Quantifying the incidence and impact of postoperative prolonged alveolar air leak after pulmonary resection

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Objective: Prolonged alveolar air leak (PAAL) is a frequent occurrence after lobectomy or lesser resections. The resulting complications and their impact are not well understood. Our aims are to prospectively determine the incidence and severity of PAAL after pulmonary resection using the Thoracic Morbidity & Mortality classification system and to identify risk factors.

Methods: A prospective collection of Thoracic Morbidity & Mortality data was performed for all consecutive pulmonary resections (n = 380; January 2008 to April 2010). Demographics, comorbidities, and preoperative cardiopulmonary assessment were retrospectively identified. The incidence and severity (grades I-V) of burden from PAAL were quantified using the Ottawa Thoracic Morbidity & Mortality system. Risk factors for PAAL and severe PAAL (defined as leading to major intervention, organ failure, or death) were sought with univariate and multivariate analyses.

Results: The incidences of PAAL and severe PAAL were 18% and 4.8%, respectively. PAAL prolonged the median hospital stay by 4 days. The majority of complications associated with PAAL were limited to pulmonary and pleural categories (90%). Significant predictors of PAAL from multivariate analysis include severe radiologic emphysema (odds ratio [OR], 2.8; confidence interval [CI], 1.2-6.2), histopathologic emphysema (OR, 1.9; CI, 1.1-3.6), percentage of predicted value for forced expiratory volume in 1 second less than 80% (OR, 1.9; CI, 1.1-3.3), and lobectomy (OR, 4.9; CI, 1.-14.1). Risk factors for severe PAAL include radiologic emphysema, percentage of predicted value for forced expiratory volume in 1 second less than 80%, forced expiratory volume in 1 second/forced vital capacity ratio less than 70%, and intraoperative difficulties ($P < .05$).

Conclusions: PAAL leads to longer hospital stays, and approximately 4.8% of patients undergoing pulmonary resection experience PAAL that necessitates placement of additional chest drains, bronchoscopy, reoperation, or life support. Further study is required to assess the cost-effectiveness of measures to reduce PAAL. (J Thorac Cardiovasc Surg 2013;145:948-54)

Prolonged alveolar air leak (PAAL) is the most common complication and reason for increased hospital length of stay (LOS) after elective lobectomy or lesser lung resections.[1,2] PAAL is defined as air leakage that lasts more than 3 to 7 days,[3-6] and its incidence ranges from 8% to 26%.[3-5,7-9] Given the important clinical impact of PAAL, attempts to delineate specific risk factors for PAAL have been reported in previous series with variable consistency. The most consistent risk factor is chronic obstructive pulmonary disease, reflected by preoperative pulmonary function test (PFT): forced expiratory volume in 1 second (FEV_1)/forced vital capacity (FVC) ratio less than 70%, FEV_1 less than 1.5 liters, FEV_1 less than 79% predicted, and diffusing capacity of carbon monoxide (DLCO) less than 80% predicted.[3-9] Other potential risk factors, including radiologic and pathologic findings of chronic obstructive pulmonary disease, have not been studied.

The impact that PAAL has on patient recovery and hospital resources is significant. It increases LOS by 5 to 13 days[2,10] and leads to additional complications in both the lung and the pleural space, such as atelectasis, pneumonia, empyema, and prolonged need for chest drains.[3,11] There has been some difficulty in quantifying what constitutes severe PAAL. As a result, the incidence, predictors, and burden of illness from severe PAAL remain elusive.

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Abbreviations and Acronyms

CI = confidence interval
CT = computed tomography
DLCO = diffusing capacity of carbon monoxide
%DLCO = percentage of predicted values for DLCO for age, gender, and height
FEV_1 = forced expiratory volume in 1 second
$\%FEV_1$ = percentage of predicted value for FEV_1
FVC = forced vital capacity
LOS = length of stay
OR = odds ratio
PAAL = prolonged alveolar air leak
PFT = pulmonary function test
POD = postoperative day
TM&M = Thoracic Morbidity & Mortality

The current study addresses the issues of stratification of burden of illness by using an adverse event monitoring and reporting system, the Ottawa Thoracic Morbidity & Mortality (TM&M) system. The TM&M system is derived from the Clavien-Dindo classification,[12-14] which classifies the severity of a complication on the basis of the impact it has on the patient, namely, a complication that occurs leading to no change in management (I), new medical therapy (II), major intervention (III), organ failure (IV), or death (V). We developed definitions of thoracic complications listed by system and stratified by severity.[12,13] Furthermore, the origin and classification of each complication were reviewed and discussed weekly over several years, helping to refine the TM&M system. In the current study, the primary outcomes of interest include rates of nonsevere (grades I-II) and severe PAAL (grades III-V). Secondary outcomes include the presence of additional adverse events, LOS, and rates of readmissions in patients with PAAL.

