

Supplementary Appendix

This appendix has been provided by the authors to give readers additional information about their work.

Supplement to: Landry CH, Allan KS, Connelly KA, Cunningham K, Morrison LJ, Dorian P. Sudden cardiac arrest during participation in competitive sports. *N Engl J Med* 2017;377:1943-53. DOI: 10.1056/NEJMoa1615710

Supplementary Appendix: Sudden cardiac arrest during competitive sport

Cameron H. Landry, MD, MSc¹

Katherine S. Allan, PhD²

Kim A. Connelly, MBBS, PhD^{3,4}

Kris Cunningham, MD, PhD⁵

Laurie J. Morrison, MD, MSc^{6,7}

Paul Dorian, MD, MSc^{1,3,8}, on behalf of the Rescu Epistry Investigators

Author's Affiliations:

¹ Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada.

² School of Nursing, McMaster University, Hamilton, Canada.

³ Division of Cardiology, St. Michael's Hospital, Toronto, Canada.

⁴ Keenan Research Centre for Biomedical Research, Li Ka Shing Knowledge Institute, St. Michael's Hospital, Toronto, Canada.

⁵ Department of Laboratory Medicine and Pathobiology, University of Toronto and Ontario Forensic Pathology Service, Toronto, Canada

⁶ Institute of Health Policy, Management and Evaluation, Faculty of Medicine, University of Toronto, Toronto, Canada.

⁷ Rescu, Li Ka Shing Knowledge Institute, St. Michael's Hospital, Division of Emergency Medicine, Department of Medicine, University of Toronto, Toronto, Canada.

⁸ Department of Medicine, University of Toronto, Toronto, Ontario, Canada.

***Corresponding Author:**

Paul Dorian, MD
Division of Cardiology, University of Toronto
St. Michael's Hospital
30 Bond St. Toronto ON M5B 1W8
Email: dorianp@smh.ca

Rescu Epistry Investigators:

Barto Nascimiento, Damon Scales, Dennis Ko, Jamie Hutchison, Katie Dainty, Laurie Morrison, Paul Dorian, Richard Swartz, Richard Verbeek, Sandro Rizoli, Sheldon Cheskes, Steven Brooks, Steve Lin and Tim Chan.

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Methods: Cardiac Etiology Descriptions

1. Ischemic/Coronary Artery Disease:

1) Moderate to severe atherosclerotic disease in ≥ 1 major coronary artery (stenosis $\geq 70\%$); 2) thrombosis or plaque hemorrhage in one or more major coronary arteries; or 3) acute or healed/chronic myocardial infarction.^{1,2}

2. Structural Heart Disease was one of:

- a. **Hypertrophic Cardiomyopathy (HCM):** Widespread myocyte fibre disarray, left ventricular hypertrophy (LVH) (ventricular wall thickness ≥ 15 mm), and marked cardiomyocyte hypertrophy are required for the diagnosis. Most hearts also exhibit cardiomegaly (heart weight ≥ 500 g) and fibrous tissue deposition.^{1,3}
- b. **Non-Specific Cardiomyopathy:** Heart weight increased over value predicted for normal body weight, LVH or both right and left ventricular wall hypertrophy, dilation of both atria and ventricles⁴.
- c. **Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC):** Right ventricular thinning or aneurysms, fatty replacement, fibrosis and microscopically fat and fibrosis of the wall of the right and/or left ventricle.^{1,3}
- d. **Myocarditis:** Multiple foci of interstitial inflammatory infiltrate with/without myocyte necrosis in the myocardium.²
- e. **Dilated cardiomyopathy:** Cardiomegaly with dilated ventricles and in the absence of hypertension, valve disease, or significant coronary artery disease.^{3,5,6}
- f. **Valvular Heart Disease:** Evidence of valvular disease on autopsy (e.g. stenosis, thickening, fibrosis, etc.) and in the absence of CAD and any other cardiac findings and considered causative for the SD event.

- g. **Williams Syndrome:** Evidence of systemic arterial stenosis, usually supraaortic stenosis or coronary artery stenosis⁷.
- 3. Primary Arrhythmia Syndrome:**
- Referring to survivors – no specific arrhythmia disorder determined; no anatomical or toxicological cause of arrest established following review of medical history or with investigations, including ECG, echocardiogram, stress testing, angiography or MRI (in select cases). These cases are also referred to as idiopathic ventricular fibrillation (VF)⁸.
- Referring to non-survivors – the etiology was presumed to be due to a *primary arrhythmia* when there was no anatomical or toxicological cause of death established after autopsy with circumstances or medical history supporting an arrhythmic event⁹.
- These cases have also been referred to as sudden unexplained death syndrome (SUDS) or sudden arrhythmic death syndrome (SADS)¹⁰.
4. **Congenital Cardiac Diseases:** Including anomalous coronary arteries, atrial-septal defects, ventricular-septal defects, repaired congenital disease (e.g. Tetralogy of Fallot), etc., considered causative if autopsy reveals no other cause of death.
5. **Cardiac Disease Unspecified:** lacking sufficient information (e.g. no autopsy or survivor with limited clinical information regarding diagnosis) to arrive at a cardiac sub-type etiology (e.g. ARVC) or that had 2 or more competing cardiac etiologies

