

Pulmonary lobectomies for patients with cognitive impairment: the importance of postoperative respiratory care

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Background: Patients with cognitive impairment (CI) may have an increased risk of complications after major thoracic surgery. However, little is known about this risk and the corresponding management.

Methods: Clinical data of patients who underwent pulmonary lobectomy via open thoracotomy between January 2006 and December 2008 in our institution were retrospectively reviewed.

Results: Overall, 1,325 patients who underwent pulmonary lobectomy via open thoracotomy were analyzed retrospectively, in which five patients were diagnosed with CI. Sputum retention was common and led to significant hypoxemia in all five patients. Four patients were re-intubated due to severe respiratory dysfunction, and three underwent tracheotomy 7 days after intubation due to respiratory infection. Regarding to duration of chest tube placement, length of hospital stay, morbidity rate, and hospital cost, CI patients were significant higher compared with cognitively normal patients undergoing lobectomy via open thoracotomy.

Conclusions: Patients with CI may have difficulties in expectoration after pulmonary lobectomy, and develop multiple respiratory complications, thus increasing hospital stay. Efficacious sputum and airway clearance is critical in these patients.

Keywords: Cognitive impairment (CI); thoracotomy; lobectomy; morbidity

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Introduction

Cognitive function is defined as the ability to learn new knowledge or recall prior acquired information, to recognize and use familiar objects, to plan or organize normal daily activities, to perform complex tasks, and to comprehend words (1). Anyone who is cognitively impaired may lack, to a greater or lesser degree, “normal” thinking facilities such as the ability to remember, learn at a normal pace, adapt behaviors to social settings, and process or understand information. People with cognitive impairment (CI) may perceive that others talk too quickly for them to understand, and may find it challenging to keep up with conversations (2).

Similarly, patients with CI undergoing thoracic surgery may face similar cognitive obstacles and may be at increased risk for postoperative complications. Several studies demonstrated impaired cognitive conditions are important predictors of postoperative complications; patients with CI are at increased risk of postoperative outcomes compared with the general hospital population (3,4). However, little is known about the impact of CI on thoracic surgery postoperative respiratory complications, as well as its corresponding treatment.

Herein, we evaluated our experience with the management of postoperative respiratory complications in patients with CI undergoing open thoracotomy.

Methods

Approval for the study was obtained from the Ethics Committee of the participated hospital. All researchers were fully complied with the following ethical standards.

Informed consent: patients or significant others signed informed consent statements for data collection and follow-up telephone contact or other interview. If eligible patients were unable to provide consent, relatives or legal representatives were asked to consent. Written informed consent was obtained from all study participants.

Confidentiality: all participants have the right for their participation to remain confidential in that only the researcher will be aware who has participated. Generally all data will also be anonymous in the final report so that nothing can be attributed back to an individual participant.

Types of cognitive impairment (CI)

CI may originate from certain types of brain disorders such as acquired brain injury, autism spectrum disorder, intellectual disability [mental retardation (MR)], organic dementia, and other neurological or psychiatric conditions.

Dementia of the Alzheimer's type (DAT) is defined as clinical evidence of memory loss and impairment of at least one other cognitive domain, with evidence of disturbance in social or occupational function (1). MR is a disability characterized by significant limitations in both intellectual functioning and adaptive behaviors as expressed in conceptual, social, and practical adaptive skills; this disability originates before age 18 (5,6). The intellectual disability meta-syndrome (syndrome grouping) is characterized by a deficit in cognitive functioning prior to the acquisition of skills through learning (7). For the purposes of this study, diagnostic criteria for DAT and MR were based on The Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR) (8).

Patients

We retrospectively analyzed 1,325 patients who underwent pulmonary lobectomy via open thoracotomy for the treatment of lung cancer between January 2006 and December 2008 at Shanghai Pulmonary Hospital. Five patients in this cohort were diagnosed with CI: two patients had DAT and three patients had MR. All five patients were diagnosed by psychiatrist, the cognitive status was assessed using the Folstein mini-mental state examination (MMSE) (9).

