Research Article

A Meta-analysis for Prevalence of Lung Cancer Patients with SARS-CoV-2 Infection during the COVID-19 Pandemic

🅛 **Mohsen Gholi-Nataj,**[1] 🅛 **Shahab Rafieian,**[2] 🅛 **Maedeh Barahman,**[3] 🅛 **Ahmad Shirinzadeh-Dastgiri,**[4] 🅛 **Mohammad Vakili,**[5] 🅛 **Reza Ershadi,**[6] 🅛 **Hamid Mirjalili,**[7] 🅛 **Fatemeh Asadian,**[8] 🅛 **Hossein Neamatzadeh**[9]

[1]Department of Internal Medicine, Shahid Sadoughi University of Medical Sciences and Health Services, Yazd, Iran
[2]Department of Thoracic Surgery, Imam Khomeini Hospital, Tehran University of Medical Sciences, Tehran, Iran
[3]Firoozgar Clinical Research Development Center (FCRDC), Firoozgar Hospital, Iran University of Medical Sciences, Tehran, Iran
[4]Department of Surgery, Faculty of Medicine, Shohadaye Hafte-e-tie hospital, Iran University of Medical Sciences, Tehran, Iran
[5]Department of Surgery, Faculty of Medicine, Ardabil University of Medical Sciences, Ardabil, Iran
[6]Department of Thoracic Surgery, Valiasr Hospital, Tehran University of Medical Sciences, Tehran, Iran
[7]Department of Medical Laboratory Sciences, School of Paramedical Science, Shiraz University of Medical Sciences, Shiraz, Iran
[8]Department of Emergency Medicine, Shahid Sadoughi University of Medical Sciences and Health Services, Yazd, Iran
[9]Mother and Newborn Health Research Center, Shahid Sadoughi University of Medical Sciences, Yazd, Iran

Abstract

Objectives: Cancer patients were found to be at higher risk of infection with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and experienced more adverse outcomes. The objective of this meta-analysis was to estimate the prevalence of lung cancer patients with SARS-CoV-2 infection during the COVID-19 pandemic.

Methods: A comprehensive search was carried out on PubMed, Web of Science, Scopus, MedRxiv, SciELO, SID, CNKI, and Wanfang databases to retrieve all relevant publications. All cross-sectional studies and consecutive case series on cancer patients with SARS-CoV-2 infection were selected.

A total of 28 studies including 5400 infected cancer patients and 767 lung cancer patients with COVID-19 were included.

Results: Combined data indicated that the prevalence of lung cancer patients with SARS-CoV-2 infection was 15.2% (95% CI, 0.111–0.205) overall. Stratified analysis by ethnicity showed that the prevalence was 16.4% and 15.4% in Asian and Caucasian lung cancer patients with COVID-19, respectively. Moreover, subgroup analysis by country of origin showed that the prevalence was highest in China (19.3.0%) followed by France (12.6%), the UK (10.7%), and the USA (8.3%).

Conclusion: This meta-analysis revealed that the prevalence of lung cancer patients with SARS-CoV-2 infection during the COVID-19 pandemic was 15.2%.

Keywords: SARS-CoV-2, COVID-19, lung cancer, infection, meta-analysis

Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has caused a major public health issue globally.[1–4]

Up to March 30, the World Health Organization (WHO) reported more than 131 million confirmed cases worldwide, and more than 2.8 million people lost their lives globally.

[5] Although mild upper respiratory tract infection is the most common clinical presentation of COVID-19, many infected patients have shown progressive respiratory failure. [6,7] Comorbidities that are widespread in infected patients with COVID-19 were hypertension, diabetes mellitus, respiratory system disease, and cardiovascular disease.[3,8,9] Therefore, the handling of persons with these underlying conditions during the COVID-19 pandemic is a crucial issue.[10,11] Moreover, it is obvious that people with chronically impaired immune host response have an increased risk of infection with COVID-19 and experience more adverse outcomes.[12,13]