Supplementary Figures S1:

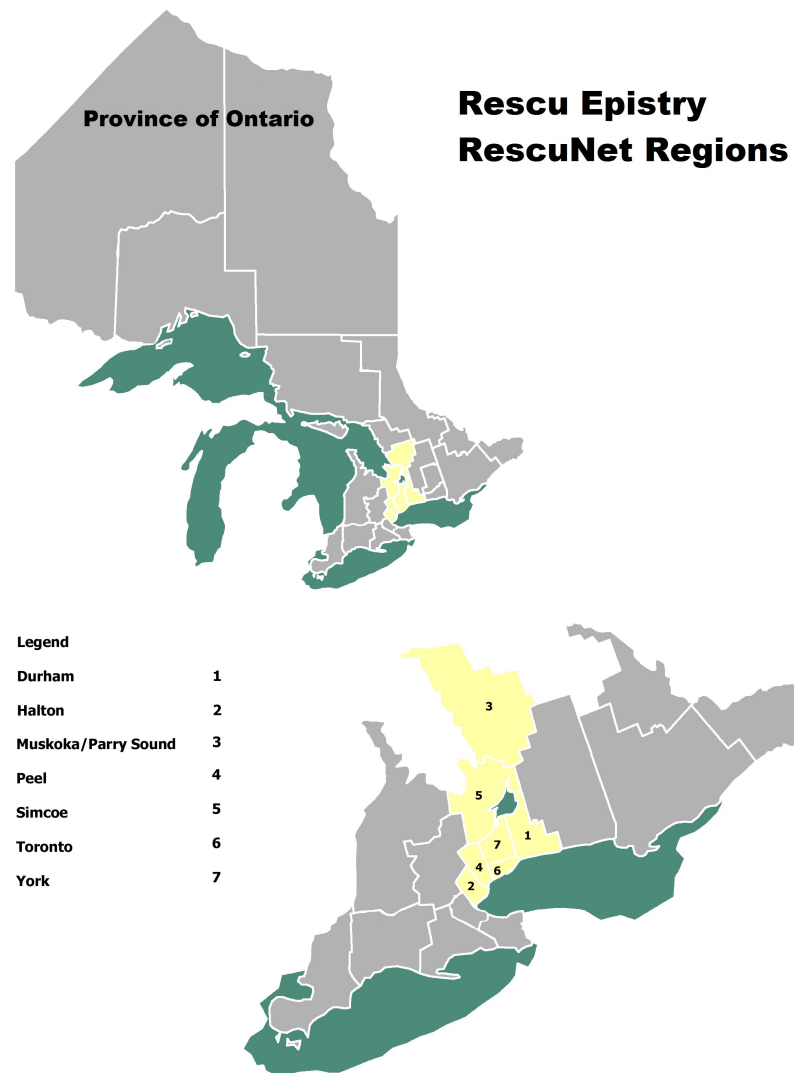


Figure S1: Map of Rescu Epistry Network (RescuNet), Ontario, Canada. The RescuNet region includes the regions of Toronto, Durham, Halton, York, Peel, Simcoe and Muskoka, each of which has a single EMS agency. Area in yellow is the geographic area covered by these agencies. Area in green represents the Great Lakes.

Supplementary Tables:**Table S1. Details of Sudden Cardiac Arrests (SCAs) in Non-Competitive Athletes**

