

# Pulmonary dysfunction after coronary artery bypass surgery

Michel A. Ghattas, M.D.

*Cleveland, Ohio*

Respiratory dysfunction and arterial hypoxemia are common causes of morbidity following cardiac surgery utilizing extracorporeal circulation. Predisposing factors can be classified as (1) related to the surgical procedure such as opening the chest, opening the pleura, trauma, postoperative pleural effusion, hemothorax, or pneumothorax; (2) associated preoperative pathologic changes such as restrictive or obstructive lung disease, chronic lung congestion secondary to heart disease; and (3) related to cardiopulmonary bypass technique with its associated physiologic and histologic changes in the lung structure.

We studied the degree of respiratory dysfunction and the course of recovery in 357 consecutive patients who had undergone coronary artery bypass surgery and were considered clinically capable of supporting their own pulmonary functions without prolonged mechanical assistance after surgery. Postoperative pulmonary management was standardized; all patients were mechanically ventilated overnight.  $FIO_2$  and ventilatory parameters were adjusted to maintain  $PaO_2$  80 to 120 mm Hg and  $PaCO_2$  35 to 40 mm Hg. Patients who had vital capacity 10 to 15 cc/kg body weight,  $PaO_2$  >80 mm Hg inspiratory negative Pr >30 cm  $H_2O$  were weaned from mechanical ventilation. All patients

received routine chest physiotherapy until the fifth postoperative day. Computer analysis was used to compare postoperative screening spirometry results done on the seventh postoperative day with preoperative values, which were used as controls. There was a significant reduction in vital capacity, forced vital capacity, forced expiratory flow rate, and peak expiratory flow rate (*Table 1*). The FEV<sub>1</sub>/FVC ratio remained the same, indicating that the changes are mainly restrictive and not obstructive.

The same group of patients experienced hypoxemia while breathing room air postoperatively. In patients with normal blood gases preoperatively, a fall of 5 to 12 mm Hg in PaO<sub>2</sub> was noted in early postoperative periods and remained so for 4 to 5 days even with stable hemodynamic conditions and normal cardiac output.

Although hypoxemia was evident on the second postoperative day the CO<sub>2</sub>

level and pH were normal and did not show any significant changes from preoperative values (*Table 2*). By the seventh postoperative day while PaO<sub>2</sub> levels returned to preoperative values, PCO<sub>2</sub> was significantly lower with pH showing respiratory alkalosis.

These changes can be explained on the basis of mismatching of ventilation and perfusion and increased shunting of venous blood into pulmonary vessels due to atelectasis as evidenced by the changes in lung volumes during the same period. Hyperventilation and low PCO<sub>2</sub> is a compensatory corrective mechanism for these changes.

The drop in vital capacity and PaO<sub>2</sub> is greater in the older age group, patients with previous lung disease, and those who have internal mammary artery anastomosis as part of the operation. Opening of the pleura during dissection of the internal mammary artery is another added factor causing more

**Table 1.** Preoperative and postoperative screening spirometry results in 357 patients with CABG

|  | Vital capacity (L) | Forced vital capacity (L) | Forced expiratory volume (L) | Forced expiratory flow (L/sec) | Peak expiratory flow (L/sec) | FEV <sub>1</sub> /FVC |
|--|--------------------|---------------------------|------------------------------|--------------------------------|------------------------------|-----------------------|
| Preoperative                           | 4.12 ± 0.89        | 4.05 ± 0.90               | 2.90 ± 0.72                  | 2.75 ± 1.18                    | 8.58 ± 2.07                  | 0.710 ± 0.08          |
| Postoperative 7th day                  | 2.81 ± 0.80        | 2.76 ± 0.79               | 1.96 ± 0.59                  | 1.93 ± 0.80                    | 6.73 ± 2.02                  | 0.709 ± 0.08          |
| Percent decrease                       | 33.4               | 31.8                      | 36.1                         | 32                             | 22.8                         | ...                   |
| Paired <i>t</i> test ( <i>t</i> value) | 36.5               | 33.5                      | 34.77                        | 18.71                          | 13.73                        |                       |
| <i>p</i> value = <i>p</i> < 0.001      |                    |                           |                              |                                |                              |                       |

CABG = coronary artery bypass grafting.

**Table 2.** Changes in blood gases in first 7 days; 357 patients

|                             | Preop        | Postop day 2 | <i>p</i> value | Postop day 7 | <i>p</i> value |
|-----------------------------|--------------|--------------|----------------|--------------|----------------|
| PaO <sub>2</sub> (room air) | 76.03 ± 11.0 | 58.32 ± 9.4  | <0.001         | 71.05 ± 9.8  | NS             |
| PCO <sub>2</sub>            | 39.59 ± 4.4  | 40.01 ± 4.22 | NS             | 31.9 ± 4.1   | <0.001         |
| pH                          | 7.41 ± 0.03  | 7.43 ± 0.02  | NS             | 7.47 ± 0.02  | <0.001         |

**Table 3.** Comparison of incidence of atelectasis and changes in vital capacity and PaO<sub>2</sub> in groups A and B

|   | Group A     | Group B     | p value   |
|---|-------------|-------------|-----------|
| Drop in vital capacity<br>(>combined<br>median value)   | 44.9% (84)  | 56.9% (96)  | p < 0.05  |
| Drop in PaO <sub>2</sub><br>(>combined<br>median value) | 71.3% (134) | 85.7% (145) | p < 0.025 |
| Atelectasis   | 8.5% (16)   | 16% (27)    | p < 0.025 |

Group A, 188 patients had saphenous vein grafting only.  
Group B, 169 patients had saphenous vein grafting plus left internal mammary artery anastomoses.

atelectasis and a further drop in vital capacity and PaO<sub>2</sub> in the postoperative period.

When we compared a group of patients who had saphenous vein grafting with another group who had saphenous vein grafting and internal mammary artery anastomosis there was a significantly higher incidence of atelectasis and a greater drop in PaO<sub>2</sub> and vital capacity in the second group (*Table 3*).

The results of the study indicate that despite prolonged mechanical ventilation and continuous postoperative pulmonary care, patients who clinically had adequate pulmonary functions and did not require further mechanical support still had a significant drop in lung capacities mainly due to varying degrees of atelectasis that may remain as long

as 7 days postoperatively. Patients with restrictive lung disease may not tolerate further reduction in lung volumes postoperatively and are susceptible to more complications such as difficulty in weaning from mechanical ventilation, atelectasis, accumulation of secretions, and subsequent infection.

Associated hypoxemia and shunting are evident in early postoperative periods accompanied by compensatory hyperventilation. Patients who have the pleura opened during the operation should be maintained on sufficient end-expiratory pressure during ventilatory management to increase functional residual capacity and maintain large lung volumes, since they are susceptible to atelectasis and shunting.