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Comparative outcomes of inpatients with lung collapse managed by bronchoscopic or conservative means

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ABSTRACT

Background Although the incidence and prevalence of atelectatic lung collapse is unknown, such events are common among inpatients, and there are no guidelines for optimally instituting bronchoscopic techniques. The aim of this study was to evaluate the outcomes of patients with complete or near-complete lung collapse managed via interventional flexible fibreoptic bronchoscopy or a conservative approach.

Methods Retrospective analysis of all adult patients admitted to BronxCare Health System between January 2011 and October 2017 with a diagnosis of lung collapse/atelectasis. The primary outcome was radiological resolution. Timing of bronchoscopy relative to radiological resolution and mortality served as secondary outcomes.

Results Of the 177 patients meeting inclusion criteria, 149 (84%) underwent bronchoscopy and 28 (16%) were managed through conservative measures only. A significantly greater number of patients in the bronchoscopy group achieved complete or near-complete resolution on chest X-ray, compared with the conservative group (p=0.007). Timing of bronchoscopy had no impact on the rate of radiological resolution, and mortality in the two groups was similar. New endobronchial malignancies were identified in 21 patients (14%).

Conclusions Our data support the central role of bronchoscopy in instances of complete or near-complete lung collapse, ensuring better radiological outcomes. Judicious use of conservative management is warranted to avoid missing significant pathology. A prime consideration in this setting is obstructive malignancy.

Key messages

- Should patients with near-complete or complete lung collapse be managed initially with bronchoscopy or with conservative measures?
- Bronchoscopy has significantly better radiological outcomes.
- We discovered that bronchoscopy has significant diagnostic and therapeutic implications for patients with near-complete or complete lung collapse.

INTRODUCTION

Atelectatic lung collapse is a common occurrence in the inpatient setting, although the exact incidence is unknown, and represents a management dilemma for physicians. Complete collapse acutely reduces lung volume and may incite or worsen hypoxaemia through shunting and introduce a risk of nosocomial pneumonia.[1 2]

Lung collapse may be broadly attributed to obstructive or non-obstructive insults. Obstructive phenomena (ie, mucous plugs, endobronchial lesions and foreign bodies) disrupt alveolar-airway continuity, eventuating in resorption of trapped distal gas and subsequent atelectasis. Non-obstructive collapse may be further characterised as extrapulmonary or intrapulmonary. Pleural diseases (ie, effusions or pneumothorax) and chest wall masses are extrapulmonary disorders that produce atelectasis via direct lung compression, whereas non-obstructive intrapulmonary atelectasis may result from surfactant deficiency or infiltrative parenchymal disease.[3]

At present, there are no standard guidelines for the management of lung collapse, which typically is focused on addressing specific underlying conditions. If obstruction is suspected, the various techniques used to relieve atelectasis/lung collapse include airway suction, chest physiotherapy (with percussion), vibration vests, postural drainage, mucolytic agents and flexible fibreoptic bronchoscopy (FFB).[4]

The intent of this study was to evaluate outcomes of patients with complete or near-complete lung collapse, comparing the interventional FFB management with a solely conservative approach.

MATERIALS AND METHODS

Study design and procedures

We conducted a retrospective review of all adult patient admissions to BronxCare Hospital Center marked by complete or near-complete lung collapse/atelectasis during the course of hospitalisation. The

study period extended from January 2011 to October 2017, contributing 185 patients. Eight patients were excluded due to extrathoracic issues, each displaying lung compression by voluminous pleural fluid and achieving resolution after drainage. The remaining 177 patients were grouped accordingly as interventional (bronchoscopic) or conservative management.

All data were drawn from the electronic medical records to include baseline demographics, comorbid conditions, chest imaging reports, therapeutic interventions and patient outcomes. Information on cultures or other diagnostics delineating the nature of lung collapse was also pursued. The primary outcome measure was degree of radiological resolution, with timing of bronchoscopy in relation to radiological resolution and mortality serving as secondary outcome.