It has been reported that patients with cancer have been negatively affected by SARS-CoV-2 infection, and the virus poses significant challenges for the management of those patients.[6,14] Cancer patients with COVID-19 have a higher risk of severe disease, increased ventilation requirements, and mortality when compared with the general population.[15–17] The immunological alternation in individuals with cancer and the use of intensely immunosuppressive medications might cause a combination of higher risk of infection with COVID-19 and likelihood of worse results of infection, such as cytokine storm and multiorgan failure. [6,11,18] Thus, managing individuals with cancer during the pandemic is a complex issue due to the vulnerable status of those patients and the nature of cancer.[19,20] Aging and smoking were associated with a higher risk of SARS-CoV-2 infection in cancer patients.[21–23] It is reported that individuals with an underlying malignancy diagnosed with SARS-CoV-2 infection were older, more probably to be smokers, and had more severe computed tomography (CT) findings. [24,25] Thus, the clinical outcome such as intensive care unit (ICU) admission and death of COVID-19 in patients with an underlying malignancy were worse when compared with patients without malignancy.[26,27]

Since the report of the first case, several theories have been postulated that patients with cancer might be at increased risk of COVID-19 infection, particularly lung cancer patients. [28,29] Moreover, some studies have shown that the severity and mortality of COVID-19 are higher in cancer patients when compared with the general population.[30] However, it is reasonable to assume that different malignancies had different risks to the SARS-CoV-2 infection,[31] especially patients with lung cancer were reported to be at high risk of pulmonary complications related to SARS-CoV-2 infection.[10] Recently, a study in New York revealed that 55% of lung cancer patients were infected with SARS-CoV-2.[32,33] It has been shown that angiotensin-converting enzyme 2 and interferon gamma-induced protein 10 are two possible biomarkers that play a crucial role in the higher risk and mortality of lung cancer patients infected with SARS-

CoV-2.[29] There is no estimation of the prevalence of lung cancer patients with SARS-CoV-2 infection. Therefore, we carried out this meta-analysis to estimate the prevalence of lung cancer patients with SARS-CoV-2 infection during the pandemic.

Materials and Methods

Identification of Relevant Studies

We performed a universal bibliographic search on PubMed/ MEDLINE, Google Scholar, MedRxiv, EMBASE, Scopus, Cochrane Library database, SciELO, Springer Link, Scientific Information Database (SID), Chinese Biomedical Database (CBD), China National Knowledge Infrastructure (CNKI) platforms, VIP, Chinese literature (Wanfang) and China Science and Technology Journal database, and Egyptian Knowledge Bank (EKB) Journals to identify all relevant studies on SARS-CoV-2 infection in cancer patients published up to February 5, 2021. The combination of the following search terms and keywords were applied: "Coronavirus Disease 2019" or "COVID-19" or "Severe Acute Respiratory Syndrome Coronavirus 2" or "SARS-CoV-2" and "Lung Carcinomas" or "Lung Adenocarcinoma" or "Lung Cancer" or "Small Cell Lung Cancer" or "Non-small Cell Lung Cancer." We restricted our search to adult human studies. However, there was no language restriction in this meta-analysis. In addition, we manually screened all references of retrieved articles and reviews for further relevant articles.

Inclusion and Exclusion Criteria

The following inclusion criteria were used to select literature for the meta-analysis: (1) cross-sectional studies and consecutive case series; (2) studies on cancer patients with SARS-CoV-2 infection; and (3) sufficient data were presented to calculate the odds ratio (OR) with 95% confidence interval (CI). The following exclusion criteria were used: (1) no usable data reported; (2) studies that did not report the number of lung cancer patients with SARS-CoV-2 infection; (3) in vitro studies; (4) posters, abstracts, case reports, nonconsecutive case series, conference papers, reviews, previous meta-analyses, and nonstandard data presentation; and (5) duplicate publications.

Data Extraction

Two authors independently reviewed the abstracts and full text of the selected studies in the primary search and extracted the necessary data into a standardized form. The duplicates were removed and the titles of articles were then evaluated. When the authors were not in agreement, a third author was involved to reach a consensus. We collected the following information from all selected primary

papers: first author's name, year of publication, country of origin, ethnic group of the study population, mean age (or age range), gender, total number of cancer patients with SARS-CoV-2 infection, total number of lung cancer patients with SARS-CoV-2 infection, and type of treatment. If a duplicate publication was found or the same population was used in multiple studies, the article with the larger sample size was selected for further analysis. The corresponding author was contacted through email or over the telephone for any missing data.