Additionally, postoperative data of 1,320 patients with normal cognition who underwent lobectomy via open thoracotomy was obtained from Shanghai Pulmonary Hospital between January 2006 and December 2008. Age, blood loss, operative times, duration of chest tube drainage, length of hospital stay, and morbidity rates were compared between the two groups. Operative time was determined as the time from beginning skin incision to closing skin incision. Length of hospital stay was defined as the date from being hospitalized to the date out of the hospital. Re-intubation time was determined as the date from operation being completed to re-intubation; tracheotomy time was determined as the date from operation being completed to tracheotomy. The post-operative complications were defined and showed in *Table 1*.

Preoperative assessment

Preoperative bronchoscopies were performed routinely in the five patients with CI. Adenocarcinoma was diagnosed via transbronchial biopsy in three patients. Preoperative computed tomography (CT) scan, whole body bone scan, and abdominal ultrasound were performed to exclude remote metastasis in these patients. Transbronchial biopsy and percutaneous needle lung biopsy were performed in the other two patients. In patients whose biopsies were negative, anti-inflammatory therapy was administered for 2 weeks; if there was no change in tumor size or symptoms, surgery was performed. Preoperative risk stratification was performed in all patients.

Operative approach

All five patients underwent posterolateral thoracotomy under general anesthesia. Epidural catheters were placed preoperatively. Systematic mediastinal lymph node dissection was performed if frozen sections of tumor demonstrated malignancy. Two chest tubes (32 and 24 Fr) and a small pleural catheter (6 Fr) were routinely inserted into the pleural space for postoperative lung expansion and drainage.

Postoperative management

All patients were extubated in the recovery room postoperatively. Continuous epidural analgesia was administered postoperatively for 2 days. Inferior chest tubes were removed 1 to 2 days postoperatively; superior chest tubes were removed after it was ensured that there was no residual air leak and that the lung had adequately re-expanded with

Table 1 Definitions of postoperative pulmonary complications

Complication	Definition
Respiratory infection	Patient who suspected respiratory infection received antibiotics and met at least one of the following criteria (10-12): fever, new or changed sputum, new or changed lung opacities, leukocyte count $>1.2 \times 10^9/L$
Respiratory failure	The criteria including: postoperative PaO ₂ less than 60 mmHg on room air, a ratio of PaO ₂ to inspired oxygen fraction less than 300 or arterial oxyhemoglobin saturation measured with pulse oximetry less than 90% and requiring oxygen therapy (13)
Atelectasis	Lung opacification with a shift of the mediastinum, hilum, or hemidiaphragm toward the affected area, and compensatory over inflation in the adjacent non-atelectatic lung (14,15)
Bronchial pleural fistula	An abnormal passageway that develops between the large airways in the lungs (bronchial tree) and the membranes that line the lungs (pleura)
Esophageal-bronchus fistula	An abnormal communication between a bronchus and the esophagus

PaO₂, partial pressure of oxygen in arterial blood.

chest radiograph. The small pleural catheter was removed when the drainage amount reached less than 50 mL/day.

Statistical analysis

Numerical data were expressed as the median [interquartile range (IQR)]. Statistical differences between the two groups were calculated using the nonparametric Wilcoxon Mann-Whitney test; categorical variables were compared using Fisher's exact test. A P value <0.05 was considered to be statistically significant.

Results

Degree of impairment

The MMSE scores of five CI patients were 20, 19, 22, 18, 17, respectively; two patients were mild impairment (Scores 20-25), while three patients were moderate impairment (Scores 10-20).

Demographic data

Five patients with CI (three male, two female; median ages 55; range, 39-72 years) were hospitalized due to suspected lung cancers on radiographs. Symptoms at presentation included a persistent dry cough (patients 1,5), hemoptysis (patients 2,3), and refractory fever (38 °C) (patient 4). On final pathology, adenocarcinomas were present in three patients while lung abscess and giant cell granuloma were confirmed in the other two. Patient demographic data is summarized in *Table 2*. When comparing the CI and normal

cognitive function groups, chest tube duration, hospital stay, and complication rate were significantly different between two groups. In CI patients, chest tube duration and hospital stay were much longer compared with patients with normal cognitive function, while complication rate and hospital cost were much higher (see *Table 3*).

