked to increased risk of COVID-19 mortality in cancer patients, specifically lung cancer compared to any other malignances [18].

Our data demonstrate that in patients with gynecologic cancer, the risk of severe COVID-19 outcomes is largely driven by age, race, and comorbidities. This corresponds with recent literature, where numerous studies have identified important demographic and clinical factors that increase risk of COVID-19 severity in the non-cancer population. Age is one of the most important risk factors for COVID-19 severity, and one meta-analysis demonstrated an exponential relationship between age and COVID-19 mortality rates, increasing from 0.01% at age 25, to 1.4% at age 65 and 15% at age 85 [19]. In our patient cohort, the median age at the time of COVID-19 diagnosis was 65 years and those over 65 years had two times greater risk of hospitalization. There is also robust evidence that pre-existing conditions, such as cardiovascular disease, chronic kidney disease, chronic lung conditions, diabetes mellitus, hypertension, and obesity predispose patients to more severe COVID-19 outcomes [20–25]. According to an American College of Cardiology clinical bulletin, COVID-19 fatality rates are 10.5% for patients with cardiovascular disease, 7.3% for diabetes, 6.3% for COPD, and 6.0% for hypertension, compared to <1% for patients without pre-existing conditions [20]. In our patient cohort, 45% of patients who had three

Table 2
Cancer characteristics.

| Characteristic                           | Overall | Mild | Moderate | Severe |
|------------------------------------------|---------|------|----------|--------|
| Cancer type, No. (%)                     | 193     | 87   | 67       | 39     |
| Uterine                                  | 87 (45.1) | 34 (39.0) | 36 (53.7) | 17 (43.6) |
| Epithelial ovarian carcinoma             | 62 (32.1) | 31 (35.6) | 15 (22.4) | 16 (41.0) |
| Cervical carcinoma                       | 24 (12.4) | 10 (11.5) | 10 (14.9) | 4 (10.3) |
| Vulvar carcinoma                         | 8 (4.1) | 7 (8.0) | 1 (1.5) | 0 (0.0) |
| Non-Epithelial ovarian carcinoma         | 6 (3.1) | 1 (1.1) | 3 (4.4) | 2 (5.1) |
| Gestational trophoblastic disease        | 3 (1.6) | 2 (2.3) | 1 (1.5) | 0 (0.0) |
| Vaginal carcinoma                        | 2 (1.0) | 1 (1.1) | 1 (1.5) | 0 (0.0) |
| Stage, No. (%)                           |         |      |          |        |
| I/II                                     | 74 (38.3) | 35 (40.2) | 25 (37.3) | 14 (35.9) |
| III/IV                                   | 100 (51.8) | 49 (56.3) | 30 (44.8) | 21 (53.8) |
| Unknown                                  | 19 (9.8) | 3 (3.4) | 12 (17.9) | 4 (10.3) |
| Cancer status, No. (%)                   |         |      |          |        |
| Remission                                | 77 (39.9) | 32 (36.8) | 31 (46.3) | 14 (35.9) |
| Evidence of disease                      | 116 (60.1) | 55 (63.2) | 36 (53.7) | 25 (64.1) |

Table 3
Characteristics of hospitalized patients.