Quality Assessment

Before the inclusion of selected studies in the meta-analysis, the methodological quality of the selected studies was assessed by the Newcastle–Ottawa scale (NOS).[34] The NOS ranges from zero to nine points: selection of patients (4 points), comparability of the groups (2 points), and ascertainment of exposure (3 points). Each selected study was interpreted to be of low quality (for scores ≤ 4), moderate quality (for scores 5–6), or high quality (for scores ≥ 7). Two authors assessed the quality of included studies independently, and all disagreements were resolved by discussion or by consulting with the third author.[35,36]

Data Synthesis

The prevalence of lung cancer patients with SARS-CoV-2 infection was assessed by OR with 95% CI based on the infection frequencies between cases (all cancer patients with COVID-19) and controls (lung cancer patients with COVID-19). The significance of pooled OR was determined using the Z-test in which $p < 0.05$ was defined as the significance threshold. Between-study heterogeneity was evaluated by the X^2-based Q-statistic in which $p \leq 0.10$ indicated significant heterogeneity. Moreover, the I^2 statistic (range of 0%–100%) was utilized to qualify the heterogeneity (I^2=0%–25%, no heterogeneity; I^2=25%–50%, moderate heterogeneity; I^2=50%–75%, large heterogeneity; and I^2=75%–100%, extreme heterogeneity). If between-study heterogeneity existed statistically, a random effect model (DerSimonian and Laird method) was adopted; otherwise, a fixed effect model (the Mantel–Haenszel method) was used in the absence of heterogeneity. A visual inspection of the funnel plot was used to assess potential publication bias. Moreover, Egger's test was performed to assess the publication bias statistically in which p<0.05 was considered statistically significant.[37] If the publication bias tests indicated the existence of the bias, the Duval and Tweedie "trim and fill" method was used to adjust the bias. All of the statistical calculations were performed using Comprehensive Meta-Analysis software version 2.0 (Biostat, USA). Two-sided p-values < 0.05 were considered statistically significant.

Results

Characteristics of Eligible Studies

As shown in Figure 1, our initial search yielded 567 studies. After removing duplicate studies, the remaining studies were 319. Among them, 206 studies were excluded after the assessment of the titles and abstracts. Subsequently, 85 studies were excluded because they did not provide useful data for analyses, reviews, case reports, nonconsecutive case series, and cancers other than lung cancer. Finally, a total of 28 studies[15,32,38–63] including 5400 infected cancer patients and 767 lung cancer patients with COVID-19 were considered. The main characteristics of the selected studies are presented in Table 1. All included studies were retrospective and case series published in English and Chinese between July 2020 and November 2020. The sample size of the infected cancer patients ranged from 12 to 1044 with 5–180 lung cancer patients with SARS-CoV-2 infection. Of the total studies, 13 studies were performed among Asians (1508 all cancer patients with 207 lung cancer patients), 14 among Caucasians (3711 all cancer patients with 553 lung cancer patients), and 1 in a mixed population (181 all cancer patients with 7 lung cancer patients). The majority of study patients came from China (n=11, with 689 all cancer patients with 106 lung cancer patients) followed by the USA (n=5), France (n=3), the UK (n=2), Italy (n=1), Spain (n=1), Pakistan (n=1), Iran (n=1), and Brazil (n=1). As shown in Table 1, quality scores ranged from 6 to 9, indicating that all included studies had high-quality scores.
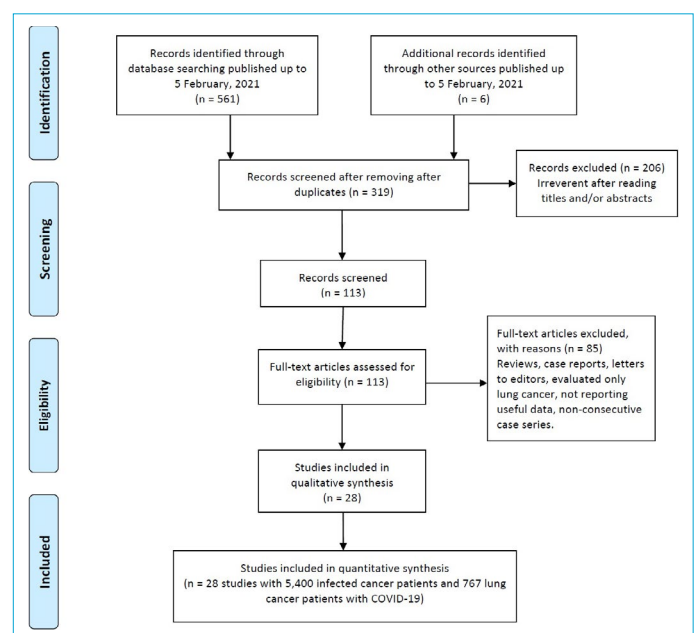

Figure 1. Flowchart of literature search and selection process in the meta-analysis.

