Abstract

Background: Several pulmonary and hemodynamic complications may occur during mechanical ventilation of the lungs. The use of a positive end-expiratory pressure (PEEP) can improve oxygenation and prevent atelectasis, although this method can cause important hemodynamic side effects. Mostly, these hemodynamic effects are due to increased airway pressure that is transferred to the intrapleural space, increasing the intrathoracic pressure, which decreases venous return to the heart. Cardiac output is significantly reduced with high PEEP levels which in turn precludes the improvement effects on blood oxygenation. The aim of this study was to evaluate hemodynamic and respiratory effects of different levels of carbon dioxide insufflations associated with different levels of PEEP under conventional two-lung ventilation in isoflurane anesthetized pigs. Materials, Methods & Results: Twelve juvenile pigs were anesthetized with ketamine and midazolam, and end tidal isoflurane 2.0 V% for maintenance. Animals were submitted to tension pneumothorax through an acute intrathoracic insufflation with carbon dioxide at 0, 5, and 10 mmHg. Mechanical lung ventilation with 100% oxygen was started with zero PEEP then increased to 5 and 10 cmH2O. Ventilatory, respiratory and hemodynamic parameters were measured, as well as blood gases. Tension pneumothorax of 10 mmHg, with both PEEP levels, induced a significant decrease in cardiac index, stroke volume, right ventricular stroke work index, dynamic compliance, arterial pH, arteriovenous oxygen difference, arterial blood pressure, in addition to significance increase in heart rate. Moreover, tension pneumothorax of 5 or 10 mmHg combined with 5 or 10 cmH2O PEEP produced a significant increase in alveolar-arterial oxygen difference, a significant decrease in arterial oxygen content, and arterial partial pressure of O2. Central venous pressure, mean pulmonary arterial pressure, physiologic dead space, and arterial partial pressure of CO2 significantly increased with tension pneumothorax of 5 or 10 cmH2O when 5 or 10 mmHg PEEP was used. Arterial oxygenation improved significantly when 10 cmH2O PEEP was applied to 5 or 10 mmHg tension pneumothorax. Discussion: In this study, a thoracoscopic trocar was used to produce the acute respiratory function impairment. All animals showed the hemodynamic effects of an increased intrapleural pressure (IPP), such as hypotension and decreased SpO2. The major change observed was the increased shunt fraction, due to increased physiologic dead space. The hemodynamic changes observed were mainly due to compression of the large thoracic vessels as well as lung compression. When PEEP was applied without increased IPP, the hemodynamic depressive effects were less important. Levels of ETCO2 in our study did not present a significant increase, demonstrating that recruitment maneuvers are not always effective when there is a concomitant increased IPP. Dead space and V/Q mismatch significantly increased, demonstrating an important respiratory depressant effect. We have demonstrated in this
study that while arterial oxygenation and tissue oxygen extraction is improved when high PEEP strategy is used in a swine tension pneumothorax model, the mechanical ventilation of the lungs with low PEEP or high PEEP strategy produced significant depression of the hemodynamic function during tension pneumothorax.

Keywords
PEEP, ventilation, pigs, intrapleural pressure, pneumothorax.