| Characteristic                           | Overall | Mild | Moderate | Severe |
|------------------------------------------|---------|------|----------|--------|
| Admitted from, No. (%)                   | 100     | 67   | 39       |
| Home                                     | 90 (90) | 58 (66) | 32 (82) |
| Skilled nursing facility/rehab           | 10 (10) | 5 (7) | 5 (12) |
| Hospital Transfer                        | 3 (3)   | 2 (3) | 1 (2) |
| Other                                    | 3 (3)   | 2 (3) | 1 (2) |
| VITAL signs on ED admission, median (IQR) |         |      |          |        |
| Temperature, median (IQR), °F            | 99 [98, 100] | 99 [98, 100] | 98 [98, 100] |
| Heart rate, beats/min                    | 104 [85, 116] | 101 [82, 112] | 109 [95, 118] |
| Respiratory rate, breaths/min            | 20 [18, 24] | 20 [18, 24] | 21 [20, 24] |
| Oxygen saturation, %                     | 94 [91, 97] | 94 [91, 98] | 94 [80, 96] |
| Highest level of respiratory intervention, No. (%) |         |      |          |        |
| Nasal cannula                            | 30 (28.3) | 26 (28.8) | 4 (10.3) |
| Non-rebreather                           | 17 (16.0) | 11 (11.6) | 6 (15.4) |
| High-flow nasal cannula                  | 13 (12.3) | 5 (7.5) | 8 (20.5) |
| BIPAP                                    | 4 (3.8) | 0 (0.0) | 4 (10.3) |
| Invasive mechanical ventilation          | 13 (12.3) | 0 (0.0) | 13 (33.3) |
| Complications, No. (%)                   |         |      |          |        |
| Multiorgan failure                       | 9 (8.5) | 0 (0.0) | 9 (23.1) |
| Pulmonary complications                   | 66 (62.3) | 33 (49.3) | 33 (84.6) |
| Cardiovascular complications             | 16 (15.1) | 3 (4.5) | 13 (33.3) |
| Renal failure                            | 21 (19.8) | 8 (11.9) | 13 (33.3) |
| Sepsis                                   | 12 (11.3) | 4 (6.0) | 8 (20.5) |
| Bleeding                                 | 3 (2.8) | 3 (4.5) | 0 (0.0) |
| Treatments, No. (%)                      |         |      |          |        |
| Chloroquine                              | 1 (0.5) | 1 (1.5) | 0 (0.0) |
| Hydroxychloroquine                       | 53 (27.5) | 32 (47.8) | 19 (48.7) |
| Azathioprine                             | 47 (24.4) | 25 (37.3) | 18 (46.2) |
| Corticosteroids                          | 6 (3.1) | 2 (3.0) | 3 (7.7) |
| Tocilizumab                              | 3 (1.6) | 3 (4.5) | 0 (0.0) |
| Plasma from recovered                    | 5 (2.6) | 3 (4.5) | 2 (5.1) |
| individuals                              |         |      |          |        |
| Anticoagulation                          | 19 (9.8) | 9 (13.4) | 9 (23.1) |
| Clinical outcome at data cutoff, No. (%)  |         |      |          |        |
| Fully recovered                          | 48 (45.3) | 47 (70.1) | 1 (2.6) |
| Recovered with complications             | 14 (13.2) | 12 (17.9) | 2 (5.1) |
| Ongoing infection                        | 10 (9.4) | 8 (11.9) | 2 (5.1) |
| Died of COVID-19 related complications   | 34 (32.1) | 0 (0.0) | 34 (87.2) |
Table 4
Demographic and cancer characteristics among hospitalized patients and survivors of COVID-19.

