



TRIATHLON DEATHS: SWIMMING-INDUCED PULMONARY EDEMA?

MARTINA SD, PEACHER DF, OTTENI C, MOON RE

CENTER FOR HYPERBARIC MEDICINE AND ENVIRONMENTAL PHYSIOLOGY, DEPARTMENT OF ANESTHESIOLOGY, DUKE UNIVERSITY MEDICAL CENTER, DURHAM, NC 27710, USA



Abstract

TRIATHLON DEATHS: SWIMMING-INDUCED PULMONARY EDEMA?

Martina SD, Peacher DF, Otteni C, Moon RE
Center for Hyperbaric Medicine and Environmental Physiology,
Dept of Anesthesiology,
Box 3823, Duke Univ Medical Center, Durham NC 27710
stefanie.martina@duke.edu

Introduction/Background: Triathlon deaths occur mostly during the swim portion of the race with unknown cause. Swimming-induced pulmonary edema (SIPE) is usually reported during scuba diving and surface swimming, with a prevalence of 1.5% among triathletes (Miller CC. *Am J Emerg Med*. 2010;28:941). We have demonstrated high pulmonary vascular pressures during immersed exercise in SIPE-susceptible individuals, possibly due to decreased left ventricular diastolic compliance (Peacher DF. UHMS 44th Sci Mtg. F128, 2011). In order to determine whether SIPE may cause some of these deaths we looked for risk factors for high pulmonary vascular pressure, including LVH, which can cause diastolic heart failure. We hypothesized that LVH is present in a disproportionate number of triathlon deaths.

Materials and Methods: We searched EMBASE and Google for triathlon deaths from October 2009 to present. After institutional approval, autopsy reports were reviewed for causes of death and cardiovascular risk factors. We compared the prevalence of LVH in the study population with the normal population and triathletes using chi square test for statistical significance.

Results: We identified 41 deaths, 36 of which occurred during the swim portion, and obtained 18 autopsy reports. Mean age was 46.6, range 33-64 years. Mean BMI was 28.5 kg/m², range 17.9-38.3 kg/m². LVH was the most prevalent cardiovascular condition (n=10, 56%), followed by CAD (n=6, 33%). A history of hypertension was reported in four individuals and atrial fibrillation was reported in one individual. The prevalence of LVH was significantly higher among the reviewed autopsies compared with the general population (16%, P<0.001) (Levy D. *Am J Cardiol*. 1987;59:956) and triathletes (24%, P<0.001) (Douglas PS. *Am J Cardiol* 1997;80:1384).

Summary/Conclusions: Our data are comparable to a similar published series (Harris KM. *JAMA*. 2010;303:1255). We conclude that some deaths during the swim portion of triathlons may be caused by SIPE.

Background

- As triathlons continue to gain popularity, the number of deaths, especially during the swim portion, has raised concern
- Swimming-induced pulmonary edema (SIPE) occurs in susceptible individuals and presents as dyspnea, hemoptysis and cough during surface swimming or scuba diving, often in cold water¹
- SIPE is consistent with hemodynamic pulmonary edema, most likely caused by pulmonary capillary stress failure due to high pulmonary artery and capillary pressures
- Redistribution of blood from the periphery to the core during immersion results in an increased blood volume in the thorax, augmenting the increase in pulmonary artery and wedge pressures (PAP, PAWP) that normally occur during exercise
- Approximately 1.5% of triathletes have reported to have symptoms consistent with SIPE²
- SIPE-susceptible individuals have significantly higher PAP and PAWP than controls during immersed exercise in cold water³, possibly due to reduced left ventricular (LV) compliance
- The most common cause of low LV compliance is left ventricular hypertrophy (LVH). A small autopsy series has revealed LVH in 6 of 9 triathlon deaths⁴

Hypothesis

We hypothesized that some deaths during triathlons are due to SIPE. We therefore proposed that LVH is more common among triathletes who die during an event than in the general and triathlete populations.



