

## What happens after pneumonectomy? A prospective study using the transpulmonary thermodilution method

Francesco Leo, MD, PhD,<sup>a</sup> Marco Tullii, MD,<sup>b</sup> Laura Della Grazia, MD,<sup>b</sup> Anna Attanasio, MD,<sup>b</sup> Antonella Tosoni, MD,<sup>b</sup> Gianfranco Manfredi, MD,<sup>b</sup> Marco Venturino, MD,<sup>b</sup> and Lorenzo Spaggiari, MD, PhD,<sup>a,c</sup> Milan, Italy

**A**fter pneumonectomy, several factors may facilitate the occurrence of pulmonary edema, such as right ventricular performance, which is usually impaired after major lung resections,<sup>1</sup> and fluid overload.<sup>2</sup> The common final event is the augmentation of the extravascular lung water (EVLW) that transudates into the alveolar space, impairing ventilation.

In the experimental model, thoracotomy, rapid fluid infusion, and manipulation of the lung result in an increase in EVLW.<sup>3</sup> In humans, the transpulmonary thermodilution method is a reliable technique for EVLW assessment, even if a moderate overestimation as compared with the double-indicator method is expected in case of pneumonectomy.<sup>4</sup> Given the paucity of available information, this study was designed to monitor EVLW modifications occurring early after pneumonectomy in humans.

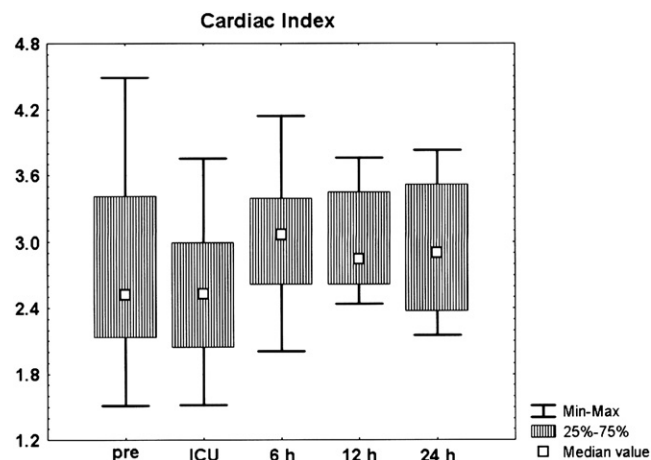
### Patients and Methods

The aim of the study was to monitor pulmonary and cardiac modifications after pneumonectomy by the transpulmonary thermodilution method using the PiCCO System (Pulsion Medical Systems, Munich, Germany).

The population was represented by 15 consecutive patients with lung cancer undergoing pneumonectomy at the Thoracic Surgery Department of the European Institute of Oncology.

### Transpulmonary Thermodilution Method

After induction of anesthesia and double-lumen intubation, (1) a venous catheter was placed in the superior vena cava through the jugular vein on the side of the operation and (2) a thermistor-tipped catheter was placed in the descending aorta through the femoral artery, connected to the PiCCO System monitor. Each measurement was repeated 3 times and performed before thoracotomy (supine position), at intensive care unit admission, and 6, 12, and 24 hours after the operation. A 20-mL dose of cold (0°C–5°C) saline solution was



**Figure 1. Modifications of cardiac index (CI) at baseline and during the first 24 hours after pneumonectomy. The stable increase in cardiac index over the first 24 postoperative hours is evident.**

injected in the superior vena cava, and the intrathoracic global end-diastolic volume (GEDV, the total amount of blood within the 4 cardiac chambers) was automatically determined by the difference between the intrathoracic thermal volume (ITTV) and the pulmonary thermal volume. The intrathoracic blood volume (ITBV) was derived by the estimate  $ITBV = 1.25 \times GEDV$ . EVLW was obtained by the difference between ITTV and ITBV. All measurements during positive ventilation were performed without the use of positive end-expiratory pressure.

Ventilation and fluids were managed according to our previously detailed protocol.<sup>5</sup>

### Results

The population was composed of 11 men and 4 women (median age 63 years) who underwent 10 left and 5 right standard pneumonectomies for lung cancer. Median preoperative forced expiratory volume in 1 second was 78% of the predicted value and the median perfusion of the removed lung was 30%. No patient had postoperative complications in the first 3 postoperative days.