|                  | Not Hospitalized | Hospitalized | Difference (95% CI) | Survivors | Nonsurvivors | Difference (95% CI) |
|------------------|------------------|--------------|---------------------|-----------|--------------|---------------------|
| Age, mean ± SD, y| 59.1 ± 13.4      | 66.2 ± 11.6  | −7.1 (−10.7, −3.5)  | 61.9 ± 13.0 | 68.1 ± 11.6  | −6.2 (−10.7, −1.7)  |
| Race, %          |                  |              |                     |           |              |                     |
| White            | 52.9             | 41.5         | 11.4 (−3.4, 26.1)   | 47.2      | 44.1         | 3.1 (−11.7, 17.9)   |
| Black            | 21.8             | 45.3         | −23.4 (−37.1, −9.8) | 33.3      | 41.2         | −7.8 (−22.2, 6.5)   |
| Other            | 25.3             | 13.2         | 12.1 (0.3, 23.9)    | 19.5      | 14.7         | 4.8 (−6.6, 16.2)    |
| Hispanic ethnicity, % | 24.1         | 17           | 7.2 (−5.0, 19.3)    | 19.5      | 23.5         | −4.0 (−16.4, 8.3)   |
| Smoking history, %|                 |              |                     |           |              |                     |
| Current Smoker   | 3.4              | 5.7          | −2.2 (−9.0, 4.6)    | 3.1       | 11.8         | −8.6 (−16.8, −0.4)  |
| Former smoker    | 16.1             | 24.5         | −8.4 (−20.5, 3.7)   | 18.2      | 32.4         | −14.1 (−27.0, −1.2) |
| Never Smoker     | 80.5             | 69.8         | 10.6 (−2.2, 23.5)   | 78.6      | 55.9         | 22.7 (9.1, 36.4)    |
| Comorbidities, % |                  |              |                     |           |              |                     |
| Hypertension     | 47.1             | 69.8         | −22.7 (−37.0, −8.4) | 56.6      | 73.5         | −16.9 (−30.9, −2.9) |
| Diabetes mellitus| 24.1             | 46.2         | −22.1 (−36.0, −8.2) | 34        | 47.1         | −13.1 (−27.6, 1.4)  |
| Coexisting malignancies | 11.5         | 10.4         | 1.1 (−8.5, 10.8)    | 8.8       | 20.6         | −11.8 (−22.5, −1.1) |
| Asthma           | 6.9              | 14.2         | −7.3 (−16.7, 2.2)   | 10.7      | 11.8         | −1.1 (−10.8, 8.7)   |
| Chronic obstructive pulmonary disease | 1.1            | 3.8          | −2.6 (−7.9, 2.7)    | 1.9       | 5.9          | −4.0 (−10.3, 2.3)   |
| Obstructive sleep apnea | 2.3            | 9.4          | −7.1 (−14.6, 0.3)   | 5         | 11.8         | −6.7 (−15.4, 1.9)   |
| Coronary artery disease | 3.4            | 9.4          | −6.0 (−13.7, 1.8)   | 5.7       | 11.8         | −6.1 (−14.9, 2.7)   |
| Autoimmune disease | 9.2             | 9.4          | −0.2 (−8.5, 8.1)    | 8.2       | 14.7         | −6.5 (−16.3, 3.2)   |
| Chronic kidney disease | 3.4             | 17           | −13.5 (−22.7, −4.4) | 8.8       | 20.6         | −11.8 (−22.5, −1.1) |
| Comorbidities: ≥3 % | 31              | 55.7         | −24.6 (−38.9, −10.3)| 41.5      | 58.8         | −17.3 (−32.0, −2.7) |
| Body mass index, mean ± SD, kg/m2 | 30.0 ± 7.5      | 33.0 ± 10.1  | −3.0 (−5.6, −0.5)   | 31.6 ± 8.4 | 32.1 ± 12.0  | −0.6 (−5.0, 3.9)    |
| Performance status ≥2, % | 4.6             | 21.7         | −17.1 (−27.2, −7.0) | 10.7      | 29.4         | −18.7 (−30.5, −6.9) |
| Stage III/IV, %  | 56.3             | 48.1         | 8.2 (−6.6, 23.0)    | 50.9      | 55.9         | −4.9 (−19.7, 9.9)   |
| Cancer status, Active disease, % | 63.2            | 57.5         | 5.7 (−8.9, 20.2)    | 58.5      | 67.6         | −9.2 (−23.5, 5.2)   |
| Currently undergoing treatment for cancer, % |                   |              |                     |           |              |                     |
| Initial cancer therapy | 24.1            | 17.9         | 6.2 (−6.0, 18.5)    | 21.4      | 17.6         | 3.7 (−8.2, 15.7)    |
| Treatment for recurrence | 18.4            | 17.9         | 0.5 (−10.7, 11.6)   | 17        | 23.5         | −6.5 (−18.7, 5.6)   |
| Noncurative/palliative therapy | 4.6             | 7.5          | −2.9 (−10.6, 4.7)   | 6.3       | 5.9          | 0.4 (−6.6, 7.4)     |
| Maintenance therapy | 6.9              | 0.9          | 6.0 (−0.4, 12.3)    | 4.4       | 0            | 4.4 (−0.6, 9.4)     |
| Most recent anticancer treatment, % |                   |              |                     |           |              |                     |
| Surgery          | 8                | 4.7          | 3.3 (−4.4, 11.1)    | 6.3       | 5.9          | 0.4 (−6.6, 7.4)     |
| Cytotoxic chemotherapy | 31              | 28.3         | 2.7 (−10.9, 16.4)   | 27.7      | 38.2         | −10.6 (−24.5, 3.4)  |
| Immunotherapy    | 5.7              | 5.7          | 0.1 (−0.4, 6.6)     | 4.4       | 11.8         | −7.4 (−15.8, 1.1)   |
| Targeted therapy | 14.9             | 5.7          | 9.3 (0.0, 18.6)     | 11.3      | 2.9          | 8.4 (0.3,16.4)      |
| Hormone therapy  | 5.7              | 5.7          | 0.1 (−6.4, 6.6)     | 6.3       | 2.9          | 3.3 (−3.4,10.1)     |
| Radiotherapy     | 5.7              | 2.8          | 2.9 (−3.7, 9.5)     | 5         | 0            | 5.0 (−0.3,10.3)     |
| History of surgery in last 60 d, % | 21.8            | 12.3         | 9.6 (−1.8,20.9)     | 15.7      | 20.6         | −4.9 (−16.5, 6.8)   |

Cancer directed therapy

Fig. 1. Percent of patients who received cancer-directed therapy within 90 days prior to COVID diagnosis.
The pandemic continues. To make informed decisions on continuing cancer-directed therapy as we found in this cohort, immunotherapy was not associated with directed therapy were associated with COVID-19 severity. Importantly, the population served by these institutions is racially and ethnically diverse. These data include outcomes of form recommendations in patients with gynecologic malignancies. As widespread vaccination becomes available, we must continue to obtain additional data to interpret the data, vouched for the data analysis, contributed to the editing of the manuscript, and agreed to publication of this study.