Patient #	Sex	Age	Bystander Witnessed	Bystander CPR	EMS Response Time (min)	Initial Rhythm	Number of Shocks	Outcome	Survived	Autopsy	Molecular Autopsy	Etiology	Basis of Diagnosis	Follow up
1	M	14	Y	N	Not documented	VF/VT	2	Admitted	Y	N/A	/	Unknown†	No Diagnosis	Unknown
2	F	27	Y	N	Not documented	VF/VT	1	Admitted	Y	N/A	/	Unknown†	No Diagnosis	Unknown
3	M	44	Y	Y	2	VF/VT	0	Admitted	Y	N/A	/	Ischemic	Angiogram	CABG
4	M	21	N	N	2	VF/VT	2	Admitted	Y	N/A	/	HCM ^y	ECHO	ICD implanted
5	M	44	Y	Y	Not documented	VF/VT	4	Admitted	Y	N/A	/	Ischemic	Angiogram	Unknown
6	M	44	Y	Y	4	VF/VT	1	Admitted	Y	N/A	/	Ischemic	Angiogram	History of CABG prior to arrest; ICD implanted
7	M	15	Y	Y	2.2	VF/VT	1	Admitted	Y	N/A	/	Primary Arrhythmic	No Diagnosis	Normal ECG, ECHO, Stress Test; MRI non-diagnostic
8	F	31	Y	N	5	PEA	0	Admitted	Y	N/A	/	Non-specific Cardiomyopathy	ECHO	Unknown
9	M	16	Y	Y	5.5	VF/VT	1	Admitted	Y	N/A	/	Unknown†	No Diagnosis	Unknown
10	M	36	N	Y	5.2	VF/VT	3	Admitted	Y	N/A	/	Dilated Cardiomyopathy	ECHO	Angiogram showed normal coronaries; ICD implanted
11	F	19	Y	Y	4.8	VF/VT	4	Admitted	Y	N/A	/	Unknown†	No Diagnosis	Unknown

12	M	38	Y	Y	6.5	VF/VT	6	Admitted	Y	N/A	/	Ischemic	Angiogram	Unknown
13	M	25	Y	Y	2.9	VF/VT	2	Admitted	Y	N/A	/	Primary Arrhythmic	No Diagnosis	Angiogram and EP studies normal
14	M	34	N	N	Not documented	VF/VT	4	Admitted	Y	N/A	/	Ischemic	Angiogram	Unknown
15	M	42	N	N	12	VF/VT	1	Admitted	Y	N/A	/	Ischemic	Angiogram	Unknown
16	M	41	Y	Y	Not documented	VF/VT	0	Admitted	Y	N/A	/	Ischemic	Angiogram	Unknown
17	M	13	Y	Y	5.8	PEA	0	Admitted	Y	N/A	/	HCM ^y	ECHO	ICD previously placed for VF/VT
18	M	44	Y	Y	4.9	VF/VT	0	Admitted	Y	N/A	/	Ischemic	Angiogram	Unknown
19	M	41	N	N	6.9	VF/VT	2	Admitted	Y	N/A	/	Ischemic	Angiogram	Unknown
20	M	39	Y	Y	4.5	VF/VT	0	Admitted	Y	N/A	/	Ischemic	Angiogram	PCI and stents placed
21	M	20	Y	Y	7.2	VF/VT	3	Admitted	Y	N/A	/	Anomalous Coronaries	Angiogram	Unknown
22	M	14	N	Y	7	VF/VT	0	Admitted	Y	N/A	/	Primary Arrhythmic	No Diagnosis	ECG, ECHO and Stress test non-diagnostic; EP studies normal; ICD implanted
23	M	15	Y	Y	5	Not shockable	3	Admitted	Y	N/A	/	Tetralogy of Fallot	History	History of ToF repair; ICD implanted
24	M	33	Y	Y	3	VF/VT	5	Admitted	Y	N/A	/	Primary Arrhythmic	No Diagnosis	Normal ECG, ECHO, and angiogram

25	M	21	Y	Y	11.5	VF/VT	5	Admitted	Y	N/A	/	Primary Arrhythmic	No Diagnosis	Normal ECG, ECHO and MRI; ICD implanted
26	M	41	N	N	4.9	VF/VT	1	Admitted	Y	N/A	/	Ischemic	Angiogram	Unknown
27	M	39	Y	Y	Not documented	VF/VT	3	Died in ED	N	Y	/	ARVC ^{sp}	Autopsy	N/A
28	M	41	Y	N	Not documented	VF/VT	7	Died in ED	N	Y	/	Ischemic	Autopsy	N/A
29	F	32	N	N	Not documented	Asystole	0	Died in ED	N	Y	/	Valvular Cardiomyopathy	Autopsy	N/A
30	M	14	Y	Y	Not documented	VF/VT	2	Admitted	N	Y	/	Anomalous Coronaries	Autopsy	N/A
31	M	44	Y	Y	Not documented	Asystole	0	Died in ED	N	Y	/	Ischemic	Autopsy	N/A
32	M	42	Y	Y	Not documented	VF/VT	5	Admitted	N	Y	/	Ischemic	Autopsy	N/A
33	M	34	Y	Y	5.9	VF/VT	0	Died in ED	N	Y	/	ARVC ^{sp}	Autopsy	N/A
34	M	37	Y	Y	6.8	VF/VT	2	Died in ED	N	Y	/	Ischemic	Autopsy	N/A
35	M	26	Y	Not Documented	5	VF/VT	3	Admitted	N	Y	/	William's Syndrome Cardiomyopathy	Autopsy	N/A
36	M	30	Not Documented	N	13	VF/VT	2	Died in ED	N	Y	/	Ischemic	Autopsy	N/A
37	M	12	N	Y	8	PEA	1	Admitted	N	Y	/	Primary Arrhythmic	Normal Autopsy	N/A
38	M	31	Y	N	7	Not shockable	0	Died in ED	N	Y	/	Ischemic	Autopsy	N/A