Complications and outcomes

All five patients experienced dyspnea and sputum retention due to ineffective cough; bronchoscopic suctioning was required on the second postoperative day. Four patients had persistent pulmonary atelectasis after two or three bronchoscopic suctioning attempts, with significant hypoxia (PaO₂ <60 mmHg) and hypercapnia (PaCO₂ >50 mmHg). These four patients (80%) were re-intubated and required mechanical ventilations between postoperative days 2 through 6 (mean, 3.2 days) (*Table 2*). The remaining patient who did not require intubation had adequate expectoration, but only after two bronchoscopic suctioning attempts.

Of the four patients who were re-intubated, one was extubated seven days later when blood gas analysis was satisfactory (SpO₂ $>95\%$; PaO₂ >80 mmHg; PaCO₂ <45 mmHg). The remaining three patients continued to have high fevers and ropy sputum with unstable pulmonary function. Sputum cultures revealed opportunistic bacteria, three patients were cured with sensitive intravenous antibiotics according to antimicrobial susceptibility testing and one patient was cured with empirical intravenous antibiotics (the complications and therapy of 5 patients were revealed in *Table 4*); tracheotomy was required after 7 days for secondary respiratory infection. Of the three

Table 2 Demographic data

Items	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5
Age (years)	72	66	49	55	39
Gender	Male	Female	Male	Male	Female
Mental illness	DAT	DAT	MR	MR	MR
MMSE scores	20	19	22	18	17
Smoking history	yes	no	yes	no	no
FEV ₁ (L)	2.09	1.34	3.09	1.78	1.27
FEV ₁ (%)	87.2	65.4	89.8	83.1	52.3
Lesion location	RUL	RML	RUL	RLL	RML
Surgical approach	RUL	RML	RUL+PRLL	RLL	RML
Cell type	Ad	Ad	Ad	Lung abscess	Giant cell granuloma
Tumor size (cm)	2×2×3	2.8×2.5×2	3.5×3×3	5.9×5.5×3.5	3×7×2
Lymph nodes (+)	0	4, 7, 10R, 11	3a, 11	–	0
TNM classification	T2N0M0	T2N2M0	T2N2M0	–	–
Postoperative stage	IB	IIIA	IIIA	–	–
Operative time (min)	168	150	110	95	175
Blood loss (mL)	200	200	100	1,000	100
Chest tube duration (days)	10	7	3	41	7
Reintubation time (days)	2	no	3	3	6
Tracheotomy time (days)	9	no	no	10	13
Hospital stay (days)	63	22	32	112	46
Outcomes	Discharged	Discharged	Discharged	Die	Discharged

FEV₁, forced expiratory volume in 1 second; DAT, dementia of the Alzheimer's type; MR, mental retardation; MMSE, mini-mental state examination; RUL, right upper lobe; RML, right middle lobe; RLL, right lower lobe; RUL + PRLL, right upper lobe and partial right lower lobe; Ad, adenocarcinoma.

Table 3 Comparison between CI and normal cognitive patients

Items	CI (n=5)	NCP (n=1,320)	P value
Age, M [IQR]	55 [44-69]	60 [52.75-67.25]	0.573
Operative time, M (IQR) (h)	2.5 (1.8-2.7)	3.0 (1.8-3.2)	0.120
Blood loss, M [IQR] (mL)	200 [100-600]	200 [150-350]	0.545
Chest tube duration, M (IQR) (days)	7.0 (5.0-25.0)	3.0 (2.0-4.0)	<0.001*
Hospital stay, M [IQR] (days)	46 [27-87]	8 [7-12]	<0.001*
Complications rate (%)	4 (80.0)	286 (21.7)	0.011*#

*, Significant difference; #, fisher's exact test; CI, cognitive impairment; M, median; IQR, interquartile range; NCP, normal cognitive patients.

patients who required tracheotomy, two recovered from respiratory infection after antibiotic management. One patient was further development to bronchial-esophageal fistula, and died on postoperative day 112. The remaining four patients were discharged with a median hospital stay of 46 (IQR: 27-87) days.

