Bronchoscopy is a commonly performed procedure for diagnostic as well as therapeutic indications. Over 500,000 bronchoscopies are performed each year in the United States (1). It is considered safe with minimal risk of grievous complications and offers a significant diagnostic and therapeutic utility (2). One risk associated with bronchoscopy is accidental transmission of disease due to its nature as an aerosol-generating procedure, possibly putting healthcare professionals at risk (3, 4). As severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the pathogen responsible for coronavirus disease 19 (COVID-19), can be transmitted via aerosols, routine bronchoscopy for these patients has been a matter of great scrutiny and frequently discouraged (5, 6). Furthermore, the use of personal protective equipment (PPE) during bronchoscopy may divert resources away from frontline workers, especially in resource-poor facilities.

Performing bronchoscopy in patients with COVID-19 is not without potential risks. This includes the possibility of SARS-CoV-2 transmission to the bronchoscopist and other involved healthcare workers (HCWs). Indeed, an increased risk of SARS-CoV-2 transmission among HCWs had been reported in several studies (7, 8). Another procedural concern is the possibility of clinical deterioration in the periprocedural period, such as precipitation of respiratory failure, the necessity for mechanical ventilation, increased hospital length of stay, or even increased mortality, especially in critically ill patients. Conversely, bronchoscopy could be beneficial. Identification of SARS-CoV-2 from the lower respiratory tract may accurately diagnose patients with COVID-19 who had an initial false-negative test. Similarly, an early diagnosis of a secondary bacterial or fungal infection is paramount as a misdiagnosis can negatively affect patient outcomes.

**KEY WORDS:** bronchoscopy; coronavirus disease 2019; diagnosis; intensive care unit; lung cancer; severe acute respiratory syndrome coronavirus 2

DOI: 10.1097/CCE.0000000000000522
### TABLE 1.
Reported Studies on Bronchoscopies Performed for Patients With Coronavirus Disease 2019

| References                  | Guarino et al (12) | Mondini et al (10) | Patrucco et al (16) |
|-----------------------------|--------------------|--------------------|--------------------|
| Number of patients          | 87                 | 109                | 131                |
| Total number of bronchoscopies | 87                | 109                | 131                |
| Diagnostic                  | 57                 | 78                 | 129                |
| Therapeutic                 | 30                 | 31 (this number included an unspecified number of bronchoscopies that were for evaluation of secondary infection) | 2 |
| Number of diagnostic bronchoscopies with negative real-time PCR | 8 patients (2 negative swabs) | 78 patients (2 negative swabs) | 86 patients with suspected COVID-19 (most with 2 negative swabs) |
| Positive COVID-19 from BAL  | 4/8 (50%)          | 43/78 (55.1%)      | 32/86 (37.2%)      |
| Secondary infection         | Of the other 4 patients, 2 patients with Legionella and 2 with fungal infection | 15 patients with negative PCR on bronchoscopy had lower respiratory tract infection by other organism | Identified in 26 additional infection for a total microbiologic diagnosis in 58/88 patients (67%) |
| Changes in antimicrobials   | NR                 | NR                 | NR                 |
| Changes in systemic steroid | NR                 | NR                 | NR                 |
| Changes in anticoagulation  | 17 patients with concerns for diffuse alveolar hemorrhage | NR | NR |
| Other                       | NA                 | NA                 | NA                 |
| Definitive non-COVID diagnosis | 15 patients had definitive alternative diagnosis (8 lung cancer, 4 alveolar hemorrhage, 2 organizing pneumonia, and 1 vasculitis) | 15 patients had definitive alternative diagnosis (8 lung cancer, 4 alveolar hemorrhage, 2 organizing pneumonia, and 1 vasculitis) | 15 patients had definitive alternative diagnosis (8 lung cancer, 4 alveolar hemorrhage, 2 organizing pneumonia, and 1 vasculitis) |

