Administration unit for ^{3}He

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Motivation:

In order to administer patients hyperpolarized (HP) noble gases (^{3}He,^{129}Xe) in defined quantities and at a predefined time during inspiration, it is necessary to develop a special administration unit. The reproducibility and reliability of this device is of particular importance for follow-up studies, for example.

Safety requirements:

The administration unit (applicator) under construction has to fulfill the obligations given by Medical Devices Law. So, for the selections of materials which are in direct contact with the breathing gas high biocompatibility is demanded. The second restriction one has is that the materials of choice should show poor spin-relaxation in contact with the HP noble gases. Both requirements, of course, strongly restrict the choice of materials.

Results:

An Anti-Helmholtz coil configuration (*Fig. 1*) is used to locally compensate the magnetic stray fields caused by the tomograph, so that there is a homogeneous guiding field in which the gas vessel containing the HP noble gases can be stored. The applicator itself is positioned inside the tomograph and both units are connected via a plastic tube for gas transfer. The use of a mechanical compressor which is attached to the setup outside the tomograph allows using the whole amount of gas in the storage vessel. This compressor also enables a high accuracy volume control of HP ^{3}He ($\Delta V / V < 3\%$). After extracting the desired amount of gas into the stroke volume, the compressor pushes the gas via the transfer tube directly into a breathing bag inside the tomograph. During all this time the patient inhales the normal breathing air mixture through the inspiratory low-pressure valve (demand valve, *Fig. 2*). At a predefined time or volume of inspiration, valve 2 is switched and the patient inhales the HP ^{3}He from the breathing bag. The demand valve contains a membrane and opens already at pressures of a few mbar. This assures that there is no blockage of air supply tubes at any time of the switching status of valve 2. This membrane also ensures that at normal breathing flows (<3 L/s) first the bag is completely emptied before the patient inhales the normal breathing air mixture through the demand valve again. For safety reasons, the applicator also contains a control valve against high pressure (10mbar PEEP-valve). With two spirometers directly connected to the applicator unit it is possible to measure both the flow rates at normal inspiration and in particular the rates during the ^{3}He-bolus. Due to sterility reasons, the inspiratory and expiratory air supply tubes are strictly separated. In order to get information about the resting expiratory position, an additional spirometer is placed in the expiratory branch. This spirometer also detects if a patient was not able to hold his breath during a MR-measurement in apnoea, which can reduce the quality of the images due to movements of the diaphragm.

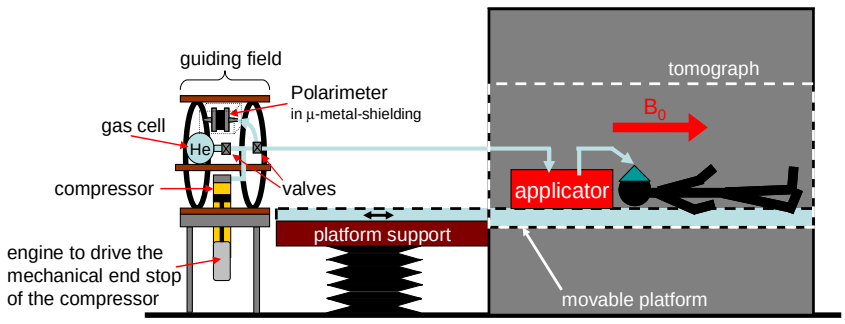

Fig. 1: setup in- and outside of the tomograph

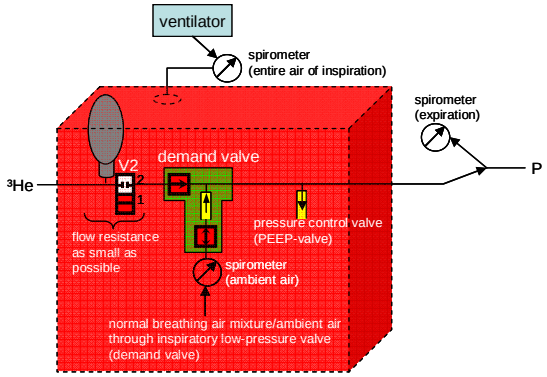

Fig.2: applicator inside of the tomograph

Conclusion:

With the applicator specified above one is able to administer HP noble gases for lung imaging. The apparatus fulfills the safety requirements of the Medical Devices Law. As an option, this device allows to administer different gas mixtures to obtain e.g. a structural contrast enhancement in diffusion weighted imaging. Furthermore, an on-line polarimeter which measures the absolute polarisation of the HP noble gases, allows quantifying exactly the magnetic moment of the inhaled HP gas given by the product of polarisation degree and the volume of the inhaled gas bolus.

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