

## Lung injury in patients following thoracotomy

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### Abstract

**Background** – Postoperative lung injury is a recognised complication of thoracotomy for which there are few data regarding incidence and outcome.

**Methods** – In a case controlled study the notes of all adult patients who developed acute lung injury (ALI) or acute respiratory distress syndrome (ARDS) following thoracotomy between 1991 and 1994 were examined and classified according to the guidelines of the American Thoracic Society/European Respiratory Society for ALI/ARDS. The predictive value of a routine preoperative assessment and duration of anaesthesia in determining those patients most likely to develop ALI/ARDS was assessed.

**Results** – Between 1991 and 1994 231 lobectomies, 103 pneumonectomies, and 135 wedge resections and segmentectomies were performed. The overall incidence of lung injury was 5.1%; 17 patients developed ARDS (two survived) and seven developed ALI (five survived). There was no significant difference compared with case matched controls in preoperative spirometric values, arterial oxygen tension ( $\text{PaO}_2$ ), or duration of anaesthesia. None of these parameters was useful in predicting those patients most likely to develop lung injury.

**Conclusion** – Lung injury after thoracotomy is associated with a high mortality. Conventional parameters for preoperative assessment do not predict those patients most likely to develop ALI/ARDS in these circumstances.

(Thorax 1995;50:990-991)

Keywords: lung injury, thoracotomy.

Pulmonary injury in adults, which in its most severe form is manifest as the acute respiratory distress syndrome (ARDS), is characterised by high permeability pulmonary oedema resulting in refractory and often terminal hypoxaemia. Although ARDS and less severe forms of acute lung injury (ALI) have been recognised clinically for over 25 years in association with many severe medical and surgical conditions, they have only recently been precisely defined.<sup>1</sup> Furthermore, although thoracotomy and lung resection have been acknowledged as precipitating ALI/ARDS, there are few data on

the prevalence, mortality, and possible predictive factors for these life threatening conditions in this patient population. In a case controlled study we therefore examined retrospectively all cases of ALI/ARDS following lung resection from 1991 to 1994 in a postgraduate teaching centre and, in particular, assessed the potential value of a number of variables in predicting susceptibility.

### Methods

The case notes of all patients who underwent thoracotomy for lung resection at the Royal Brompton Hospital between 1991 and 1994 were reviewed. ALI/ARDS were defined by the criteria recently established by the American Thoracic Society and the European Respiratory Society.<sup>1</sup> Briefly, ALI was defined as an arterial oxygen tension ( $\text{PaO}_2$ , kPa):inspired oxygen concentration ( $\text{FiO}_2$ ) ratio of  $<40$ , bilateral diffuse infiltrates on chest radiography, and a pulmonary capillary occlusion pressure (PAOP) of  $<18$  mm Hg. ARDS was defined as a  $\text{PaO}_2$ : $\text{FiO}_2$  ratio of  $<25$ , bilateral diffuse infiltrates, and a PAOP of  $<18$  mm Hg. The diagnoses were made at varying times in the postoperative period when patients were observed to be in respiratory difficulty. Patients with respiratory failure following pneumonectomy were classified as above, but were required only to have unilateral diffuse pulmonary infiltrates. All patients thus identified were matched for age, sex, and procedure with three controls or (in two cases where this was impossible) with two, making a total of 70. Preoperative predicted and actual spirometric values (forced expiratory volume in one second ( $\text{FEV}_1$ ), forced vital capacity (FVC) and  $\text{FEV}_1/\text{FVC}$ ), arterial oxygen pressure ( $\text{PaO}_2$ ), and general anaesthetic time were recorded.

The data are expressed as mean (SE). Conditional logistic regression analysis was used to determine the value of the measured parameters in predicting those patients most likely to develop ALI/ARDS. These parameters were also compared between patients with ALI and ARDS using the Mann-Whitney U test. A p value of  $<0.05$  was considered statistically significant.

### Results

During the study period a total of 231 lobectomies, 103 pneumonectomies, and 135 wedge resections/segmentectomies were per-

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Reprints will not  
be available.