Radiological resolution was based on follow-up chest X-rays (CXRs), performed after the chosen management strategy. As per divisional policy, all patients undergoing FFB receive a CXR postprocedure. Radiological resolution in patients undergoing FFB was determined based on the review of this postprocedure film. In the conservative arm, a post-intervention CXR was performed in all 28 patients with a mean time of 1.8 days after initiating conservative therapy.

Patients with recurrent lung collapse were counted once, based on initial episodes.

A standard flexible bronchoscope (Olympus America, Melville, New York, USA) was used for all bronchoscopic interventions. The procedures were performed in either a dedicated suite (under local anaesthesia with conscious sedation) or in an operating room (under general anaesthesia), as dictated by preoperative risk. Eight full-time pulmonologists and six pulmonary fellows were engaged.

No patient and public involvement

As this was a retrospective study, this research was done without the patient involvement. Patients were not invited to comment on the study design and were not consulted to develop patient relevant outcomes or interpret the results. Patients were not invited to contribute to the writing or editing of this document for readability or accuracy.

Definition of terms

Complete lung collapse was equated with total hemithoracic opacification. At least two lobes of the right lung or one lobe of the left lung were affected in near-complete collapse.

Conservative management entailed physiotherapy via high-frequency chest wall oscillation (HFCWO), conducted alone or aided by mucolytic agents, such as nebulised N-acetylcysteine 10% solution. At our institution, HFCWO treatments involved pressures of ~50 cm H_2O at frequencies of ~525 Hz, delivered via pneumatic vest for 30 min every 4–6 hours over a 24-hour period.

Bronchoscopy performed with or without other conservative measures constituted interventional management. Full re-expansion of all collapsed lobes signalled complete resolution. Near-complete resolution corresponded with persistent partial collapse of at least one lobe, whereas partial resolution was indicated by full persistent collapse of at least one lobe. Two study investigators reviewed all CXRs and confirmed the validity of findings.

Statistical analysis

For categorical analysis, χ^2 test was used, applying Student's t-test to continuous parametric data and Wilcoxon-Mann-Whitney test to continuous non-parametric data. Results were expressed as counts (percentages) for

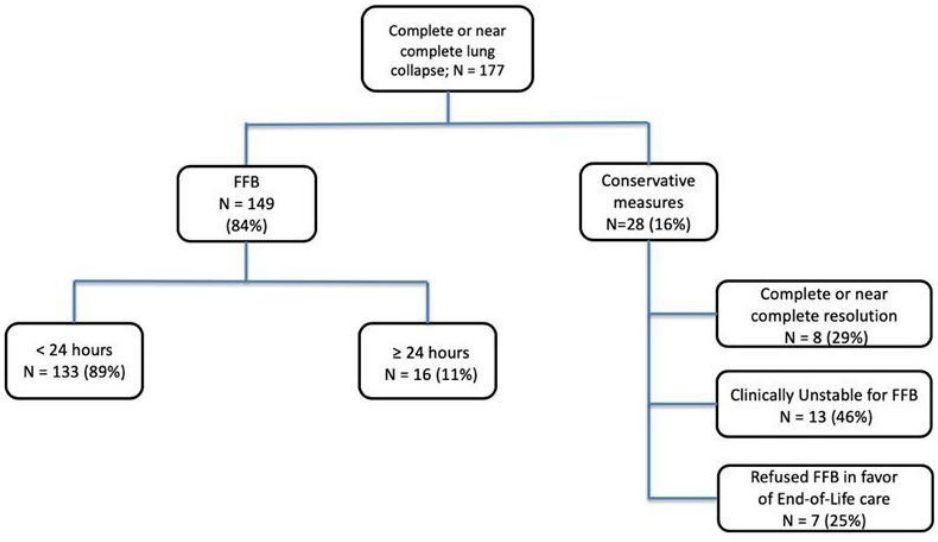

Figure 1 Study enrolment. FFB, flexible fibreoptic bronchoscopy.

