

# Safety of Sports for Athletes With Implantable Cardioverter-Defibrillators

## Long-Term Results of a Prospective Multinational Registry

Until 2015, consensus statements<sup>1,2</sup> advised against sports participation more vigorous than golf for patients with implantable cardioverter-defibrillators (ICDs) because of the postulated risks of death caused by failure to defibrillate, injury resulting from arrhythmia-related syncope or shock, or device damage. The multinational, prospective, observational ICD Sports Safety Registry quantified risks associated with sports participation for athletes receiving ICDs on the basis of standard criteria. Initial results (2013<sup>3</sup>) demonstrated no death, failure to defibrillate, or injury resulting from arrhythmia or shock during sports. On the basis of these data, the 2015 eligibility and disqualification recommendations for competitive athletes with cardiovascular disease<sup>4</sup> now state that competitive sports may be considered for athletes with ICDs. This report describes 4-year follow-up of the completed registry.<sup>3</sup> Methods are as reported previously.<sup>3</sup> The Yale University Human Investigation Committee approved the study. All participants gave written informed consent.

Among 440 participants, 393 in organized sports and 47 in high-risk sports, the most common diagnoses were long-QT syndrome (n=87, 20%), hypertrophic cardiomyopathy (n=75, 17%), and arrhythmogenic right ventricular cardiomyopathy (n=55, 13%). Of 201 subjects with a preimplantation history of ventricular fibrillation (VF) or tachycardia (VT), 61 (30%) had VT/VF during sports. At enrollment, median time since implantation was 26 months (interquartile range, 11–59 months), with 126 subjects (29%) enrolled within 1 year of implantation. The most common organized sports were running, basketball, and soccer; the most common dangerous sport was skiing. Seventy-seven subjects (18%) engaged in varsity/junior varsity/traveling team competition, (highly competitive subgroup). Seventy-two postcollege athletes (16%) participated at a national/international level.

Median follow-up was 44 months (interquartile range, 30–48 months), totaling 1446 person-years. Thirty-seven participants did not complete the study: 20 were lost to follow-up (all confirmed alive), 5 withdrew, 6 developed worsening cardiac/medical conditions, 4 had the ICD removed, and 2 died (neither death was sports related, as reported previously<sup>3</sup>).

There were no tachyarrhythmic deaths or externally resuscitated tachyarrhythmias during or after sports participation or injury resulting from arrhythmia-related syncope or shock during sports. The 95% confidence interval for the occurrence of adverse event based on 376 participants followed up at least 2 years was 0% to 0.9% and based on 167 participants followed up at least 4 years was 0% to 2.2%.

The numbers and rhythms of shocks received for the overall group and the highly competitive subgroup are shown in the Table. Forty-six (10%) received appropriate shocks (for VT/VF) during competition or practice, a rate of 3 per 100 person-years (identical to the initial report<sup>3</sup>). More participants received shocks during competition/practice or physical activity than rest (20% versus 10%;  $P<0.0001$ ), but the proportion receiving a shock during competition/practice was similar to the proportion receiving a shock during other physical activity (12% versus 10%;  $P=0.56$ ). Similarly, the

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**Table. Number of Shock Events and of Individuals Receiving Shocks**

Rhythm	Competition Related, n*	Physical Activity Related, n †	Rest, n	Total, n (%)
Total cohort				
VT	29/21	15/11	19/13	63/41 (9)
VF	12/10	9/8	14/9	35/25 (6)
VT/VF storm	4/4	3/3	2/2	9/9 (2)
NSVT	1/1	0	0	1/1 (1)
SR	8/7	4/3	1/1	13/10 (2)
AF	7/5	14/10	4/4	25/14 (3)
Other SVT	3/3	4/4	1/1	8/8 (2)
SR storm	0	1/1	0	1/1 (1)
AF/SVT storm	0	2/2	0	2/2 (1)
T-wave oversensing	2/2	3/2	3/3	8/7 (2)
Noise	1/1	7/7	11/10	19/17 (4)
Total	67/51	62/46	55/42	184/121 (28)
Highly competitive subgroup				
VT	1/1	5/5	2/2	8/3 (3)
VF	4/3	3/1	5/2	12/4 (4)
VT/VF storm	1/1	0	0	1/1 (1)
AF	1/1	2/1	0	3/2 (2)
Other SVT	0/0	2/2	2/2	4/4 (5)
AF/SVT storm	0/0	1/1	0/0	1/1 (1)
T-wave oversensing	1/1	2/1	2/2	5/4 (5)
Noise	1/1	1/1	1/1	3/3 (3)
Total	9/8	16/13	12/8	37/25

