Physical Properties of Helium and Application in Respiratory Care

Subjects: Respiratory System
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Helium is a low-density, inert, monoatomic gas that is widely used in medical applications. In respiratory care, Helium is mainly used as an adjunct therapy for patients with severe upper airway obstruction and asthma. To better understand the action mechanism of helium, the physical properties of several therapeutic gas mixtures with helium are calculated using kinetic theory. Flow in a simplified lung airways model is also shown to support the discussion of helium's respiratory benefits, including reduced work of breathing.

Keywords: helium ; physical properties ; kinetic theory ; medical gases ; airway resistance ; work of breathing ; respiratory care

Helium is a noble gas that is used in a variety of applications. As the coldest liquefied gas, liquid helium makes it ideally suited in cryogenics, notably in the cooling of superconducting magnets in MRI (magnetic resonance imaging) scanners and NMR (nuclear magnetic resonance) spectrometers [1]. In gaseous form, helium has several industrial applications as a shielding gas during welding [2], a purge and pressurization gas [3], in leak detection [4], as a non-reactive carrier gas used in chromatography [5], and in semiconductor and optical fiber production [6]. Helium is also well known for its use as a lifting gas in balloons and blimps or in components of deep-diving breathing mixtures. As early as 1926, Sayers and Yant pointed out that the low solubility of helium compared to nitrogen could reduce the formation of gas bubbles and therefore decompression accidents among deep-sea divers [7]. In the medicine practice [8], helium is used in microscopy [9], radiology [10], and surgery [11], and it also has other promising applications in cardiology [12] and neurology [13]. However, the subject that has attracted a great deal of interest relates to the physiological benefits of breathing a mixture of helium and oxygen in patients suffering from severe upper airway obstruction and asthma. Helium was indeed considered a therapeutic gas from the 1930s due to its inert nature and its lightness compared to oxygen and nitrogen [14]. The respiratory care applications of helium capitalize on the unique properties of helium, which are examined in detail in this paper in relation to respiratory mechanics, and particular attention is paid to the several misconceptions about its viscosity and hypothetical hypothermic properties. A simple lung airways model based on pipe flow equations is also used to review the benefits of using helium mixtures as a function of the Reynolds number.

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