Table 1 Patient demographics and comorbidities

Parameter	Fibreoptic bronchoscopy n=149 (%)	Conservative measures n=28 (%)	P value
Age (mean±SD)	61.8±14.4	71.9±12.2	0.075
Sex			
Male	87 (58.4)	15 (54)	0.679
Female	62 (41.6)	13 (46)	0.679
Comorbid condition			
Obstructive airway disease	71 (47.7)	13 (46.4)	1.00
Congestive heart failure	33 (22.1)	8 (28.6)	0.469
End-stage renal disease	29 (19.5)	3 (10.7)	0.769
Lung cancer	15 (10.1)	4 (14.3)	0.509
Dementia	16 (10.7)	3 (10.7)	1.00
Stroke	26 (17.4)	5 (17.9)	1.00
Cirrhosis	18 (12.1)	4 (14.3)	0.756
Neuromuscular disease	1 (0.7)	0	1.00
Chronic respiratory failure	38 (25.5)	4 (14.3)	0.235
Ventilator dependency	32 (18)	4 (14.3)	0.454

discrete variables and as mean values (±SD) for continuous variables. Statistical significance was set at p≤0.05.

RESULTS

Patient data

A total of 184 patients met our inclusion criteria. Eight were excluded due to extrathoracic lung compression that resolved after drainage of pleural fluid, leaving 177 patients for analysis. Invasive measures (ie, bronchoscopic procedures) were undertaken in 149 patients (84%), using conservative methods only in 28 (16%). In the conservative arm, 8 patients had complete or near-complete resolution of atelectasis and FFB was not pursued, in seven cases, the patient or the healthcare proxy refused bronchoscopy in lieu of end-of-life care and 13 patients were deemed as clinically unstable by the medical team to undergo FFB (see figure 1). There were 102 men (57.6%) in our cohort (mean age, 66 years). We found no groupwise differences in demographics or comorbid conditions (table 1). Among 42 patients (23.7%) with chronic respiratory failure, 36 (20%) required long-term ventilator support via tracheostomy.

The hospital length of stay was shorter in the conservative group (mean: 13.15 vs 33.63 days; p<0.0001).

Radiological outcomes

Patients subjected to bronchoscopy achieved resolution of lung collapse at a significantly higher rate (p<0.0070) than those managed through conservative measures only (table 2). In comparing patients by timing of FFB (≤24 vs >24 hours) after confirmed lung collapse, resolution rates did not differ significantly (table 3).

Bronchoscopic findings

In most patients (125/149, 84%) undergoing bronchoscopy, bronchoalveolar lavage fluid (BALF) was submitted for cultures. Bacterial infections were confirmed in 88 (70.4%) and largely involved gram-negative organisms. Extended-spectrum beta-lactamase-producing organisms were detected in five of our patients. The most common gram-positive organism identified was methicillin-resistant *Staphylococcus aureus*, found in 13 patients. Overall, respiratory cultures were obtained more frequently in the bronchoscopy (vs conservative) group (84% vs 21%).

All patients in our study received antibiotics for presumptive bacterial lung infections leading to collapse, adjusting treatments to accommodate cultures results. Respiratory cultures were obtained from six patients (21.4%) of the conservative group, and all yielded gram-negative organisms.

Table 2 Comparison of radiological outcomes

Radiological outcome	Fibreoptic bronchoscopy n=149 (%)	Conservative measures n=28 (%)	P value
Complete or near-complete resolution	85 (57)	8 (28.6)	0.0070
Partial or no resolution	64 (43)	20 (71.4)	

Table 3 Timing of bronchoscopy and resolution of lung collapse

Radiological outcome	FFB ≤24 hours n=133(%)	FFB >24 hours n=16 (%)	P value
Complete or near-complete resolution	59 (44.3)	7 (43.8)	1.000
Partial or no resolution	74 (55.7)	9 (56.2)	

FFB, flexible fibreoptic bronchoscopy.