Table 1. Main characteristics of the included studies in the current meta-analysis

Reference	Country (ethnicity)	Sample size*	Age (range)	F/M	Lung cancer with COVID-19	Cancer treatment in total cases					NOS
						Surgery	Radiotherapy	Chemotherapy	Targeted therapy	Immunotherapy	
Yang et al., 2020	China (Asian)	52	63 (56–70)	24/28	10	2 (3.8)	0 (0.0)	6 (11.5)	0 (0.0)	0 (0.0)	7
Yang et al., 2020	China (Asian)	205	63 (56–70)	109/96	24	4 (2.0)	9 (4.4)	31 (15.1)	12 (5.9)	4 (2.0)	8
Tian et al., 2020	China (Asian)	232	64 (58–69)	113/119	23	197 (84.9)	214 (92.2)	32 (13.8)	8	8	
Yu et al., 2020	China (Asian)	12	66 (48–78)	2/10	7	0 (0.0)	3 (25.0)	3 (25.0)	1 (8.3)	2 (16.7)	7
Liang et al., 2020	China (Asian)	18	62 (56–68)	6/12	5	1 (5.6)	0 (0.0)	2 (11.1)	2 (11.1)	1 (5.6)	8
Ma et al., 2020	China (Asian)	37	62 (59–70)	17/20	8	NA	NA	NA	NA	NA	8
Zhang et al., 2020	China (Asian)	28	65 (56–70)	11/17	7	5 (17.9)	4 (14.3)	10 (35.7)	3 (10.7)	1 (3.6)	7
Zhang et al., 2020	China (Asian)	107	66 (36–98)	47/60	21	5 (4.7)	NA	15 (14.0)	NA	6 (5.6)	6
Zhang et al., 2020	China (Asian)	67	66 (37–90)	26/41	15	NA	2 (2.9)	9 (13.4)	NA	2 (2.9)	6
Dai et al., 2020	China (Asian)	105	64 (55–69)	48/57	22	8 (7.6)	13 (12.4)	17 (16.2)	4 (3.8)	6 (5.7)	8
Wang et al., 2020	China (Asian)	283	63 (55–70)	142/141	51	23 (8)	NA	46 (16)	12 (4)	NA	6
Ali et al., 2020	Pakistan (Asian)	201	45 (18–78)	115/86	3	22 (10.9)	13 (6.5)	146 (72.6)	2 (1)	0 (0.0)	8
Aznab et al., 2020	Iran (Asian)	161	NA	NA	11	NA	NA	NA	NA	NA	6
Barlesi et al., 2020	France (Caucasian)	137	61 (21–90)	79/58	12	0 (0.0)	0 (0.0)	48 (35.0)	18 (13.1)	12 (8.8)	8
Basse et al., 2020	France (Caucasian)	141	62 (52–72)	102/39	18	11 (7.8)	13 (9.2)	69 (48.9)	22 (15.6)	8 (5.7)	7
Assaad et al., 2020	France (Caucasian)	302	58.2	158/144	42	NA	NA	NA	NA	NA	6
Garassino et al., 2020	TERAVOLT	200	68 (62–75)	59/141	180	0 (0.0)	0 (0.0)	68 (34.0)	28 (14.0)	54 (27.0)	9
Mehta et al., 2020	USA (Caucasian)	218	69 (10–92)	91/127	11	0 (0.0)	49 (22.5)	42 (19.3)	0 (0.0)	5 (2.3)	8
Robilotti et al., 2020	USA (Caucasian)	423	0–64	211/212	35	NA	NA	191	NA	31	6
Jee et al., 2020	USA (Caucasian)	309	NA	150/159	29	NA	NA	102 (33.0)	49 (15.9)	18 (5.8)	6
Miyashita et al., 2020	USA (Caucasian)	334	NA	NA	23	NA	NA	NA	NA	NA	6
Kabaritti et al., 2020	USA (Caucasian)	107	70 (30–95)	54/53	14	NA	NA	NA	NA	NA	6
Russeli et al., 2020	UK (Caucasian)	156	65	66/90	17	NA	NA	45 (55.6)	5 (6.2)	7 (8.6)	7
Lee et al., 2020	UK (Caucasian)	1044	70 (60–77)	445/595	111	NA	NA	NA	NA	NA	6
Elkrief et al., 2020	Caucasian**	252	73 (4–95)	125/127	36	NA	NA	NA	NA	NA	6
Stroppa et al., 2020	Italy (Caucasian)	25	71 (50–84)	5/20	8	NA	NA	8 (66.67)	NA	4 (33.33)	6
Yarza et al., 2020	Spain (Caucasian)	63	66 (63–68)	29/34	17	NA	NA	26	3	7	6
de Melo et al., 2020	Brazil (mixed)	181	55 (2–88)	110/71	7	12 (6.6)	10 (5.5)	63 (34.8)	9 (5.0)	NA	6