39	M	13	Y	Y	Not documented	VF/VT	3	Died in ED	N	Y	/	Primary Arrhythmic	Normal Autopsy	N/A
40	F	21	Y	N	4.2	VF/VT	10	Admitted	N	Y	/	Long QT Syndrome	ECG	N/A
41	M	42	Y	Y	6.7	VF/VT	5	Died in ED	N	Y	/	ARVC ^y	Autopsy	N/A
42	M	44	Y	Y	3.8	VF/VT	2	Died in ED	N	Y	/	Ischemic	Autopsy	N/A
43	M	43	N	Y	2.7	VF/VT	3	Died in ED	N	Y	/	Ischemic	Autopsy	N/A
44	M	42	N	N	5.9	VF/VT	2	Died in ED	N	Y	/	Ischemic	Autopsy	N/A
45	M	36	Y	Y	8	Not shockable	0	Died in ED	N	Y	Mutation of unknown significance **	ARVC ^y	Autopsy	N/A
46	M	22	N	N	4.5	Asystole	0	Died in ED	N	Y	/	Primary Arrhythmic	Normal Autopsy	N/A
47	M	30	Y	Y	8.7	VF/VT	1	Died in ED	N	Y	/	Ischemic	Autopsy	N/A
48	M	40	Y	Y	Not documented	VF/VT	2	Died in ED	N	Y	/	Ischemic	Autopsy	N/A
49	M	32	N	N	8.5	Not documented	0	Died at scene	N	Y	/	Ischemic	Autopsy	N/A
50	M	44	Y	N	6.9	VF/VT	4	Died in ED	N	Y	/	Ischemic	Autopsy	N/A
51	M	39	N	N	8.3	VF/VT	6	Died in ED	N	Y	/	Ischemic	Autopsy	N/A
52	M	44	Y	Y	4.8	VF/VT	5	Died in ED	N	N ^φ	/	Cardiac Disease Unspecified	Coroner Record	N/A
53	M	43	N	Y	14.4	Asystole	0	Died at scene	N	Y	/	HCM ^y	Autopsy	N/A

54	M	40	Y	N	3	VF/VT	3	Died in ED	N	Y	Pathogenic mutation ^Δ	HCM ^Ψ	Autopsy	N/A
55	M	41	Y	Y	4.8	VF/VT	3	Died in ED	N	Y	No mutations detected	Dilated Cardiomyopathy	Autopsy	N/A
56	F	42	Y	Y	2.5	VF/VT	8	Admitted	N	Y	Variant of unknown significance ^Ω	Non-specific Cardiomyopathy	Autopsy	N/A
57	M	40	Y	Y	7.5	VF/VT	1	Died in ED	N	Y	Variant of unknown significance ^Π	Aortic Dissection	Autopsy	N/A
58	M	44	N	N	Not documented	VF/VT	1	Died in ED	N	N*	/	Ischemic	Coroner Record	N/A

† The designation “unknown” was used as no clinical testing information were available for these patients

Ψ Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC)

Y Hypertrophic Cardiomyopathy (HCM)

* In-hospital investigations and clinical data determined ischemia; autopsy not indicated

Φ In-hospital investigations and clinical data determined likely ischemia; autopsy not indicated

** Negative for ARVC mutations; missense variant c.1826C>G (p.A609G) in TRPM4 gene

Δ MT-ND5 Val147Met

Ω DSP Ser2843Arg2846del

Π MYH11 Exon 28 Lys 256 del

Table S2. Total Number of Arrests by Sport Type in Non-Competitive Athletes

Sport	Total Arrests 2009-2014
Running	9
Baseball	0
Basketball	7
Cricket	3
Cycling	3
Golf	1
Gymnastics	0
Hockey (ice)	5
Hockey (ball)	4
Jiu Jitsu	0
Lacrosse	0
University/College	0
Rugby	0
Soccer	3
Softball	0
Squash	2
Swimming	7
Tennis	0

Volleyball	0
Gym	12
Other Φ	2
Total	58

Φ Includes alpine, badminton, boxing, cross country, curling, disc sports, dive, equestrian, fencing, field hockey, football, rowing, sailing, scooter, Special Olympics, table tennis, handball, water polo, weight lifting, wheelchair spots, wrestling, etc

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