During bronchoscopy, newly diagnosed endobronchial lesions were encountered in 21 patients (14%) (table 4). Malignancy, chiefly non-small cell lung cancer, was the predominant histopathologic finding. Only one patient had early-stage lung cancer. Details and management of such tumours are summarised in table 5. There was no difference in all-cause inpatient mortality between the two study groups (p=0.679).

DISCUSSION

General comments

Through this retrospective analysis, aimed at patients with complete or near-complete lung collapse, we determined the following: (1) radiological resolution was more likely in patients undergoing bronchoscopy; (2) timing of bronchoscopic procedures had no impact on degree of resolution; (3) endobronchial malignancies surfaced in a substantial number of patients, calling for changes in management and (4) respiratory or BALF cultures yielded important microbial information for tailoring appropriate antibiotic treatment.

In a prospective study, Snow and Lucas[5] examined morbidity and outcomes of 51 patients undergoing bronchoscopy while under the surgical intensive care. The primary procedural indications included lobar collapse (60%), persistent pulmonary infiltrates (3%) and suspected aspiration (21%). They reported significant improvement in instances of lobar collapse, compared with other indications. However, they did not compare bronchoscopy with conservative management, nor did they report culture results or bronchoscopic findings.

Marini *et al*[6] conducted a small randomised control trial of chest physiotherapy versus FFB with lavage in managing acute lobar atelectasis. A total of 14 patients underwent bronchoscopy on emergency basis, followed by chest therapy every 4 hours for 48 hours. Another 17 patients were randomly assigned to chest therapy alone (every 4 hours), performing bronchoscopy at 24 hours if atelectasis persisted. Unlike our efforts, the rates of resolution did not differ. Both groups displayed nearly 80% restoration of lost volume by 24 hours. We suspect this disparity relates to our inclusion criteria, which limited eligible patients to those with complete or near-complete lung collapse.

The greatest benefit and advantage of a bronchoscopic approach is the prospect of directly inspecting the airway and the option of obtaining fluid or tissue specimens for definitive diagnostics. Barrett[7] has described a 5-year experience performing bronchoscopy in critically ill patients, noting that in 30 cases of atelectasis, a lobar bronchus or an entire lung was involved. Ultimately, bronchogenic carcinoma was diagnosed in two patients, both FFB failures. The therapeutic value of bronchoscopy in clearing secretions under similar circumstances has also been echoed by others.[8] Results of another study,[9] examining the role of FFB in endobronchial lesions, have underscored that unexplained lung collapse (one of the main indications for bronchoscopy) may well promote discovery of endobronchial lesions. Pneumonic collapse emerged as one of the most common radiological presentations for both malignant and benign lesions. However, the authors did not specify degree(s) of collapse.

The present study includes one of largest series of newly detected malignant endobronchial lesions in hospitalised patients with lung collapse. Most of the cancers were advanced, but our institution serves one of the poorest congressional districts in the nation. It is reported that health in the USA is patterned along socioeconomic and racial/ethnic lines, suggesting a link between hierarchies of social advantage and health.[10] Such inequities may, thus, deter those seeking preventative care, especially in inner-city populations such as ours, encouraging late presentations and diagnoses. Furthermore, the Bronx has the third highest percentage of current smokers in all New York City, with 13.6% of residents (145 000 adults) who smoke. Lung cancer rates are the highest among men in all boroughs of New York, but men within the Bronx rank second in lung cancer incidence; and of all New York City boroughs, the Bronx has the second highest rate of lung cancer mortality.[11]

Pulmonary infections may lead to lung collapse or atelectasis, especially if patients are unable to mobilise

Table 4 Aetiologies of lung collapse

Aetiology	Fibreoptic bronchoscopy n=149 (%)	Conservative measures n=28 (%)	P value
Endobronchial malignancy	21 (14)	0	0.0491
Gram-positive infection	21 (14)	0	0.0491
Gram-negative infection	67 (45)	6 (21)	0.0107