*All cancer cases with SARS-CoV-2 infection; **Multinational (European countries); TERAVOLT: Thoracic cancers international COVID-19 collaboration; NA: Not available; F/M: Female/male; NOS: Newcastle–Ottawa scale.

Quantitative Data Synthesis

The pooled data on the prevalence of lung cancer patients with SARS-CoV-2 infection are shown in Table 2. As shown in Table 2, the Q-statistic test showed that there was a significant heterogeneity (I^2=79.53%, p≤0.001). Thus, we used the random effect model (DerSimonian and Laird method) for the prevalence in the overall population. Combined data from 28 publications showed that the prevalence of lung cancer patients with SARS-CoV-2 infection was 15.2% (95% CI, 0.111–0.205, Fig. 2) overall. Stratified analysis by ethnicity showed that the prevalence was 16.4% (95% CI, 0.120–0.220, Fig. 3a) in Asian and 15.4% (95% CI, 0.093–0.245, Fig. 3b) in Caucasian lung cancer patients with SARS-CoV-2 infection. Moreover, subgroup analysis by country of origin showed that the prevalence of lung cancer patients with SARS-CoV-2 infection was highest in China (19.3.0%, 95% CI, 0.152–0.243, Fig. 4a) followed by France (12.6%, 95% CI, 0.101–0.156, Fig. 4b), the UK (10.7%, 95% CI, 0.090–0.125, Fig. 4c), and the USA (8.3%, 95% CI, 0.069–0.099, Fig. 4d).

Heterogeneity Test

In this meta-analysis, there was statistically significant between-study heterogeneity (I^2=93.83 and pH≤0.001) overall. Thus, we carried out stratified analysis by ethnicity and country of origin to explore the potential source of heterogeneity in this study. Results showed that the heterogeneity did not reduce by ethnicity in Asian (I^2=79.79 and pH≤0.001) and Caucasian (I^2=96.39 and pH≤0.001) lung cancer patients with SARS-CoV-2 infection (Table 2). However, subgroup analyses by country of origin revealed that the heterogeneity was reduced or disappeared in the US (I^2=46.60 and PH=0.113), France (I^2=12.34 and PH=0.320), and the UK (I^2=0.00 and PH=0.920) lung cancer patients with SARS-CoV-2 infection, but not in Chinese (I^2=65.78 and pH≤0.001). These results indicated that ethnicity might be the main source of heterogeneity in this study (Table 2).
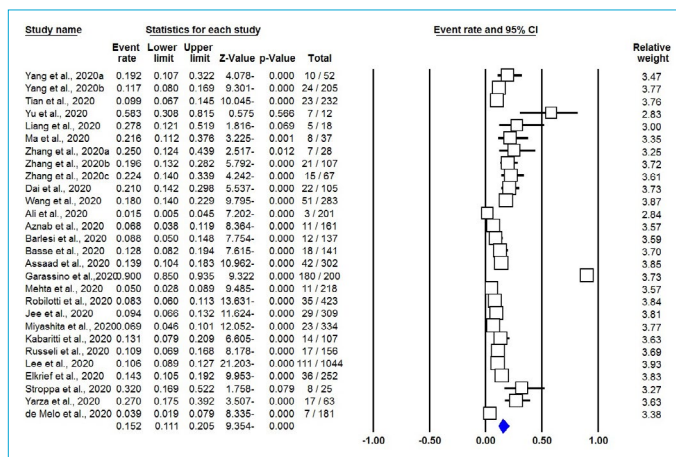

