DIVERS WITH IMPLANTABLE CARDIAC DEVICES

Clinical Characteristics and Variations in Diving Practice

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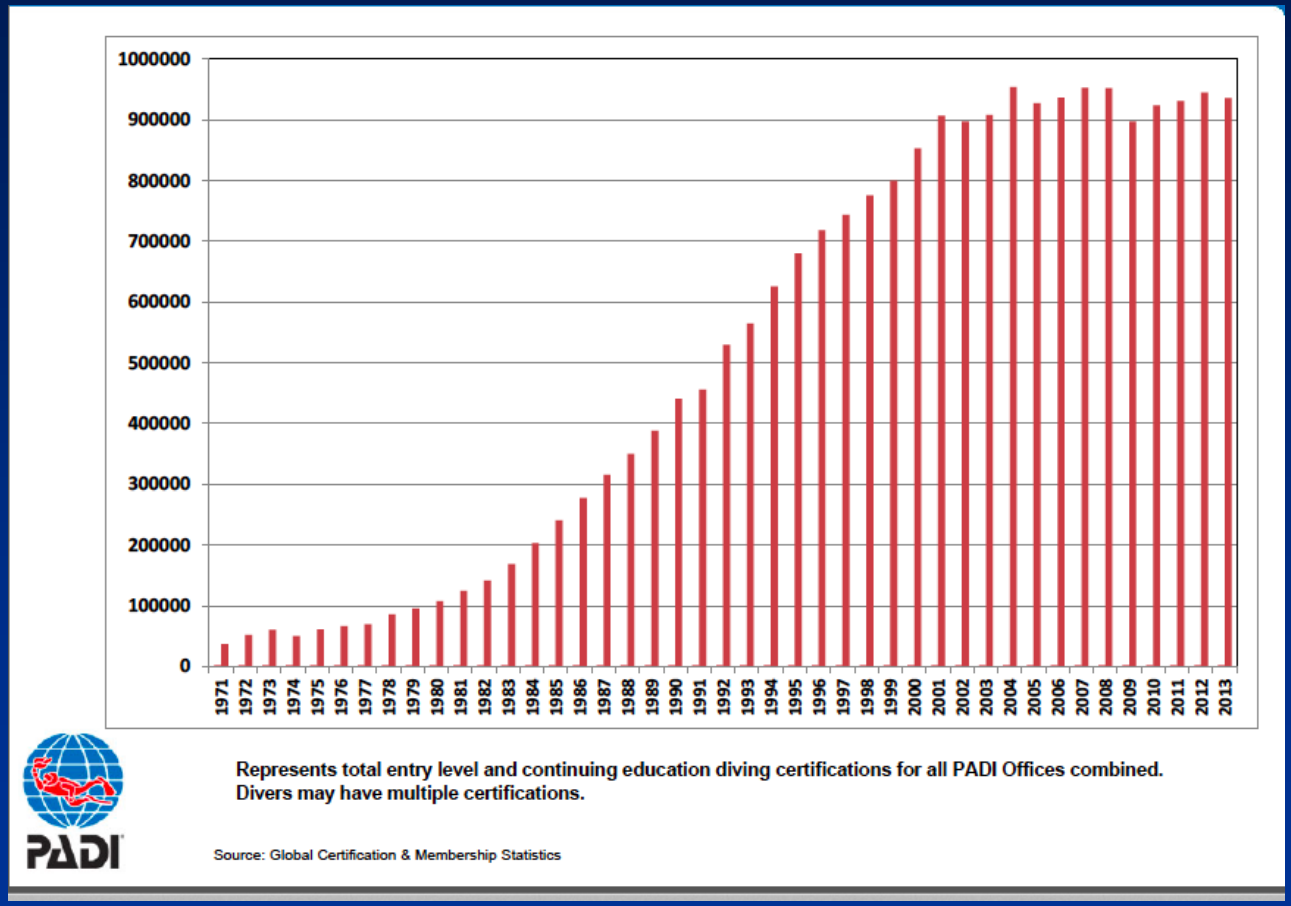
Research performed with: Divers Alert Network

