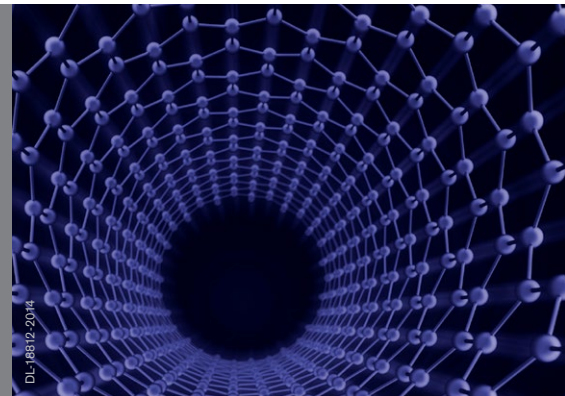


# Technology Insights

## for intraoperative alveolar recruitment

Protective ventilation in the OR poses major requirements to anaesthesia workstations. Dräger works closely with clinicians and nursing staff around the world to understand the precise needs and requirements for protective ventilation in the OR.

Below we describe the latest ventilation technologies in our anaesthesia workstations enabling successful protective ventilation strategies.



The influence of protective ventilation strategies on the incidence of postoperative pulmonary complications (PPC) has been a topic of lively discussion in the anaesthesia community for several years. We have also already provided you with some aspects of this discussion in a clinical white paper ([Link](#)).

Intraoperative alveolar recruitment plays an important role in this discussion. For this special aspect of lung protection during intraoperative ventilation, we have provided a clinical white paper ([Link](#)).

In the following, we will give you an overview of two approaches to alveolar recruitment, which are often discussed in current literature on intraoperative ventilation, as well as on the technical features of Dräger anaesthesia devices, which support you in applying recruitment manoeuvres.

Firstly, literature on this subject frequently describes the one-step recruitment manoeuvre (often also known as the Lachmann manoeuvre), whereby the inspiratory pressure is increased and held for a certain amount of time. In doing so, the applied respiratory pressure should correspond to the opening pressure of the atelectatic lung area. Literature often indicates an opening pressure for patients of normal

weight of approx. 40 cmH<sub>2</sub>O. The duration of the recruitment manoeuvre must allow sufficient time for the alveoli to yield to the pressure and open. The amount of time allotted is often indicated as approx. 40 seconds. Thereafter, the positive end-expiratory pressure (PEEP) should be adjusted in such a way so that the opened lung area does not begin to collapse again.

Secondly, the multi-step recruitment manoeuvre is also described in current literature, frequently referred to as "incremental recruitment" or "in/decremental PEEP trial". In this procedure, both the inspiratory pressure as well as the PEEP are gradually increased, maintained at the maximum level for a certain amount of time, and then gradually decreased again. The patient is constantly ventilated during the entire recruitment procedure. This ensures oxygenation and ventilation for the entire duration of the manoeuvre. Since both pressures, PEEP and inspiratory pressure, are gradually increased, the so-called driving pressure (difference in pressure between PEEP and inspiratory pressure) remains constant, if so desired. Once the maximum pressure level has been attained and held over the desired time span, both pressures are likewise reduced in several stages. Therefore, the multi-step recruitment manoeuvre consists of an incremental and a decremental phase. Likewise, a multi-step recruitment manoeuvre should be followed up with a patient specific PEEP, so that the recruited alveoli are held open. During the decremental phase, the PEEP level at which the alveoli remain open can be determined by monitoring patient compliance and/or tidal volume. So, apart from opening the atelectatic lung area, the multi-step recruitment manoeuvre also permits



Manual one-step recruitment – Lachmann manoeuvre

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determining the optimal PEEP. Customised ventilation and haemodynamic patient monitoring is obligatory for all recruitment manoeuvres. In particular, lung mechanics, SpO<sub>2</sub> and blood pressure must be monitored precisely during such procedures.

### TECHNICAL PROCEDURE FOR RECRUITMENT MANOEUVRES

Both recruiting manoeuvres can be performed manually with all Dräger anaesthesia devices. Moreover, our Perseus® A500 anaesthesia workstation offers you specific procedures, which support alveolar recruitment.

#### One-step manoeuvre:

One-step recruitment is normally performed manually. To do so, you switch to the "Man/Spont" mode. The APL valve is set to the anticipated opening pressure and the manual ventilation bag pressed for the duration required. This is where the role of the APL valve is of particular importance. The applied pressure should be limited to the opening pressure as reliably as possible. On the one hand, appropriate scales on the Dräger APL valves permit good adjustment, and, on the other hand, pressure limit is limited reliably to the set level. Care should be taken that the manual breathing bag is not pressed too strongly or vigorously, in order to avoid high peak pressures and corresponding shear forces.