Figure 2. Forest plot for the prevalence of lung cancer patients with SARS-CoV-2 infection during the COVID-19 pandemic in overall cancer patients.
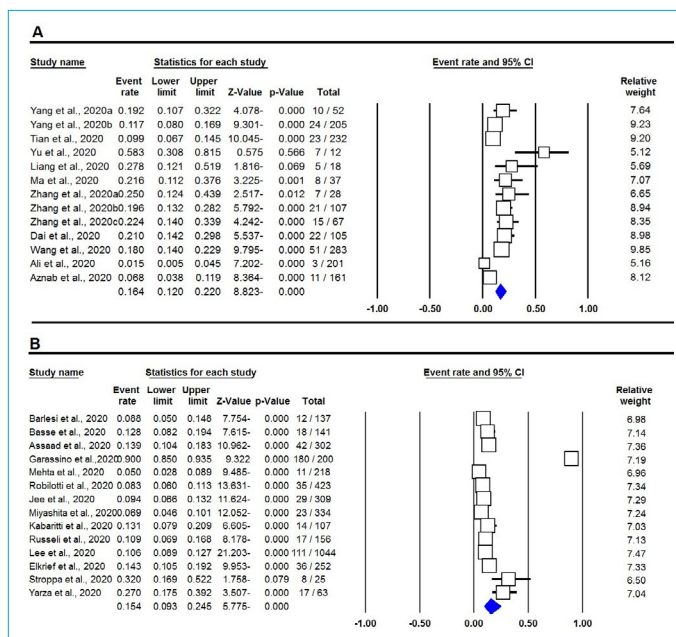

Figure 3. Forest plot for the prevalence of lung cancer patients with SARS-CoV-2 infection during the COVID-19 pandemic by ethnicity: **(a)** Asian and **(b)** Caucasian.

Table 2. Summary estimates for the proportion of lung cancer patients with SARS-CoV-2 Infection

| Subgroup	Type of model	Heterogeneity		Odds ratio				Publication bias	
		I^2 (%)	pH	OR	95% CI	Z-test	pOR	pBegg's	pEgger's
Overall	Random	93.83	≤0.001	0.152	0.111–0.205	-9.354	≤0.001	0.441	0.464
By ethnicity									
Asian	Random	79.79	≤0.001	0.164	0.120–0.220	-8.823	≤0.001	0.502	0.805
Caucasian	Random	96.39	≤0.001	0.154	0.093–0.245	-5.775	≤0.001	0.661	0.451
By country of origin									
China	Random	65.78	≤0.001	0.193	0.152–0.243	-9.596	≤0.001	0.008	0.050
USA	Fixed	46.40	0.113	0.083	0.069–0.099	-24.337	≤0.001	0.806	0.846
France	Fixed	12.34	0.320	0.126	0.101–0.156	-15.363	≤0.001	0.296	0.314
UK	Fixed	0.00	0.920	0.107	0.090–0.125	-22.725	≤0.001	NA	NA
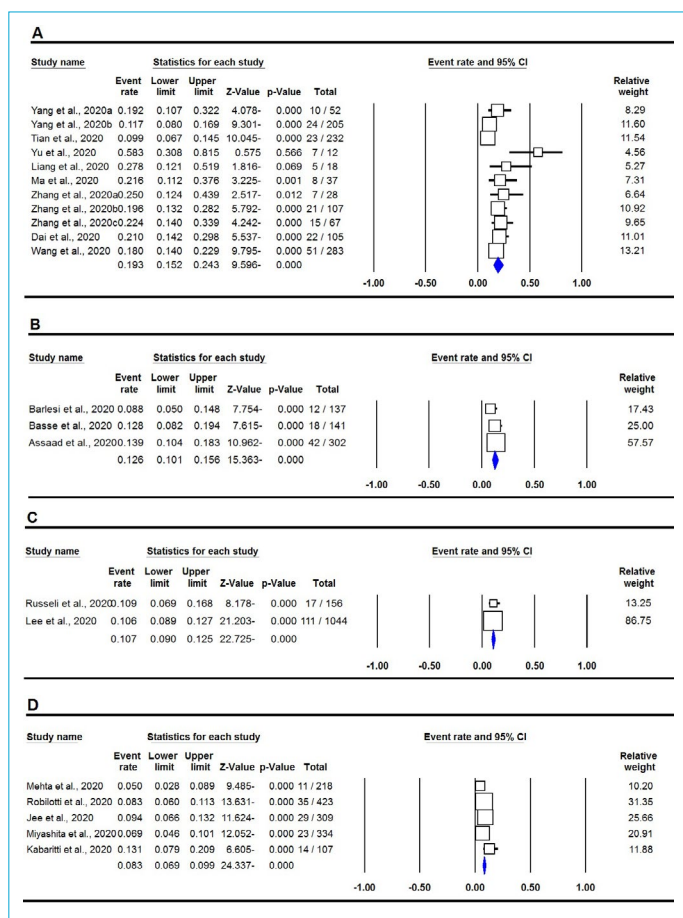
Figure 4. Forest plot for the prevalence of lung cancer patients with SARS-CoV-2 infection during the COVID-19 pandemic by country of origin: **(a)** China, **(b)** France, **(c)** UK, and **(d)** USA.