Table 5

| Exposure Variable                          | Hospitalization OR (95% CI) | Mortality OR (95% CI) |
|-------------------------------------------|----------------------------|----------------------|
| Age: 65 years old or older                | 2.12 (1.11, 4.07)          | 1.74 (0.75, 4.14)    |
| Black/African American                    | 2.53 (1.24, 5.32)          | 1.20 (0.50, 2.85)    |
| Other race                                | 0.80 (0.33, 1.92)          | 0.92 (0.26, 2.88)    |
| Performance status: ≥2                    | 3.67 (1.25, 13.55)         | 2.59 (0.96, 6.80)    |
| Comorbidities: ≥3                        | 2.00 (1.05, 3.84)          | 1.51 (0.67, 3.42)    |
| History of smoking                        | 1.65 (0.80, 3.49)          | 2.75 (1.21, 6.22)    |
| Cytotoxic chemotherapy*                   | 0.83 (0.41, 1.68)          | 1.56 (0.67, 3.53)    |

* Cytotoxic chemotherapy administered within 90 days of COVID-19 diagnosis.

or more comorbidities and were more likely to require hospitalization for COVID-19.

Initial studies reporting COVID-19 outcomes suggested patients with cancer harbored a 2-fold higher risk of COVID-19 infection compared with the community [1,26]. Patients with lung cancer were found to be of higher risk of developing COVID-19 representing the majority of cancer patients in these single institution studies. Additionally, these studies found fewer than half of patients with cancer had received cancer-directed therapy prior to developing COVID-19 offering limited insight into continuing cancer therapy.

Subsequent studies have yielded contradictory results. A single institute study from NYC of 5688 patients of which 6% had cancer revealed the rate of death between cancer and noncancer patients was not significantly different [27]. In the largest cohort of 800 patients with cancer, which included only 45 patients with gynecologic cancers, recent chemotherapy use was not significantly associated with increased mortality. No association between recent immunotherapy, hormonal therapy, targeted therapy or radiotherapy and COVID-19 mortality was observed [28]. These results are in line with our findings that COVID-19 mortality in patients with cancer is largely driven by age, and the presence of comorbidities.

Our analysis has a number of limitations. Our outcomes are based on data collected during the first wave of the COVID-19 pandemic in NYC. Given our limited testing capabilities at this time we likely under captured a subset of patients with asymptomatic or mild infections who were not tested; thus, we may have overestimated the rate of hospitalization and mortality due to COVID-19. Hospital admission criteria varied between institutions, which is also a limitation of this study. Additionally, we examined outcomes in patients who were largely symptomatic who sought help through established care, biasing our outcomes further. By limiting our data collection to the first months of the pandemic we did not evaluate the effect of recent treatment modalities, including monoclonal antibodies, on the course of COVID-19 infection. Finally, with our small sample size we were unable to identify determinants of mortality. The ongoing Society of Gynecologic Oncology COVID-19 registry will help to establish a larger sample size to confirm the generalizability of our results. Finally, our findings also represent data prior to the implementation of COVID-19 vaccinations. As widespread vaccinations become available, we must continue to obtain additional data to inform recommendations in patients with gynecologic malignancies.

Despite these limitations, our study represents data collected from 8 academic hospital systems across NYC. These data include outcomes of both private and public hospitals in a high COVID-19 burden area. Additionally, the population served by these institutions is racially and ethnically diverse and has provided data on racial disparities in patients with COVID-19 and gynecologic malignancy [29].

In summary, this study highlights that in patients with gynecologic malignancy and COVID-19 neither their cancer burden, nor cancer-directed therapy were associated with COVID-19 severity. Importantly we found in this cohort, immunotherapy was not associated with COVID-19 severity or mortality. These findings should allow clinicians to make informed decisions on continuing cancer-directed therapy as the pandemic continues.

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Author contributions

O.D.L., M.S., and B.P. contributed to the study design, acquired and analyzed data, generated figures, and wrote the manuscript. R.O.C., C.C., S.V.B., E.C.D., V.K., A.K., J.E., L.G., S.C., J.F., Y.L., contributed to data acquisition. Y.W. and M.L. performed statistical analysis. R.O.C., J.W., S.V.B. and S.I. provided intellectual input. All authors contributed to the interpretation of data, vouched for the data analysis, contributed to the editing of the manuscript, and agreed to publication of this study.

Declaration of Competing Interest

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