BAL = bronchoalveolar lavage, COVID-19 = coronavirus disease 2019, NA = not applicable, NR = not reported, NS = not significant, PCR = polymerase chain reaction.
| Chang et al (14) | Torrego et al (9) | Bruyneel et al (13) | Mehta et al (17) | Baron et al (18) | Loor et al (11) |
|------------------|------------------|---------------------|-----------------|-----------------|-----------------|
| 107              | 93               | 32                  | 61              | 24              | 75              |
| 241              | 101              | 90                  | 98              | 28              | 222             |
| NS               | 63               | 30                  | NS              | 28              | 29              |
|                  | 38               | 60                  |                 |                 | 193             |

| NA                            | NA                            | 2                              | NA                            | 13 patients with recent negative swab | NA                            |

| NA                            | NA                            | 1/2 (50%)                      | NA                            | 5/13 patients (38%) tested positive from BAL | NA                            |

| 35/54 (65%) had secondary infection from BAL compared with tracheal aspirate (45%) | 18/63 patients (28.6%) had a secondary bacterial infection | 30/51 samples (58.8%) had a secondary bacterial infection | 53/98 patients (54%) had bacterial superinfection | Positive bacterial culture in 14/28 (50%) | NS |

| 16% false-negative tracheal aspirate culture | 6% of BAL had 2 organisms |

| NR                           | New antibiotic was prescribed in 15/18 patients (83%) | New antibiotic was prescribed in 9/30 patients (30%) | Antibiotics were changed/escalated in 31 cases (31.6%) | Modification of antibacterial therapy in 8 (29%) | Modification of antifungal therapy in 5 (18%) | Change in antimicrobials 31 (14%) | Negative cultures leading to stopping antibiotic 3 (1.4%) |

| NR                           | NR                           | NR                           | Decreased steroid use in 6 patients (6%) | Initiation of corticosteroid therapy in 6 (21%) | NR                           |

| NR                           | NR                           | NR                           | Anticoagulation was reduced from intermediate to preventive in 6 patients (6%) | NR                           | Adjustment of anticoagulant 5 (2.3%) |

| NA                           | NA                           | NA                           | Fluid administration was reduced, and diuretics added in 12 patients (12.2%) based on the visual perception of pulmonary edema (frothy copious upwelling secretions) | NA                           | Mucus plug extraction that improved ventilation 62 (27.9%) |

| NR                           | NR                           | NR                           | NR                           | NR                           | NR                           |
outcomes. Additionally, bronchoscopy enables the operator to perform therapeutic interventions, which can be lifesaving.

Several observational studies have shed light on the complications of bronchoscopy. Based on the available data, bronchoscopy appears to be associated with a low risk of clinical deterioration, even in critically ill mechanically ventilated patients. The most reported complication was mild transient oxygen desaturation (defined as an oxygen saturation < 90%). Torrego et al (9) performed 101 bronchoscopies in a cohort of 93 mechanically ventilated patients and “occasionally” observed transient hypoxemia. Mondoni et al (10) reported transient hypoxemia in 4.5% of 109 bronchoscopies. Loor et al (11) specified seven mild desaturation episodes (3.1%) in their cohort. In contrast, severe hypoxemia occurred when bronchoscopies were performed in patients requiring noninvasive positive pressure ventilation (NIPPV). Guarino et al (12) performed bronchoscopy on seven patients requiring NIPPV that were complicated by severe desaturation (below 60%), and five of these patients were eventually intubated. Bruyneel et al (13) also reported worsening respiratory failure needing intubation following bronchoscopy in a patient on NIPPV. Other minor complications included fever, mild hemoptysis, and repositioning of the endotracheal tube (10, 11, 14). There was no report of pneumothorax, cardiac arrhythmia, or death in any of the studies. The transmissibility of SARS-CoV-2 among bronchoscopists and other HCWs has also been described. Gao et al (15) serologically evaluated 35 bronchoscopists who had performed more than 450 procedures in 280 mechanically ventilated patients over 5 months (March to August 2020) in the ICU setting. The operators were also tested by real-time polymerase chain reaction (RT-PCR) of the nasopharyngeal swab if there was any concern for acute infection. At the end of the study, 27 of 35 bronchoscopists had serologic results available. One of 27 tested positive by serologic assay. This individual was asymptomatic during the study period and spent more than 5 weeks in the COVID-19 ICU and performed 10–30 bronchoscopies. Sixteen of 35 operators who had received RT-PCR were all negative. Torrego et al (9) reported one of the two bronchoscopists getting infected during the second week of their study requiring replacement by a third bronchoscopist. Except these two operators, there has been no other reported transmission of SARS-CoV-2 in the literature (10–14, 16–18).

