



Clinical Update

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PEEP and CPAP Effects on Chest Drainage

Positive end expiratory pressure (PEEP) and continuous positive airway pressure (CPAP) are used commonly to improve oxygenation. Since chest drainage depends on the physics of air flow and pressure gradients, it's important to know about the changes resulting from therapeutic positive pressure. First, we'll review pulmonary physiology, then the effects of PEEP and CPAP.

Pressure's On

Normally, pleural pressure is negative but it is not uniform throughout the chest. A pressure gradient results mainly from gravity's effects on the lung. At the apices, the pressure is about $-8\text{cmH}_2\text{O}$; in the middle of the chest, $-5\text{cmH}_2\text{O}$; and at the bases closer to $-2\text{cmH}_2\text{O}$.

As with the pressure gradient, inhaled air is unevenly distributed as well. When airways are patent, alveolar pressure is consistent, so lower pleural pressure results in higher volume in the apices, gradually decreasing toward the bases.¹⁻³ Regional volume distribution is determined by the interaction between forces within the lung (pressure and elastic recoil) and characteristics of the chest wall and abdomen.^{2,4} Gravity is also an important factor, with ventilation and perfusion distribution changing when a person is upright, supine, or prone.³

Where Does Air Go?

Resistance and compliance also determine air distribution.^{1,5} *Resistance* describes how easy or difficult it is for air to flow through the airways. It is determined by the viscosity of the air (e.g., helium is "lighter" or less viscous than air, so it flows more easily); the length of the airway (longer airways reduce flow); and the internal diameter of the airway (narrower airways reduce flow). High resistance limits flow; low resistance improves flow.¹ *Compliance* describes the pressure differential needed to deliver a given volume to the alveoli. A stiff lung has low compliance so it needs more pressure to expand. A lung with high compliance needs less pressure. Lung diseases such as ARDS and pneumonia create higher resistance and lower compliance in diseased regions, and air will preferentially go to healthier areas. Emphysema, with bullae, results in higher compliance so air will go to those areas, increasing the risk of overdistention and rupture.⁴

Patients with lung disease, particularly those with intrapulmonary shunt (perfusion without ventilation), are often given positive pressure to recruit more alveoli, increase ventilation and reduce shunt. Both CPAP and PEEP eliminate negative intrapulmonary pressure that normally occurs during inhalation.⁶

How Much Pressure is Transmitted

The amount of PEEP transmitted to the pleural space is determined by chest wall and lung compliance. If lung compliance is low (the lung is stiff), but chest wall compliance is high (it expands freely) very little PEEP is transmitted to the pleural space, resulting in a large differential between lung pressure and pleural pressure.⁴ If lung compliance is high and the chest wall compliance is low (chest wall expansion is limited by factors such as obesity or skeletal conditions), much more PEEP is transmitted to the pleural space. Pleural pressure can be significantly higher than body surface pressure.^{4,6,7}

When chest wall and lung compliance are equal, the pleural pressure increase is about one-half of the PEEP applied.⁶ Keep in mind that it is the difference between lung pressure and pleural pressure that leads to barotrauma, not the absolute level of PEEP.^{4,8}

Pressure is also transmitted to the pericardium; patients without severe lung disease will have about 70% of PEEP transmitted to the heart.⁹ Greater pressure will reduce venous return (preload) and can reduce ventricular filling and cardiac output.^{9,10} Central venous pressure will rise as a result. Cardiac output is preserved when the lungs are stiff and pressure is not transmitted effectively.⁴

Pneumothorax, Air Flow & Chest Drainage

Since air moves along a pressure gradient from higher pressure to lower pressure, air will flow out of an opening in the lung until pressure equalizes between the lung and the pleural space.^{6,11,12} With positive pressure ventilation, the intrapulmonary pressure will be significantly higher than the pleural pressure, particularly if the lungs are stiff and compliance is low. Resistance in a 2 mm distal airway is higher than in a 5.3 mm (ID) chest tube. Air will take the path of least resistance and go out the chest tube rather than into the tiny distal airways. In addition, "exhaled" gas may preferentially flow out of the chest tube. Research shows that air leaving the chest through a chest tube has participated in gas exchange.¹²