Table 5 Histotype, management and outcomes of patients with endobronchial malignancies

Tumour type and stage		Patient totals n=21 (%)	Management/outcomes	
Squamous cell carcinoma n=10 (47%)	Stage III B	2 (9)	Chemoradiation	2
	Stage IV	8 (38)	Chemotherapy and EB stent	1
			Palliative chemotherapy	1
			Hospice	2
			Inpatient deaths	4
Adenocarcinoma n=8 (38%)	Stage IA	1 (5)	LUL wedge resection	1
	Stage IIIB	1 (5)	Inpatient death	1
	Stage IV	6 (29)	Palliative chemotherapy	3
			Hospice	2
			Inpatient death	1
Small cell carcinoma n=3 (14%)	Extensive	3 (14)	Inpatient deaths	3

EB, endobronchial; LUL, left upper lobe.

secretions. A substantial number of our patients harboured pathogenic organisms, as shown by respiratory cultures. The utility of sputum versus BALF culture has been widely debated. Results of a large 12-year retrospective study indicate good agreement in microbial analyses of BALF and sputum samples, citing 93.7% and 96.5% rates of concordant culture-positive paired specimens isolated within 1 and 7 days, respectively.[12] Therefore, patients with suspected respiratory infections should be undergo cultures if feasible.

Based on our findings and others as well, bronchoscopy is an important initial management option in patients with complete or near-complete lung collapse, given the diagnostic and therapeutic implications. Conservative management may then be reserved for patients with segmental or subsegmental atelectasis,[13 14] subjecting any non-resolving or persistent areas of collapse to eventual bronchoscopic evaluation.

Study limitations

This study has several acknowledged limitations, the first being its single-centre retrospective design, open to selection bias. In addition, the techniques and implementation of chest therapy were not standardised, left instead to the discretion of treating physicians. Also, we did not assess physiologic parameters (eg, oxygenation or ventilation) before and after bronchoscopy or chest therapy, although others have documented postbronchoscopic improvement in ventilation.[8 15 16]

Another issue is that precise radiological definitions or interpretations of collapse and resolution may differ among providers. We attempted to correct for this, using two study investigators to review CXRs and reach a consensus, apart from official radiology readings. Furthermore, a considerable number of our patients experienced recurrent lung collapse, which we did not fully explore. However, respiratory infections seemed to be especially problematic.

Finally, we did not track rates of complete radiological resolution or other follow-up data after patient discharge. Despite these various drawbacks, an important association between underlying malignancy and complete or near-complete lung collapse was brought to light.

CONCLUSIONS

To our knowledge, this is one of the largest comparative studies of bronchoscopy and conservative management in patients with atelectatic lung collapse. Our data confirm the central role of bronchoscopy in this setting. A conservative approach should otherwise be judiciously applied, closely monitoring patient status. Respiratory cultures are also warranted in such patients, who may harbour antibiotic-resistant organisms. In those with lung collapse and risk factors for malignancy, early bronchoscopic airway evaluation should be considered to exclude obstructive neoplasms and avoid diagnostic/therapeutic delays.

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Contributors OGT: made substantial contributions to data acquisition of data and drafted the initial manuscript. He was also involved in the analysis and interpretation of data. Additionally, he was involved in the editing of the manuscript and approved the final version to be considered for publication. He had agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. MA: principal investigator was involved in the conception and design of the study as well as analysis and interpretation of the data. He also critically revised the drafted manuscript and approved the final version to be considered for publication. He had agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. SAAZ: this author had made significant contributions to the acquisition of data, revised the drafted manuscript and had provided approved the final version to be considered for publication. He had agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated

and resolved. GD-F: this author was involved in the conception and design of the study as well as analysis and interpretation of the data. She also critically revised the drafted manuscript and approved the final version to be considered for publication. She had agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval This study protocol adhered to the amended Declaration of Helsinki and was approved by our Institutional Review Board (approval number 11091702).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request.

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