If possible, this manoeuvre should always be followed by an adequate PEEP. To this end, the blower-ventilator technology in the anaesthesia systems Zeus® IE and Perseus® A500 makes it possible to set an active CPAP in the "Man/Spont" mode. This avoids a pressure drop in the respiratory tract to a level below the alveolar closing pressure after completion of the manoeuvre and, as a result, prevents recurrent atelectasis formation. As of summer 2017, Perseus® A500 will offer additional procedures, by which such a one-step recruitment manoeuvre is possible during normal ventilation - without the previously described manual effort. To do so, the desired pressure level and time are set, after which the manoeuvre can be started by the touch of a button. After the manoeuvre has been conducted, the device

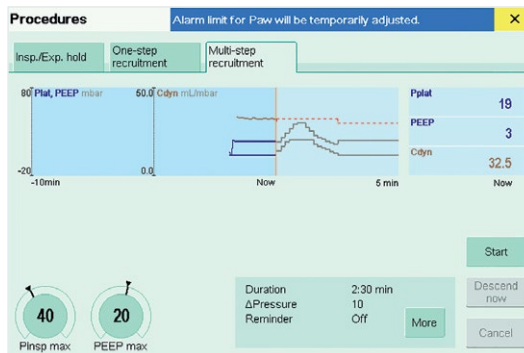
automatically switches back to the previously set ventilation. This ensures that the preset pressure and time are kept reliably and that, following the manoeuvre, the desired PEEP will be maintained.

#### Multi-step manoeuvre

The idea behind this manoeuvre is to carry out the alveolar recruitment, not only effectively, but also as gently as possible with respect to the lung and haemodynamics. In order to do so, inspiratory pressure and PEEP are ideally increased step-by-step while maintaining a constant driving pressure. The maximum inspiratory pressure (alveolar opening pressure) is maintained for a desired amount of time, after which both inspiratory pressure and PEEP are gradually decreased. Each stage is maintained for a user-defined time/number of breaths. By linking PEEP and inspiratory pressure, Dräger anaesthesia devices facilitate the manual implementation of these manoeuvres.

As of summer 2017, the Perseus® A500 will also offer a procedure to automate the manual set-up effort for these kind of manoeuvres, which can take up to more than 5 minutes. The recruitment manoeuvre can be adjusted to suit the patient intuitively with just a few settings. The following two settings are the main parameters:

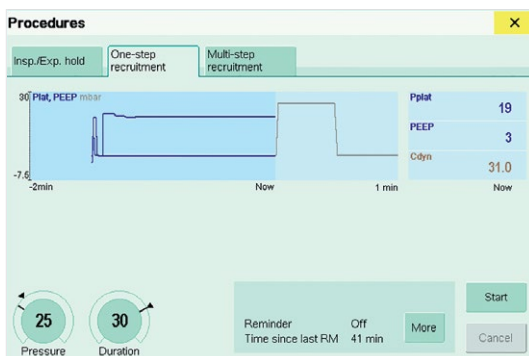
- Maximum inspiratory pressure
- Maximum PEEP



Perseus® A500 – multi-step recruitment (optional)

If so desired, further settings can be made, such as for driving pressure, number of mandatory breaths per pressure stage, and number of mandatory breaths while in the maximum pressure stage.

While monitoring the manoeuvre, should the user determine that the objective of the recruitment has been achieved even before reaching the maximum pressure stage, Perseus® A500 offers the possibility of prematurely transferring to the decremental phase and to begin with gradual pressure decrease - all without having needed to exert the pre-set maximum pressure. During the decremental phase, compliance and tidal volume can be monitored during the pressure stages in order to determine patient-specific PEEP.

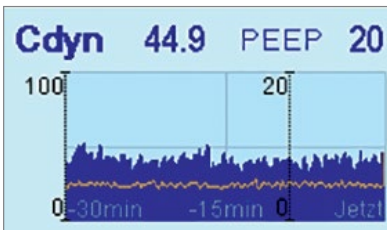


Perseus® A500 – one-step recruitment (optional)

**MONITORING OF RECRUITMENT MANOEUVRES**

The Perseus® A500 offers suitable ventilation monitoring for both recruitment procedures, where pressure level as well as compliance and tidal volume, respectively, are displayed. Comparison of lung mechanics before and after the manoeuvre, as well as during the current manoeuvre, facilitate the evaluation of the success of the recruitment. For multi-step manoeuvres, cursor functions allow for determining the optimal PEEP.

Moreover, the Dräger Zeus® IE, Perseus® A500 anaesthesia workstations and the products of the Primus® family offer trend graphs for patient compliance, as well as pressure volume flow loops with the possibility of setting reference loops. These functions allow monitoring of the lung mechanics, particularly temporal changes, thus simplifying indication of a recruitment manoeuvre.



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PEEP combined with patient compliance (e.g Primus® / Primus® IE – optional)

Dräger Infinity® Acute Care System (IACS) patient monitoring offers, in combination with Dräger anaesthesia devices, a dedicated analysis display that enables the monitoring, in parallel, of haemodynamic and ventilatory parameters. The combination of monitoring parameters can be configured freely, so that all values of clinical relevance are visible at a glance. Arrow indicators simplify assessment and a cursor function permits detailed analysis of the recruitment manoeuvre.



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IACS patient monitoring – analysis view

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