

IMMERSION PULMONARY EDEMA: CARDIORESPIRATORY FACTORS

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Abstract

Introduction/Background: IPE is characterized by the acute onset of dyspnea, hemoptysis, cough, and related symptoms during swimming or diving. We hypothesized that in the general population IPE occurs due to identifiable cardiac or pulmonary risk factors.

Materials/Methods: A literature search for cases of IPE was conducted using PubMed, Web of Science, Embase, and cited references in published articles.

Results: We identified 234 individuals who experienced one or more episodes of IPE, from articles published between 1984 and 2012 (87 civilian, M/F=41/46; 147 military, M/F=146/1). Of these, 107 were from individual reports (civilian 47.1 ± 11.2 y mean \pm SD, range 12-72 y; military 23.4 ± 6.5 y, range 18-43 y) and 127 from series. There were 13 primary cardiac causes, including 6 cases of LV dysfunction: confirmed or possible Takotsubo cardiomyopathy (4), MI (1), alcoholic cardiomyopathy (1), valve disease (7). Other cardiopulmonary comorbidities included hypertension (13), LVH (3), AF (2), cardiomegaly (1), sleep apnea (2), PVD (1), diabetes (1), hypercholesterolemia (6), asthma (4), exercise-induced cough (possible asthma, 1). Hypertension developed in 7 individuals after their IPE episode. Other post-episode manifestations included AF (1) and Raynaud's phenomenon (1). No comorbidities were reported in the military divers.

Summary/Conclusions: In 234 IPE cases we identified 37 with known cardiovascular or respiratory disease that could have contributed to IPE. In 9 individuals cardiovascular conditions were noted afterward, which could conceivably have been present at the time of the IPE episode. Clinically identifiable risk factors were therefore present in 46/234 (19.7%) of the entire cohort and 46/87 (52.9%) of the civilian cases. We conclude that cardiorespiratory factors may be responsible for most cases of IPE in civilians. In military personnel other important factors may involve preload (venoconstriction) or afterload (arteriolar constriction) in response to cold water immersion, or impaired diastolic filling due to mild LVH ("athlete's heart").

Author, date	N	Source	Gender M/F	Age y (mean \pm SD, range)
Compiled individual cases	107	Mixed	61/46	47 \pm 11.2 years, 12-72
Wilmshurst et al., 1989	11	Civilian	8/3	45.6 \pm 2.6, 38-60
Shupak et al., 2000	21	Military	21/0	(no mean, SD) 18-19
Mahon et al., 2002	3	Military	3/0	(no mean, SD) 22-28
Adir et al., 2004	70	Military	70/0	(no mean, SD) 18-19
Ludwig et al., 2006	11	Military	11/0	27 (no SD), 20-35
Gempp et al., 2011	11	Military	11/0	29 \pm 5, 20-47

Background

- Immersion pulmonary edema (IPE) classically presents with dyspnea, hemoptysis and cough during swimming or diving in cold water, often in highly fit individuals
- IPE may be the result of pulmonary capillary stress failure and disruption of blood-gas barrier in the lungs due to high capillary pressure
- Exertion levels, fluid intake, water temperature, wetsuit tightness, obstructive lung disease and female gender have been suggested as contributing factors
- IPE may be underreported due to resolution of symptoms typically within 24-48 hours. However 1.5% of triathletes experience symptoms consistent with IPE during a race (Am J Emerg Med 28:941, 2010)
- We hypothesized that among cases of IPE there is a high prevalence of cardiac or pulmonary risk factors, such as hypertension, valve disease, cardiomyopathy or obstructive lung disease