Follow up

All patients underwent postoperative follow up every 3 months for the first 2 years after surgery, and every 6 months thereafter. The median follow-up period was 56 (range, 36-84) months and the end follow-up point was December

Table 4 Complications of five patients

Items	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5
Complication	Respiratory infection; respiratory failure; atelectasis	No	Respiratory failure, atelectasis	Respiratory infection; respiratory failure; esophageal-bronchus fistula	Respiratory infection; respiratory failure; atelectasis
Symptom*	Dyspnea; fever; purulent sputum	Normal	Difficulty in respiration	Purulent sputum; dyspnea; fever	Purulent sputum; dyspnea; fever
Leukocyte count*	18×10 ⁹ /L	7.8×10 ⁹ /L	12.8×10 ⁹ /L	21×10 ⁹ /L	15.5×10 ⁹ /L
X-ray*	Opacification and patchy shadows in right lung field	Normal	Small patchy shadows; opacification in RLL	Patchy shadows in low field of right lung	Diffuse patchy shadows and opacification in RLL
Bacteria in sputum culture	<i>Streptococcus viridans</i> ; <i>Klebsiella Pneumoniae</i> ; <i>Neisseria</i>	No	Normal flora	<i>Streptococcus viridans</i> ; <i>Neisseria</i>	<i>Candida tropicalis</i>
Tracheotomy	Yes	No	No	Yes	Yes
Treatments	Ventilation + drug sensitivity	Normal	Ventilation + antibiotics	Ventilation + drug sensitivity	Ventilation + drug sensitivity

*, the symptom, leukocyte count and X-ray were noted before tracheotomy. RLL, right low lobe.

2011. Complete follow-up data was obtained in 4/5 cases. One patient (patient 3) died of cancer recurrence 47 months postoperatively; one patient (patient 2) died 65 months postoperatively due to respiratory infection. Two patients (patients 1,5) remained alive at the final follow-up date.

Discussion

This study shows that patients with CI had high postoperative complication rates, length of hospital stay, and hospital cost compared with patients of normal cognitive function. In our CI patient cohort, complications included respiratory failure and respiratory infection due to sputum accumulation. Postoperative retention of airway secretions is an important risk factor for atelectasis and pulmonary infection (14,16), also seen in our group. Patients with CI may also have barriers to understanding, for example, instructions to actively cough. This may result in increased retention of secretions and subsequent complications. This is especially detrimental in patients who have just undergone thoracotomy, due to the underlying pulmonary compromise from sudden loss of lung volume.

Prompt and effective sputum clearance is critical in these patients. Although bronchoscopy is commonly performed in the setting of sputum retention and atelectasis in the ICU, its role in treating atelectasis secondary to excess airway

secretions or decreased cough efficiency is controversial (17). According to a review performed by Kreider *et al.*, bronchoscopy has been shown to be moderately effective in removing retained secretions and improving atelectasis (18). Four CI patients in our study cohort required bronchoscopic suction up to three times and ultimately required re-intubation due to respiratory failure.

Mini-tracheostomy (MT) utilizes a thin un-cuffed tracheal tube (4.5 mm internal diameter), inserted through the cricothyroid membrane under local anesthesia (19). It is reported that Cricothyroid MT usually does not alter the ability to speak or swallow and thus does not compromise quality of life; MT facilitates early and regular suctioning of the tracheobronchial tree during the critical postoperative period, and is well-tolerated without significant side effects (20). Learning from peer experience, MT may be a suitable method for preventing retention of secretions and subsequent complications for patients with CI.

Postoperative pain may also result in impaired sputum clearance and reduced ventilator capacity (21). Thoracotomy can be associated with severe postoperative pain (22). Chest tubes and pleural drains represent an additional activator of pain-sensing fibers and directly influence maximum pain scores (23,24); removal reduces pain and improves ventilatory function (25). We typically position a small tube in the posterior plural cavity, in addition to apical and basal

drainage. The basal drainage tube is generally removed 1 to 2 days postoperatively to reduce pain; the smaller tubes are maintained for blood and fluid drainage.

Conclusions

Patients with CI after thoracic surgery were strongly associated post-operative respiratory complications due to ineffective expectoration, sputum clearance are important for these patients. Pain-control managements or prophylactic MT may be a good option to relieve secretion retention.

Our study was a retrospective study and only five cases with CI were included; therefore, the small population may potentially influence the results. A larger number of cases are required to determine the optimal pre- and post-operative management of CI patients undergoing pulmonary lobectomy via thoracotomy.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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