

Wednesday, 05/20/2020
Centennial I

10:30 AM

[S-54]: PANEL: HYPOXIC PULMONARY VASOCONSTRICTION REFLEX: AEROMEDICAL IMPLICATIONS

Chair: Gregg Bendrick

Co-Chair: Charles Mathers

PANEL OVERVIEW: The Hypoxic Pulmonary Vasoconstriction (HPV) reflex is a condition in which pulmonary arterioles constrict (thereby reducing blood flow) in response to decreased levels of alveolar oxygen. Upon exposure to hypoxia, as can occur during flight at higher altitudes, the HPV reflex increases pulmonary vascular resistance (PVR). This Panel will examine some cardiac conditions in which the HPV reflex is of concern, the current data and testing for passengers and/or pilots with pulmonary hypertension, as well as the technical challenges of assessing RV function using echocardiography. Specifically, after a short review of the background and physiology of the Hypoxic Pulmonary Vasoconstrictive reflex, the Panel will feature Dr. Thomas Smith, from the United Kingdom, who will discuss studies investigating hypoxic pulmonary vasoconstriction during actual and simulated commercial airline flights. Then Dr. Leigh Seccombe, from the University of Sydney, who will be discussing effects of hypoxia experienced during commercial air travel on patients with pre-existing cardiopulmonary disease. After that Dr. Matthew Cooper, an FAA Consultant from the USA, will discuss concerns regarding congenital heart disease (e.g. hypoplastic right ventricle)—with or without surgical correction. Finally, the team of Dr's. Kamine & Formanek (Surgeon and Anesthesiologist, respectively, from the USA) will discuss the echocardiographic evaluation of the right heart in passengers and airmen, to include some of the technical challenges associated with echocardiographic assessment.

[272] HYPOXIC PULMONARY VASOCONSTRICTION: GENERAL BACKGROUND AND PHYSIOLOGY

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(Education - Program / Process Review Proposal)

BACKGROUND: Hypoxic Pulmonary Vasoconstriction (HPV) is a reflex contraction of the pulmonary arterial smooth muscle cells in response to a decreased partial pressure of alveolar oxygen (PAO₂). It was first identified in 1894 by Bradford & Dean, and was later described in more detail in 1946 by von Euler & Liljestrand. Since then the HPV reflex has been elucidated in even more detail. **OVERVIEW:** The minimal PAO₂ for HPV to occur is 86 mmHg. There is a half-maximal response at 57 mmHg, and a maximal response at 36 mmHg. (Of note, at 8000 feet—the maximum allowable cabin altitude for commercial airliners—the PAO₂ = 69 mm Hg). With regard to timing of onset, HPV has two distinct phases. In moderate hypoxia (i.e. PAO₂ = 30 - 50 mmHg) Phase 1 begins within a few seconds and reaches a plateau at 15 - 30 minutes. Phase 2 begins after 30 - 60 minutes and achieves its maximum level at about two hours. Sensitization also appears to occur, where a second hypoxic exposure will result in a greater response than the first. Also, when a normal PAO₂ is once again restored, the PVR does not immediately return to normal; return to normal may in fact take several hours. Certain medications attenuate the HPV reflex. These include phosphodiesterase inhibitors (e.g. sildenafil), calcium channel blockers (e.g. diltiazem, verapamil, nifedipine), angiotension-converting enzyme (ACE) inhibitors, angiotension II receptor blockers, steroids, acetazolamide, nitroglycerin and nitroprusside. **DISCUSSION:** Although there has been some discussion of HPV in the etiology of such things as High Altitude Pulmonary Edema (HAPE), the importance of HPV in commercial air travel, for both pilots and passengers, has been appreciated only more recently. There are certain conditions in which an increase in PVR could have serious consequences during air travel. These include Pulmonary Hypertension, right-sided heart failure, or congenital heart disease such as hypoplastic right ventricle (with or without surgical correction). Properly evaluating such individuals with

regard to either passenger travel or pilot selection can be challenging, and will sometimes require a more focused assessment.

Learning Objective

- To understand the physiologic action of the Hypoxic Pulmonary Vasoconstriction reflex, to know the levels of hypoxia at which this reflex occurs, to know the onset and duration of the effect, and to know at least three medications that can decrease this reflex.

[273] HYPOXIC PULMONARY VASOCONSTRICTION DURING AIR TRAVEL

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(Education - Program / Process Review Proposal)

BACKGROUND: Until quite recently it was unknown whether the mild hypoxia experienced during air travel was sufficient to trigger hypoxic pulmonary vasoconstriction. Such a response could cause a potentially dangerous increase in pulmonary artery pressure in-flight, but guidelines regarding fitness-to-fly for passengers with relevant medical conditions, such as pulmonary arterial hypertension, were based on extrapolation from animal experiments. Several years ago we embarked on a series of studies investigating the pulmonary vascular response to air travel during commercial airline flights and in a hypobaric chamber.

OVERVIEW: Healthy volunteers were studied using in-flight echocardiography on a London-Denver flight, during which systolic pulmonary artery pressure (SPAP) was found to increase by approximately 20%. A patient with Chuvash polycythemia, a rare genetic condition that causes increased hypoxic pulmonary vasoreactivity, was studied throughout a London-Dubai flight, during which SPAP rapidly increased into the pulmonary hypertensive range. During simulated commercial airline flights in a hypobaric chamber, SPAP increased more in older participants (> 60 years) than in younger participants (< 25 years). **DISCUSSION:** Pulmonary artery pressure increases during air travel in healthy passengers, and in a susceptible individual this response can result in flight-induced pulmonary hypertension. This response is greater in older people. Although clinically inconsequential for most people, hypoxic pulmonary vasoconstriction during air travel can harm vulnerable passengers by provoking or exacerbating in-flight cardiopulmonary emergencies. An extended hypoxic challenge test with simultaneous echocardiography may be particularly informative in assessing the likelihood of such adverse sequelae.

Learning Objective

- To gain greater understanding of the physiological effects of routine aircraft cabin hypoxia, in particular the pulmonary vascular response.

[274] ECHOCARDIOGRAPHIC EVALUATION OF THE RIGHT HEART IN PASSENGERS AND AIRMEN

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(Education - Program / Process Review Proposal)

BACKGROUND: Transthoracic echocardiography (TTE) can be a useful screening tool for passengers or airmen with baseline pulmonary hypertension or congenital heart disease in which hypoxic vasoconstriction associated with altitude can precipitate right heart failure. **OVERVIEW:** Tetralogy of Fallot is the most common cyanotic congenital heart defect, although most of these patients are repaired early in life but may have downstream consequences. Primary pulmonary arterial hypertension is another rare cause of right heart disease in young patients. However, the most common causes of right heart failure are left heart failure and lung disease. The right side is a low-pressure system and may be acutely pressure and volume overloaded. Chronic hypoxemia causes pulmonary vasoconstriction with ensuing RV enlargement and hypertrophy, but RV function is typically relatively spared. However, worsening hypoxemia or hypercarbia with may acutely cause right pressure overload. **DISCUSSION:** The use of TTE to evaluate the RV is more difficult than the evaluation of the left ventricle (LV) because of the complex geometry of the RV, and complete exams are often unable to be obtained even by experienced sonographers. Assessment of RV function consists of assessment of ventricular pressure, volume, and contractility. Right ventricular systolic pressure (RVSP) is typically used as a surrogate for pulmonary artery (PA)