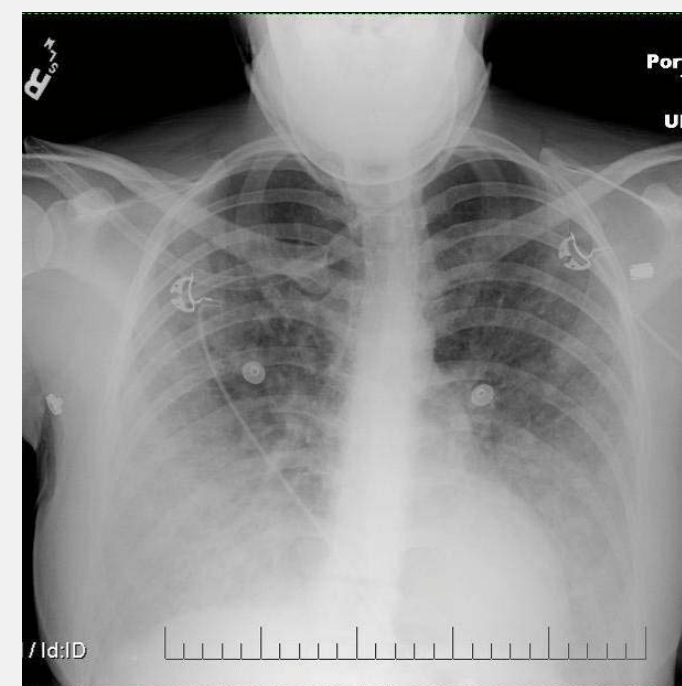


Figure 1. Chest x-ray of 35 year old healthy female who developed dyspnea and hemoptysis after approximately 200 m into open-water swim. Patient was admitted to the ICU with SpO₂ of 55%. X-ray is consistent with IPE. Pulmonary edema resolved with diuresis. LV function and valves were normal and investigations for coronary disease were negative

Methods

A literature search for cases of IPE was performed using PubMed, Web of Science, and Embase. Duplicate reports were excluded. Reports were not limited to the English language. Reports were scrutinized for evidence of systolic or diastolic cardiac muscle disease, valve disease, ischemic heart disease, hypertension, peripheral vascular disease and obstructive lung disease. Risk factors for vascular disease were also recorded

Results

A total of 234 individuals (87 civilian, 147 military) who experienced one or more cases of IPE were identified from articles published between 1984-2012. There were 107 cases from individual reports and 127 from case series

Table 2. Identified Primary Cardiac Pathology

Identifiable Primary Cardiac Causes (N=13)	N
Left Ventricular Dysfunction	
Takotsubo cardiomyopathy	4
Myocardial infarction	1
Alcoholic cardiomyopathy	1
TOTAL	6
Valve Disease	
Mitral regurgitation	5
Ruptured chordae	1
Mitral valve prolapse	1
TOTAL	7

Table 3. Event-Related Manifestations Suggesting Primary Cardiac Causes

Clinical Manifestations	N
Cardiac arrest	5
Hypotension	1
Diffuse hypokinesia	1
Jugular venous distension	1
Transient T wave inversion	1
TOTAL	9

Table 3. Known Lung or Vascular Disease or Cardiac Risk Factors

Co-morbid conditions (N=45)	N
Pre-existing	
Hypertension	13
Left ventricular hypertrophy	3
Atrial fibrillation	2
Unspecified systolic heart murmur	1
Extrasystoles	1
Cardiomegaly	1
Sleep apnea	2
Peripheral vascular disease	1
Diabetes	1
Hypercholesterolemia	6
Asthma	4
Exercise-induced cough (possibly asthma)	1
TOTAL	36
Developed after IPE Event	
Hypertension	7
Atrial fibrillation	1
Raynaud's phenomenon	1
TOTAL	9

Conclusions

- In 234 individuals with cases of IPE, we identified 37 with either primary cardiac or pulmonary pathology, or cardiovascular risk factors that could have contributed to IPE
- Cardiovascular risk factors were noted in 9 individuals after the IPE episode and could conceivably have been present at the time of the event
- No co-morbid conditions were identified in military reports
- Clinically identifiable risk factors were therefore present in 19.7% of the entire cohort and 52.9% of civilian cases
- We conclude that cardiorespiratory factors may contribute to the majority of civilian cases of IPE, but other factors may be more important in IPE occurring in military personnel. These could include exaggerated increase in pulmonary vascular pressure response to the increased preload and afterload effects of cold water immersion (arteriolar or venoconstriction), or impaired diastolic filling associated with left ventricular hypertrophy ("athlete's heart")

Acknowledgment

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