Photo courtesy of Ms. Katherine Calder-Becker

Methods

EMBASE and Google were searched for triathlon deaths occurring between October 2008 to March, 2014. With institutional approval, autopsy reports were obtained and reviewed for causes of death, cardiac dimensions, and cardiovascular risk factors. Criteria for LVH included LV wall thickness >12 mm, increased heart weight¹⁰, or as determined by pathology report. Significant coronary artery disease (CAD) was defined as >70% stenosis. We compared the prevalence of LVH in the study population with the normal and triathlete populations. Statistical significance (P<0.05) was assessed using the chi square test (JMP 11.0, SAS Institute, Cary, NC).

Results

Table 1. Decedent demographics and autopsy findings

Decedent	Age	Sex	BMI (kg/m ²)	Heart weight (g)	LV thickness (mm)	Medical history	Additional findings
1	33	M	38.2	530	50	n.r.	Significant CAD
2	43	F	31.1	470	17	kidney disease since age 16	Subendocardial myocyte degeneration
3	38	F	17.9	311	10	n.r.	RV dilation, mitral valve enlargement
4	40	F	27.6	310	11	seasonal allergies	MVP
5	64	M	32.4	430	12	BPH	
6	58	M	28.7	470	26	n.r.	Biventricular myocardial hypertrophy/SRAD
7	46	M	32.1	520	17	HTN	Myocardial scarring of posterior-lateral LV
8	46	M	26.0	450	12	n.r.	
9	43	M	24.8	290	13	n.r.	
10	42	M	n.r.	410	42	HTN	Significant CAD
11	57	M	22.1	430	10	n.r.	Dilated cardiomyopathy
12	44	M	26.4	400	n.r.	n.r.	Evidence of ventricular fibrillation
13	45	M	24.9	400	n.r.	n.r.	
14	51	M	38.2	630	25	HTN, gout	
15	46	M	30.7	540	10	none	Significant CAD
16	42	M	25.6	440	n.r.	AFib	Flecainide in blood
17	48	M	33.6	540	10	Elevated PSA	
18	53	M	24.7	428	15	HTN, hyperlipdemia	

Red denotes abnormal values. n.r.= not reported. LV= left ventricle. RV= right ventricle. A-fib= atrial fibrillation. HTN= hypertension. CAD= coronary artery disease. AV= atrioventricular. PSA= prostate specific antigen. BPH= benign prostatic hyperplasia. SRAD= spontaneous renal artery dissection.

Demographics

- 41 deaths during triathlon identified, 36 during the swim leg
- 18 autopsy reports obtained
- 15 male, 3 female
- Age: 46.6 ± 7.6, range 33-64 years
- BMI: 28.5 ± 5.4, range 17.9-38.3 kg/m²

Findings

- LVH: 100%, n=18
- Significant CAD: 17%, n=3
- History of hypertension: 22%, n=4
- History of atrial fibrillation: 0.6%, n=1
- Dilated cardiomyopathy: 0.6%, n=1
- Mitral valve prolapse: 0.6%, n=1

Statistics

- LVH is more common in the reviewed series than in the general population (16%, p<0.001)⁵
- LVH is more common in the reviewed series than the expected triathlete population (24%, p<0.001)⁶

Conclusions

LVH is present in the majority of triathletes who die during an event and is significantly more prevalent amongst decedents than the expected for the triathlete population. These data are comparable to a previously reported series.⁴ Numerous deaths have been reported as consequence of SIPE in recreational divers and snorkelers.^{7,8,9} We conclude that LVH may be a risk factor for SIPE, and in conjunction with increased preload due to immersion, SIPE may be causing deaths during the swim portion of triathlons.

References

- Adir Y, et al. *Chest* 2004;126(2):394-9.
- Miller CC III, et al. *Am J Emerg Med* 2010;28:941-6.
- Peacher DF, et al. *ASA Annual Meeting Abstract #A4070*, 2013.
- Harris KM, et al. *JAMA* 2010;303(13):1255-7.
- Levy, et al. *Am J Cardiol* 1987;59:956-960.
- Douglas PS, et al. *Am J Cardiol* 1997;80:1384-8.
- Cochard G, et al. *Undersea Hyperb Med* 2005;32(1):39-44.
- Cochard G, et al. *Undersea Hyperb Med* 2013;40(5):411-6.
- Edmonds C, et al. *Diving Hyperb Med* 2012;42(1):40-4.
- Smith, H. A. *Am Heart Journal* 1928;4(1):79-93