MATERIALS AND METHODS

Patients

The data for 380 consecutive pulmonary resections for malignant and benign disease within the Ottawa Hospital from January 2008 to May 2010 were prospectively collected by the Ottawa Hospital Division of Thoracic Surgery, approved by the Ottawa Hospital Research Ethics Board. The funding agency had no role in designing the study, analyzing the data, writing the report, or making the decision to submit the manuscript for publication. Prospective TM&M data were initially recorded by the chief resident, reviewed weekly by thoracic staff surgeons, and presented monthly at morbidity and mortality rounds. Patients with pancoast tumors (n = 0), patients with tumors requiring pneumonectomy (n = 24), or patients who did not have any preoperative evaluations before surgery on record (n = 4) were excluded. The records of 352 pulmonary resections remained for analysis. Four patients had 2 separate pulmonary resections during the study period. The data for each surgery were considered as an independent entry in the analysis.

Collection of Preoperative Data

The preoperative evaluations included complete history, physical examination, PFT, arterial blood gas, computed tomography (CT) scan of the chest, echocardiography or cardiac stress tests, and biopsy. The severity of emphysema was graded by a chest radiologist and recorded in the radiologic reports. Operative, radiologic, and pathology reports and the TM&M database were reviewed to document the procedure, intraoperative complications, and pathologic stage. Data were collected on paper case report forms and entered into a Microsoft Excel computer database (Microsoft Corp, Redmond, Wash).

Intraoperative and Postoperative Collection of Prolonged Alveolar Air Leak and Thoracic Morbidity & Mortality Data

The techniques of pulmonary resection, chest tube placement, and management were not controlled; however, general principles guided surgical intraoperative and postoperative practice. Mechanical staplers were mostly used to complete incomplete fissures; however, in open cases, cautery often was used to develop fissures overlying the pulmonary artery. All bronchial stumps were verified to be airtight before closure. If vigorous air leaks were identified intraoperatively, the parenchymal source of bubbling was repaired with sutures. In general, patients who underwent lobectomy received two 28F chest tubes or one 28F chest tube and one 14F pigtail pleural catheter. Those patients who underwent segmentectomy or wedge resection received one 28F chest tube. Immediately after the surgery, the chest tubes were attached to the Sahara S-11000 (Teleflex, Research Triangle Plus, Durham, NC) analogue chest drainage system and placed on –10 to–20 cm H_2O suction. The tubes were converted to water seal on the morning of postoperative day (POD) 1 after chest radiography. The forced expiratory air leak was determined by visualizing bubbles in the analogue drainage system while the patient coughed in an upright sitting position. Patients remained on water seal unless they had an enlarging symptomatic pneumothorax or subcutaneous emphysema developed. When no air leak was detected, the chest tube was removed. If the air leak was equivocal, the tube was clamped and chest radiography was performed, followed by removal of the chest tube if no new pneumothorax or subcutaneous emphysema was identified. If the patient continued to have an air leak on the day of discharge, the patient was discharged with the chest tube attached to a Pneumostat Chest Drain Valve (Atrium Medical Corp, Hudson, NH) and re-evaluated 5 to 7 days later.

Classification of Postsurgical Complications

In the current study, PAAL is defined as a forced expiratory air leak present on POD 5. The 5-day definition also is consistent with that used in the European Society of Thoracic Surgeons and the American Society of Thoracic Surgeons research databases. The presence and severity of postoperative PAAL were classified using the validated Ottawa TM&M,[12,13] developed in accordance with the Clavien classification system.[14] The types of complications are pulmonary, pleural, anastomotic, cardiac, renal, gastric, neurologic, and wound, and there are smaller categories within each of these categories (not analyzed in the current study). In the context of PAAL, the complication grade starts at II, which requires a chest tube for more than 5 days after surgery; and proceeds to grade III, which requires the insertion of an additional chest tube (grade IIIA) or reoperation (grade IIIB); grade IV, which requires intensive care and life support; and grade V, which results in mortality within 30 days. The use of the Pneumostat Chest Drain Valve (Atrium Medical Corp) by itself was considered a grade II complication, as long as the patient did not require interventions listed in the higher grades.

Statistical Analysis

Data were collected as categoric variables and converted to binary numeric data where applicable. Univariate analysis using chi-square tests