It is crucial to emphasize that the authors reported strict adherence to guidelines recommended by the World Health Organization, Centers for Disease Control and Prevention, and other professional organizations. Most procedures were performed in negative pressure rooms, and all involved HCWs used appropriate PPE. In addition, measures were undertaken to reduce the risk of aerosolization, such as apneic bronchoscopy and neuromuscular blockade to eliminate cough (14, 15, 17). The number of HCWs involved in the actual procedure was also minimized. Disposable bronchoscopes were used in most studies (9, 11, 13–15). However, reusable bronchoscopes were also used without any safety concerns (16). Bruyneel et al (13) reused disposable bronchoscopes for future bronchoscopies if the same patient required repeat procedures. The data presented here suggest procedural safety and a low risk of SARS-CoV-2 transmission when appropriate recommendations are followed.

Bronchoscopy has played a crucial role in the care of COVID-19 patients. “Thick and sticky” mucus causing airway obstruction had been reported early in the pandemic (19). The airway occlusion resulted in atelectasis, radiologic chest infiltrates, worsening hypoxemia, and increased airway pressures. Chang et al (14) reported 33% of their mechanically ventilated patients requiring bronchoscopies. Loor et al (11) performed 222 bronchoscopies in their 75 ventilated patients, and 150 of these procedures were done for airway clearance. Thick “limestone like” mucus was reported by Bruyneel et al (13). Bronchoscopic mucus plug removal improved oxygenation and ventilation in 28% of cases (11). Difficult to manage airway secretion requiring frequent bronchoscopies was also reported by more researchers (9, 10, 17). A recent study found a higher risk of mortality in patients who required therapeutic bronchoscopy for mucus plugging (20). Other emergent therapeutic interventions were performed for hemoptysis, assistance with intubations, and management of airway injuries, including stent placement (10–12). Table 1 summarizes all reported studies regarding bronchoscopy in patients with COVID-19.

| Study | No. of Bronchoscopies | Patients | Complications |
|-------|-----------------------|----------|---------------|
| Torrego et al (9) | 101 | 93 | Transient hypoxemia
| Mondoni et al (10) | 109 | 4.5% | Transient hypoxemia
| Loor et al (11) | 109 | 3.1% | Mild desaturation
| Guarino et al (12) | 7 | 60% | Severe desaturation
| Bruyneel et al (13) | 222 | 75 | Airway clearance

Bronchoscopy for diagnosis of SARS-CoV-2 infection has been rightly discouraged. Although bronchoalveolar lavage (BAL) may provide the highest diagnostic yield (21), appropriately performed
RT-PCR of the upper airway specimen is also highly sensitive (22). Additionally, chest CT can offer further diagnostic clues (23). Several studies reported a positive yield from BAL in a significant number of patients with two negative RT-PCR from nasopharyngeal swab (10, 12, 16). However, this result is not surprising as it had been shown that the positivity of the lower respiratory tract sample might decline slower than the upper respiratory tract (24).

Appropriate determination of secondary pulmonary infection is essential. A significant number of COVID-19 patients have been reported to have suffered from superadded bacterial and fungal infections (25). Chang et al (14) identified a secondary bacterial infection (SBI) in 65% of their patients. Similarly, Mehta et al (17) and Bruyneel et al (13) reported SBI in 54% and 59%, respectively. Baron et al (18) demonstrated fungal infection among 25% of their cohort, whereas Mehta et al (17) found evidence of fungal involvement in 7%. Bronchoscopy aided in the appropriate selection of antibiotics in a significant number of patients. Torrego et al (9) needed to change antibiotics following bronchoscopy in 83% of patients diagnosed with SBI. Other authors reported such changes in approximately 30% of patients (13, 17, 18). The higher occurrence of SBI in these patients is likely related to their severity of illness and the necessity of mechanical ventilation. The organisms responsible for SBI were not different from pathogens known to cause ventilator-associated pneumonia in non–COVID-19 acute respiratory distress syndrome (9). As systemic corticosteroid has become the standard of care for critically ill patients with SARS-CoV-2 pneumonia, early identification of secondary bacterial and fungal infection is vital (26). Patrucco et al (16) identified 15 patients with a noninfectious diagnosis that could have been missed unless bronchoscopy had been performed. Eight of these patients suffered from pulmonary malignancy, four from alveolar hemorrhage, two were diagnosed with organizing pneumonia, and one with vasculitis. There had been concerns that a delay in bronchoscopic evaluation may lead to a cancer epidemic in the near future.

The risks of periprocedural complications and SARS-CoV-2 transmission among HCWs during bronchoscopy appear to be low. An outbreak is unlikely if appropriate safety measures are followed. Therefore, any patient determined to benefit from a bronchoscopic procedure should undergo such intervention. We believe that the time has come to perform all bronchoscopic procedures confidently and safely in a timely manner to prevent any potential for future harm for our patients.

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