Combine the decreased resistance of the chest tube and the driving pressure created by PEEP and CPAP, and you can see how these can amplify and prolong air leaks, seen as continuous bubbling in the water seal chamber of the chest drain. PEEP and CPAP effects on pleural pressure, the heart, and great vessels depend on both the level of pressure, and lung and chest wall compliance. As with most therapeutic strategies, benefits of improved oxygenation from reduced shunting need balance with potential challenges of enlarging and prolonging pulmonary air leak and effects on the cardiovascular system. The balance will be different from patient to patient and with some critically ill patients, may be different from hour to hour or day to day.

Sources on page 2.

In The Literature

Evidence-Based Family Presence Policy

The current issue of the *Journal of Emergency Nursing* provides a detailed description of an evidence-based practice project examining family presence. The authors describe their review of the literature and practice guidelines, developing a policy, educating staff, conducting a pilot study and evaluating the policy and pilot implementation. The researchers discovered more questions during this process and describe their next steps. This article is a terrific example of the importance of a pilot and evaluation, not just as a rubber stamp, but to learn from the people affected by any new policy.

Source: Dougal RL, Anderson JH, Reavy K, Shirazi CC: Family presence during resuscitation and/or invasive procedures in the emergency department: one size does not fit all. *Journal of Emergency Nursing* 2011;37(2):152-157. [PubMed Citation](#)

Patients Decide When to Make Changes

A fascinating article in the current issue of *American Nurse Today* describes a new approach to nursing care: motivational interviewing. Rather than telling patients they need to quit drinking or smoking, this approach helps patients understand the effect their behavior has on their condition(s) and helps them determine the changes they need to make and are willing to make. It treats the patients as experts on themselves, a truly patient-centered approach.

Source: Morrison S: Motivational interviewing: a collaborative path to change. *American Nurse Today* 2011;6(3):16,18.

Is Adequate Staffing Enough?

In a previous study, the authors validated a Nursing Teamwork Survey used in this study to evaluate the relationship between staffing levels and nursing teamwork. Researchers found that units with greater numbers of nursing hours per patient day had higher levels of teamwork. The greater percentage of RNs in the unit skill mix also contributed to higher teamwork scores. When nursing staff is stressed by understaffing, they seem to develop tunnel vision in which they only see their patients' needs and teamwork suffers.

Source: Kalisch BJ, Lee KH: Nurse staffing levels and teamwork: a cross-sectional study of patient care units in acute care hospitals. *Journal of Nursing Scholarship* 2011;43(1):82-88. [PubMed Citation](#)

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On the World Wide Web



Center for Innovation

The Centers for Medicare and Medicaid Services (CMS) has opened the Center for Innovation. Their mission is to test, evaluate and spread the best solutions from innovators across the country. Their goals are to achieve better health through improved, cost-effective health care practices that deliver the right care at the right time in the right setting – every time. You can also sign up for e-mail updates on the center's activities.

<http://innovations.cms.gov/>

Innovation Exchange

The Agency for Healthcare Research and Quality identified a need for healthcare professionals to share innovations and ideas before they went through the lengthy process of peer-review in professional journals. The Innovation Exchange was established, and to date, nurses comprise the largest group of users, at 33%. The exchange offers free Webinars, e-mail updates and a searchable database of innovations with details on how they can be implemented in another setting.

<http://www.innovations.ahrq.gov>

Implementation Science

This is an international online, open source, peer-reviewed journal that publishes research about the scientific study of applying research to practice in health care. There are a variety of resources here about the science behind creating effective change in health care delivery.

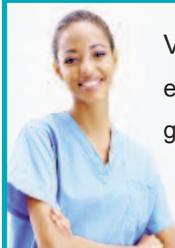
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