Baseline values of cardiac index, GEDV, and EVLW were 2.5, 1124 mL, and 440 mL, respectively. Early after pneumonectomy (at intensive care unit admission), the cardiac index did not change (2.5); meanwhile, GEDV and EVLW significantly decreased (872 mL and 298 mL, respectively). During the following hours (Figure 1), cardiac index increased to reach a median value of 2.9 24 hours after pneumonectomy. Oppositely, in 3 (20%) patients,

From the Departments of Thoracic Surgery<sup>a</sup> and Anesthesia and ICU,<sup>b</sup> European Institute of Oncology, Milan, Italy; and School of Medicine,<sup>c</sup> University of Milan, Italy.

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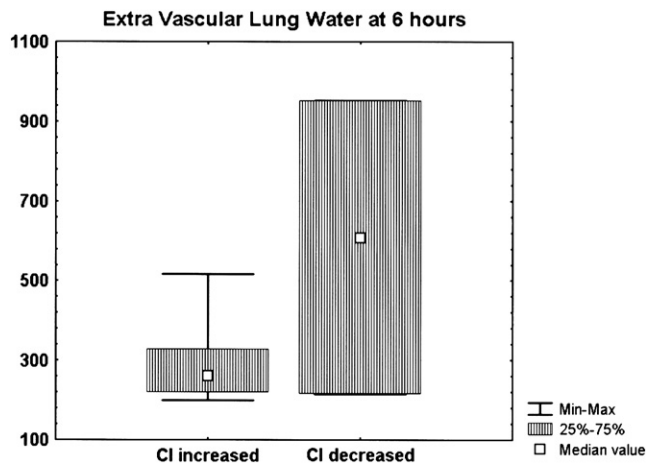
Address for reprints: Francesco Leo, MD, PhD, Thoracic Surgery Department, European Institute of Oncology, Via Ripamonti 435, 20100 Milan, Italy (E-mail: francesco.leo@ieo.it).

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**Figure 2.** In 3 patients, cardiac index decreased after pneumonectomy. In such a situation, 6 hours after surgery a significant increase of extravascular lung water (EVLW) was recorded.

cardiac index failed to increase and all recorded values were below the preoperative value. GEDV recovered within the first 12 hours, almost reaching the preoperative value (median at 12 hours, 1089 mL); meanwhile, EVLW remained relatively stable over the first 24 hours (median values at 6, 12, and 24 hours were 267, 279, and 275, respectively).

Patients whose cardiac index failed to increase after pneumonectomy had a significant increase of EVLW at 6 hours ( $P = .007$ , Figure 2) and an increased GEDV at 12 hours ( $P = .08$ ).

## Discussion

Data from this series of patients who underwent uneventful pneumonectomy add useful information on postoperative pulmonary and

cardiac modifications, which at present had been only marginally investigated.

First, an increased cardiac output is the first answer occurring within a few hours after pneumonectomy, probably as the result of the acute reduction of the pulmonary vascular bed. At the same time, GEDV increases, probably because of the increase in the right ventricular diastolic volume occurring after pulmonary resection.<sup>1</sup>

Second, EVLW is reduced by about 30% after pneumonectomy and this reduction is maintained for the first 24 hours.

Third, a minority of patients do not respond to pneumonectomy by an increase in cardiac output. They tend to accumulate more EVLW and their GEDV further increases, even in the absence of clinical signs or symptoms of cardiac failure. All of the patients who did not increase their cardiac index had no risk factors but preoperative chemotherapy, which impairs alveolocapillary function and may therefore increase the risk of extravascular fluid accumulation.

The model linking these data is only speculative: the physiologic increase in cardiac index necessary to counterbalance the reduction in the pulmonary vascular bed may be limited in some cases by the occurrence of moderate pulmonary hypertension, which may facilitate EVLW accumulation and GEDV increase. At this point, any adverse event (hypotension, cardiac ischemia, fluid overload) may result in complications.

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