Values refer to number of events or number of unique individuals. Percents refer to percent of study population. AF indicates atrial fibrillation; NSVT, nonsustained ventricular tachycardia; SR, sinus rhythm; SVT, supraventricular; VF, ventricular fibrillation; and VT, ventricular tachycardia.

Among the total cohort, 33 shocks did not have available implantable cardioverter-defibrillator–stored data; the diagnosis is based on that of the treating physician. Of these, 13 were ventricular arrhythmia, 4 SVT, 13 noise, and 3 other. Among the highly competitive subgroup, 6 shocks did not have available implantable cardioverter-defibrillator–stored data: 3 noise, 1 VF, 1 T-wave oversensing, and 1 other SVT.

\*Includes competition, postcompetition, or practice for competition.

†Includes physical activity and postphysical activity.

proportion receiving appropriate shocks during competition/practice or other physical activity was greater than the proportion receiving appropriate shocks during rest (11% versus 6%;  $P=0.005$ ), but there was no difference between competition/practice and other physical activity (7% versus 5%;  $P=0.08$ ). The only clinical or demograph-

ic variable associated with receiving appropriate shocks during competition/practice was presence of arrhythmogenic right ventricular cardiomyopathy. The percentage of individuals in the highly competitive subgroup receiving appropriate shocks during competition/practice (12%) was not different from the percentage of those not in the competitive subgroup (10%). Of 51 subjects receiving shocks during sports (11% of total), 7 stopped all sports, and 13 stopped 1 or several sports; 5 of these 20 returned after 6 to 18 months.

Sixteen individuals (4% of total) received multiple appropriate shocks for VT/VF because of shock failure ( $n=2$ ), immediate recurrence within a single device-defined episode ( $n=6$ ), or electric storm ( $>1$  device-defined episode within 24 hours,  $n=8$ ). Eight occurred during competition/practice, 4 during other physical activity, and 4 at rest. The rate of arrhythmias requiring multiple shocks for termination was 0.5 per 100 person-years, similar to the previously reported 0.4 per 100 person-years.<sup>3</sup> Among all appropriate shock episodes occurring during competition/practice, 23% required multiple shocks for termination versus 15% during other physical activity and 11% during rest ( $P=NS$ ). Among the 12 participants experiencing multiple shocks during competition/physical activity, 3 (of 45) had coronary artery disease, 3 (of 48) had idiopathic VF, 3 (of 55) had arrhythmogenic right ventricular cardiomyopathy, and 1 each had CPVT (of 12), dilated cardiomyopathy (of 35), and sarcoidosis (of 1).

There were 31 definite and 13 possible lead malfunctions. The estimated lead survival free of definite malfunction (from implantation date) was 95% at 5 years and 89% at 10 years and free of definite plus possible malfunction was 94% at 5 years and 85% at 10 years. There were no generator malfunctions.

Limitations have been detailed previously.<sup>3</sup>

In conclusion, in longer-term follow-up of the ICD Sports Registry, athletes with ICDs engaged in vigorous competitive sports without physical injury or failure to terminate arrhythmia, despite the occurrence of inappropriate and appropriate shocks in some. Underlying disease should be considered, in particular arrhythmogenic right ventricular cardiomyopathy, because exercise increases disease progression<sup>5</sup> and arrhythmia. These data can guide more informed individualized physician and patient decision making for sports participation for athletes with ICDs and continue to support the recent change in eligibility recommendations.<sup>4</sup>

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