Publication Bias

Publication bias is a widespread problem in meta-analyses that might seriously distort our attempts to estimate the prevalence of lung cancer patients with SARS-CoV-2 infection. In the current meta-analysis, we carried out both Egger's test and Begg's tests to assess the potential publication bias in the literature. As shown in Figure 5, the shape of Begg's funnel plot revealed that there was no evidence of any publication bias in this meta-analysis. Moreover, the Egger's test statistically confirmed evidence of funnel plot (pBegg's=0.441, pEgger's=0.464), indicating that the current study conclusions were statistically reliable.

Discussion

Previous studies have described that the course of CO-VID-19 in lung cancer was longer and more severe than the general population.[64,65] It is suggested that the severity of SARS-CoV-2 infection might be associated with the immune response to SARS-CoV-2.[66,67] Many studies have reported that mortality rates range from 17.7% to 55%
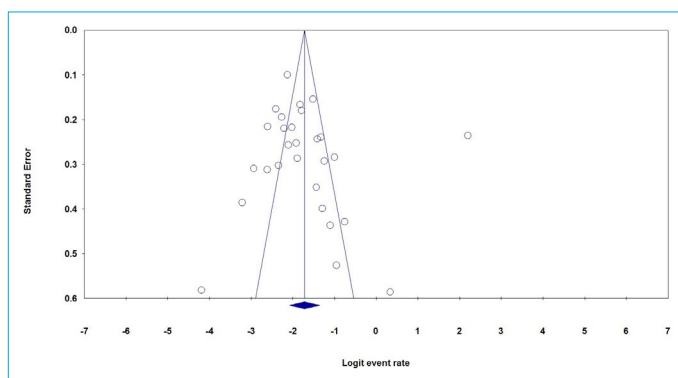

Figure 5. The funnel plots of publication bias for the prevalence of lung cancer patients with SARS-CoV-2 infection during the COVID-19 pandemic in overall cancer patients.

among lung cancer patients with SARS-CoV-2 infection.[68] Peravali et al., in a systematic review, described that SARS-CoV-2 infection in lung cancer patients was associated with a severe course of the disease and increased mortality than other malignancies.[68] Luo et al., in a study on 102 infected lung cancer patients with COVID-19, reported that the severity of the disease was largely dependent on patient-specific particularity such as smoking and chronic obstructive pulmonary disease. However, the severity of the infection did not associate with previous thoracic surgery, radiation, and recent systemic therapies.[69] Thus, it is necessary to carefully perform differential diagnosis and assess the risk of SARS-CoV-2 infection in lung cancer patients.[67]