Received 31 January 1995  
Returned to authors  
19 April 1995  
Revised version received  
6 June 1995  
Accepted for publication  
7 June 1995

Mean (SE) demographic and clinical details of patient population

	ARDS (n=17)	ALI (n=7)	Controls (n=70)
M:F	14:3	6:1	60:10
Age (years)	64.6(2.0)	59.9(6.7)	63(12)
Time to presentation (days)	4.5(1.0)	5.3(1.7)	
Pneumonectomy	5	2	18
Lobectomy	12	5	52
Pao <sub>2</sub> (pre-op,kPa)	11.1(0.5)	10.8(1.8)	11.4(0.2)
FEV <sub>1</sub> (preop,%pred)	71.4(1.7)	55.3(2.3)	74.8(2.3)
FVC (preop,%pred)	81.4(3.9)	79.3(11.3)	85.0(2.1)
FEV <sub>1</sub> /FVC	68.5(2.1)	60.0(7.3)	67.7(1.4)
Anaesthetic time (hours)	2.8(0.2)	2.5(0.4)	2.7(0.1)
No. of deaths	15	2	0

formed. Of these, 24 developed respiratory failure; 17 fulfilled the criteria for ARDS (five after pneumonectomy) and seven for ALI (two after pneumonectomy). The demographic details are outlined in the table. No patient developed ALI or ARDS following a wedge resection or segmentectomy. The mean (SE) time to presentation postoperatively was 5.3 (1.7) days for ALI and 4.5 (1.0) days for ARDS. Two patients with ARDS and five with ALI survived. Although the patients with ALI were younger (59.9 (6.7) years) and had shorter anaesthetic times (2.5 (0.4) hours) than those with ARDS (64.6 (2.0) years and 2.8 (0.2) hours, respectively), the difference was not statistically significant. There was no difference between the two groups in terms of preoperative FEV<sub>1</sub> (% predicted), FVC (% predicted), FEV<sub>1</sub>/FVC, predicted postoperative FEV<sub>1</sub>, and preoperative Pao<sub>2</sub>. Using conditional logistic regression, preoperative assessments of FEV<sub>1</sub>, FVC, FEV<sub>1</sub>/FVC, and Pao<sub>2</sub> were not predictive of ALI/ARDS, nor was the duration of the operative intervention.

### Discussion

Lung injury occurred in 5.1% of all patients following thoracotomy. Those who developed ARDS after thoracotomy had a very poor prognosis (mortality 88%) compared with an overall mortality for ARDS in our centre over the same period of 65%.<sup>2</sup> In this retrospective study we were unable to identify preoperative predictive factors for the development of lung injury.

Other data in this area are sparse and none have been published since the emergence of consensus guidelines concerning the diagnosis of ALI/ARDS. Specifically, ALI has not been previously defined nor treated as a separate descriptive entity. Thus, if the incidence of "non-cardiogenic pulmonary oedema" of 4.4% of pneumonectomies and 1% of all lobectomies detected in a previous study<sup>3</sup> is considered to be synonymous with ARDS, our own incidence of 3.9% following pneumonectomy is broadly comparable. By contrast, we cannot explain our higher incidence of ARDS after lobectomy (5.6% of all cases). No significant relationship was observed between the side on which the procedure was performed and the development of lung injury, either by ourselves or others.<sup>3</sup> It is worth noting that no patient who underwent wedge resection or a segmentectomy developed signs of lung injury in the current study.

There was an apparent, but not statistically significant, difference in the age of patients with ARDS compared with those with ALI,

although we have previously found that age over 60 years is a predictor of those patients most likely to develop ARDS following cardiopulmonary bypass.<sup>4</sup> The preoperative spirometric values were similarly not helpful in identifying those patients who went on to develop ALI/ARDS. The use of predicted postoperative FEV<sub>1</sub> in identifying patients at risk of postoperative complications following thoracotomy has been explored by others and found (together with radioisotope perfusion scans) to be unhelpful.<sup>5</sup> Nevertheless, most investigators suggest that a predicted postoperative value for FEV<sub>1</sub> of less than 0.8 l is likely to be associated with postoperative insufficiency. Although not calculated as part of the original protocol, this value was exceeded by all the patients who developed ALI/ARDS in this study. This suggests that our population was not at particular risk of developing lung injury by these criteria, although this cannot be excluded. To explore this possibility further the anaesthetic records of the 24 patients with ALI/ARDS were examined. No record of abnormal endotracheal tube placement or other anaesthetic complication could be identified. Lastly, as oncotic pressure may determine in part individual susceptibility to the development of pulmonary oedema, we examined serum albumin levels in our patients. The precise temporal relationship between preoperative albumin levels and the time at which lung injury became manifest was difficult to ascertain in all cases, but no significant difference emerged between control and lung injured patients.

The precise mechanism of lung injury therefore remains unknown, although perioperative fluid overload is unlikely to be an important factor. Thus, it has been postulated that, at least in some patients, increased postoperative blood flow through the remaining lung may disrupt the capillary endothelial cell-alveolar barrier.<sup>6</sup> Alterations in respiratory mechanics during thoracic surgery, particularly in patients with compromised pulmonary function, may also contribute to the development and severity of lung injury.<sup>7</sup>

ARDS following thoracotomy is associated with a high mortality. Neither age, the use of preoperative standard spirometry and arterial blood gas analysis, nor the duration of the procedure are useful predictors of those patients most likely to develop lung injury following thoracotomy.

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