Lung Mechanics with Tension Pneumothorax during Mechanical Ventilation

Masahiko MIMA, Kazufusa SAKATA
Heiji OKUDA and Koshiro HIOKI*

(Key words: lung mechanics, mechanical ventilation, tension pneumothorax)

The placement of a Swan-Ganz catheter via internal jugular vein subcutaneously is a commonly used technique for evaluating hemodynamic status in patients undergoing major surgery. The tension pneumothorax is one of the most serious complications of internal jugular cannulation, particularly in patients receiving mechanical ventilation. The detection of a tension pneumothorax with the aid of computerized measurement of the airway dynamics has not been previously reported.

A 52-year old male was scheduled for hepatectomy. His past medical history was unremarkable and preoperative laboratory studies, physical examination, chest roentgenogram, and electrocardiogram were normal. The patient was classified as ASA physical status I. Anesthesia was induced with 200 mg of thiopental and the trachea was intubated with the aid of 6 mg of pancuronium. Manual ventilation of the patient's lung was uneventful. In order to obtain hemodynamic parameters Swan-Ganz catheter through internal jugular cannulation was employed. The vein was cannulated from anteriorly 3 cm above the right clavicle (supraclavicular approach) with a 7.5 French gauzed catheter. The placement of the catheter was successful on the first attempt and all the values of central venous pressure (C.V.P.), the right atrial pressure, right ventricle pressure, pulmonary artery pressure and wedge pressure were within normal limits. Mechanical ventilation with an Engström Erica ventilator (Gambro, Sweden) was performed in a volume-limited, time cycled mode ($F_{I_{O_2}} = 1.0$, tidal volume 390 ml and frequency $20 \cdot min^{-1}$). The ventilator provided the computerized measurement of the maximum and mean airway pressure, resistance, compliance etc., every ten seconds without discontinuation of the ventilation. Diazepam, 10 mg i.v. was given for maintenance of anesthesia. Five minutes after the placement of the Swan-Ganz catheter, neither auscultation nor percussion on either side of the chest revealed eventful sounds. It was shown that the peak airway pressure of 22 cmH_2O, mean airway pressure 3 cmH_2O, airway resistance 5 $cmH_2O \cdot l^{-1} \cdot sec^{-1}$, compliance 51 $ml \cdot cmH_2O^{-1}$, and PEEP 0 cmH_2O. Blood gas analysis showed Pa_{O_2} of 564 mmHg ($F_{I_{O_2}} = 1.0$) and Pa_{CO_2} of 38 mmHg. The Erica ventilator was replaced with a Servo D ventilator (Siemens, Sweden) equipped with an enflurane vaporizer installed and anesthesia was maintained by 0.8% enflurane in 6 $l \cdot min^{-1}$ of 50:50 nitrous oxide: oxygen mixture. Over the following 15 min, the patient was prepared for surgery. The airway dynamics, then, indicated a peak airway pressure of 35 cmH_2O, mean airway pressure of 6 cmH_2O, airway resistance of 2 $cmH_2O \cdot l^{-1} \cdot sec^{-1}$, approximate fall to 40% of the previous value, and a compliance of

Department of Anesthesia and Surgery, Kansai Medical University, Moriguchi, Japan*

Address reprint requests to Dr. Mima: Department of Anesthesia, Kansai Medical University, 1 Fumizono, Moriguchi, Osaka, 570 Japan

J Anesth 5:177–179, 1991

11 ml·cmH_2O^{-1}, an approximate decrease to 22% of the previous value. A PEEP of 2 cmH_2O was noted at the same time, indicating a certain amount of insufflation gas to possibly remain in the thorax during expiration period. Hydrothorax was ruled out since percussion of the back sides of the thorax did not give forth a dull sound. Consequently pneumothorax was suspected immediately. Arterial blood gas analysis showed Pa_{O_2} of 143 mmHg (FI_{O_2} = 0.5). The surgeons, however, considered the value of Pa_{O_2} to be sufficiently safe to conduct the operation. On deep dissection of the abdominal cavity, the surgeons found that there was a markedly tensile caudad distension of the right hemidiaphragma. The right chest was then found to be tympanitic. Immediate examination of the chest X-ray showed a typical tension pneumothorax of the right side, and blood gas analysis revealed a Pa_{O_2} of 90 mmHg (FI_{O_2} = 0.6) and Pa_{CO_2} of 39 mmHg. Immediately after, a No. 14 gauge needle was inserted percutaneously into the right pleural cavity with an audible rush of air spouted out.

Discussion

Swan-Ganz catheterization through internal jugular vein by the supraclavicular approach is presumably the cause of the tension pneumothorax[1], which is one of the most serious complications[2]. Misplacement of the central venous catheter into the pleural cavity is rarely observed with the high internal jugular approach[3]. When ventilation is controlled mechanically, the tip of the introducing needle for the Swan-Ganz catheter may come into contact with the right upper lung during a maximal insufflation period, thus causing injury to the lung afrer which pneumothorax occurs. Therefore, mechanically controlled ventilation should be carefully administered during cannulation of the internal jugular vein. The decreases in compliance and resistance indicate a diminished elasticity in the lung and non-elastic resistance in the peripheral airway due to the collapsed lung with rupture. The ruptured lung may possibly have functioned as a check valve and, created tension pneumothorax. It is also possible that the pneumothorax may have been enlarged by the inhalation of nitrous oxide[4], with notable change in the airway dynamics of the patient. These changes in airway dynamics as early signs of tension pneumothorax have apparently not been documented previously, although there are reports of increased airway pressure etc[5,6]. Since a decrease in arterial oxygen tension may not be useful in predicting the onset of pneumothorax during mechanical ventilation[7], the appropriate interpretation of changes in lung mechanics will be useful monitoring in detecting the onset of tension pneumothorax, and their changes become evident more earlier than changes in arterial blood gases or common vital signs.

An incident of tension pneumothorax during the insertion of Swan-Ganz catheter through internal jugular vein was detected with the aid of computerized measurements of airway dynamics in a patient receiving mechanical ventilation. It was shown that there was a marked decrease in both airway resistance and total thoracic compliance as well as an elevation in the mean airway pressure and peak airway pressure. A characteristic, spontaneously occurred "PEEP" was also shown. These changes in the airway dynamics were recognized before serious decrease in the arterial oxygen tension.

(Received May 1, 1990, accepted for publication Sep. 13, 1990)

References

1. Haapaniemi L: Supraclavicular catheterization of the superior vena cava. Acta Anaesthesiol Scand 18:12–22, 1974
2. Martin JT, Patrick RT: Pneumothorax: Its significance to the anesthesiologist. Anesth Analg 39:320–429, 1960
3. Rosen M, Latto IP, Ng WS: Handbook of percutaneous central venous catheterization. The internal jugular vein. Philadelphia, WB Saunders, 1981:76–113
4. Eger EI 11, Saidman LJ: Hazards of nitrous oxide anesthesia in bowel obstruction and pneumothorax. Anesthesiology 26:61–66, 1965
5. Hamilton WK, Moyers J: Pneumothorax during surgery. JAMA 198:187–188, 1966

6. Cook TL, Dueker CW: Tension pneumothorax following internal jugular cannulation and general anesthesia. Anesthesiology 45:554–555, 1976
7. Bitto T, Mannion JD, Stephenson LW, Hammond R, Lanken PN, Miller W, Geer RT, Wagner HR: Pneumothorax during positive pressure mechanical ventilation. J Thoracic Cardiovasc Surg 89:585–591, 1985