To date, several studies have addressed the prevalence of patients with lung cancer in different populations tested for SARS-CoV-2 infection.[15,41,59–63] However, there is conflicting evidence on the prevalence of lung cancer with SARS-CoV-2 infection. In the current meta-analysis, we estimated the prevalence of lung cancer with SARS-CoV-2 infection based on 28 studies with 5400 infected cancer patients and 767 lung cancer patients. By pooling those studies, the results showed that the prevalence of lung cancer patients with SARS-CoV-2 infection was 15.2% overall. Stratified analysis by ethnicity found that the prevalence was 16.4% and 15.4% in Asian and Caucasian lung cancer patients with SARS-CoV-2 infection, respectively. Moreover, subgroup analysis by country of origin showed that the prevalence of lung cancer patients with SARS-CoV-2 infection was highest in China (19.3.0%) followed by France (12.6%), the UK (10.7%), and the USA (8.3%). Venkatesulu et al., in a meta-analysis, reported that the prevalence of lung cancer patients with SARS-CoV-2 infection was 23.7%, which was highest after hematological malignancies and breast cancers. Moreover, they have shown that the mortality was highest in hematological

malignancies (OR = 2.43) followed by lung cancer (OR = 1.8).[70] A multicancer study in New York showed that 21% of lung cancer patients were identified from 105 cancer patients with SARS-CoV-2 infection.[15] Wang and Huang, in a meta-analysis, evaluated the prevalence of COVID-19 in seven different malignancies. Their data revealed that the prevalence of the SARS-CoV-2 infection among lung cancer and colorectal cancer patients was more frequent than other cancers.[71] Yu et al., in a study among 1524 people with cancer who admitted to the Department of Radiation and Medical Oncology at Zhongnan Hospital of Wuhan University in Wuhan, China, estimated that the infection rate of COVID-19 in patients with cancer was 0.79% (95% CI, 0.3–1.2) versus 0.37% (95% CI, 1.89–3.02) of the general population of Wuhan over the same time. Moreover, they revealed that patients with nonsmall cell lung cancer (NSCLC) seemed to have a higher incidence of COVID-19, especially among those patients over 60 years of age (4.3% vs 1.8% in those aged less than 60 years with NSCLC). Their results showed an association of SARS-CoV-2 infection with age and concurrent NSCLC diagnosis.[59] Zhang et al., in a retrospective case study among people with cancer (most frequently, advanced lung cancer), reported that the patients were at higher risk of severe complications and unfavorable outcomes than those hospitalized without a malignancy.[61] Liang et al., and Calabrò et al., demonstrated that the history of smoking might increase the risk of COVID-19 complications in patients with lung cancer (1.4-fold) and the need for mechanical ventilation due to COVID-19.[24,60]

Our findings should be interpreted carefully due to the following limitations. First, we found only studies published in English or Chinese language which might cause potential selection bias. Second, most of the included studies in the current meta-analysis were performed in Asian and Caucasian cancer patients with SARS-CoV-2 infection, which may cause ethnicity bias. Third, we did not assess the prevalence of lung cancer patients with SARS-CoV-2 infection in African and mixed populations due to the lack of relevant data across the included studies. This led to difficulty in conducting a comparison of the prevalence of lung cancer patients with SARS-CoV-2 infection between different ethnicities. Finally, the assessment of the prevalence of lung cancer patients with SARS-CoV-2 infection was based on unadjusted estimates, whereas clinically relevant confounding factors, such as age, gender, stage of disease, cigarette smoking, treatment regimen, comorbidities, and lifestyle, remain difficult to assess due to the lack of original data. Therefore, further validation of our findings and more in-depth research is necessary.

Conclusion

Considering all the results, this meta-analysis revealed that the prevalence of lung cancer patients with SARS-CoV-2 infection was 15.2%. The prevalence in Asian and Caucasian lung cancer patients with SARS-CoV-2 infection was 16.4% and 15.4%, respectively. Moreover, the prevalence of lung cancer patients with SARS-CoV-2 infection was highest in China (19.3.0%) followed by France (12.6%), the UK (10.7%), and the USA (8.3%). This finding amplifies the importance of maintaining an urgent focus on the needs of patients with lung cancer and optimizing cancer care during the COVID-19 pandemic. However, further multicenter studies across different ethnic groups with larger sample sizes are required to make a better assessment of the prevalence.

Disclosures

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

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