Background



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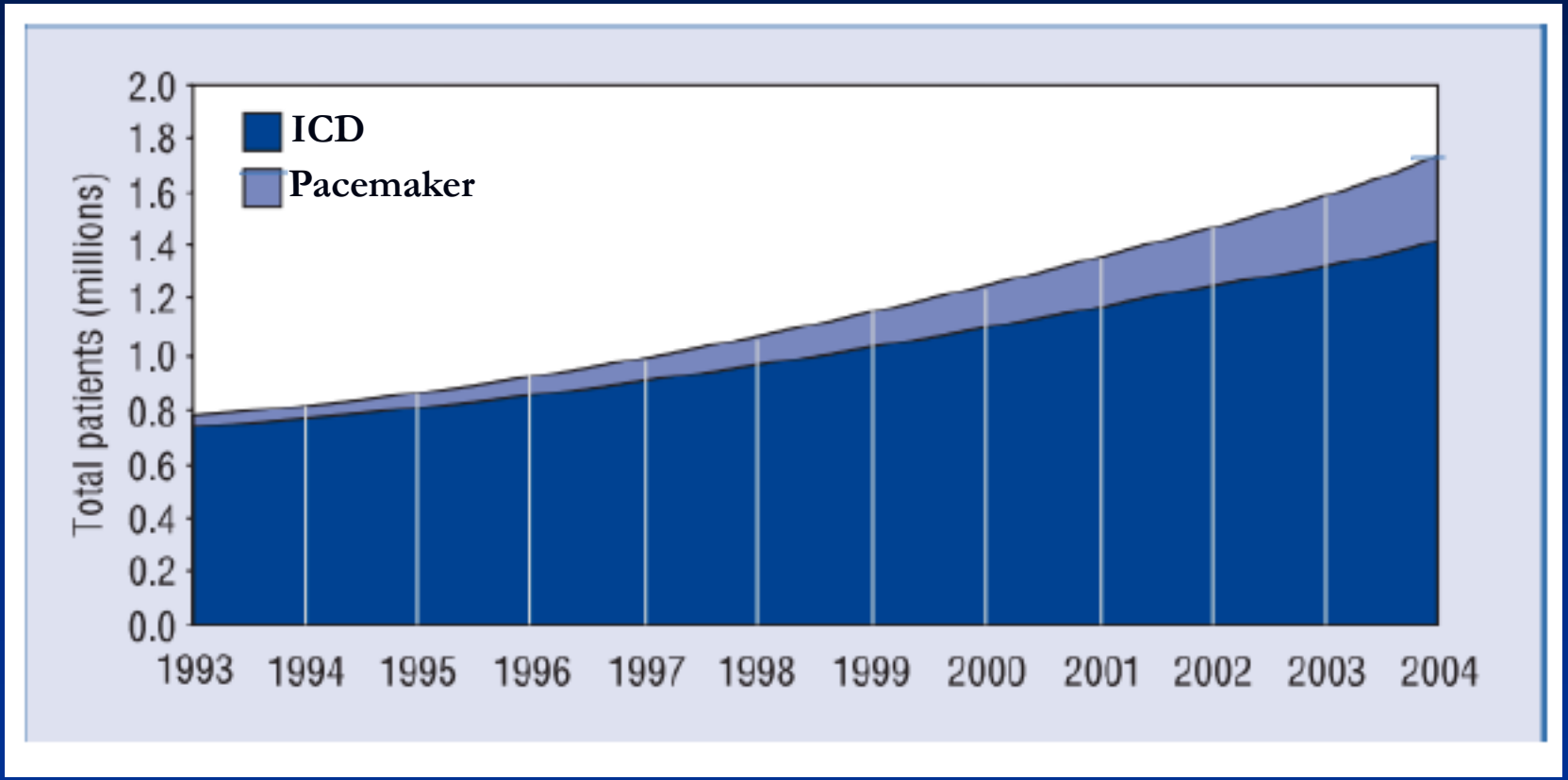
Rates of Cardiac Device Implantation



Adapted from: IMV Medical Information Division. 2007 MRI Benchmark Report.

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Potential Risks

- Device malfunction
  - Substantial can compression in >50% of devices tested at <60 feet
- Complications even with successful therapy
  - Syncope
  - Pulmonary edema
- Unknown effects of pressure changes on arrhythmia precipitation

Guidelines

PRACTICE GUIDELINES: FULL TEXT

ACC/AHA/HRS 2008 Guidelines for Device-Based Therapy of Cardiac Rhythm Abnormalities

American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the ACC/AHA/NASPE 2002 Guideline Update for Implantation of Cardiac Pacemakers and Antiarrhythmia Devices)

Developed in Collaboration With the American Association for Thoracic Surgery and Society of Thoracic Surgeons

No recommendations.

Study Purpose

- To identify the key demographics, cardiac history, device characteristics, symptoms, diving characteristics, physician advice, and complications of the cohort that continue to dive after implantation of a cardiac device.

Methods

- An investigator-developed survey was available over a 3-month period
- Volunteers were invited through online media
  - Inclusion: certified, active divers >18 years of age with an implanted cardiac pacemaker or defibrillator
  - No exclusion criteria
- Survey was administered electronically
- Follow-up by telephone was made for clarification and to verify all post-diving complications

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Demographics & Cardiac History

Demographic	Respondents (n=29)
Age (median (25th, 75th percentile)	62 (56, 69)
Male gender	27 (93.1%)
Cardiac comorbidity (listed below)	17 (58.6%)
History of myocardial infarction	2 (6.9%)
History of coronary revascularization	3 (10.3%)
Congestive heart failure	2 (6.9%)
Atrial fibrillation	10 (34.5%)
Ventricular tachycardia	4 (13.8%)
Prior cardiac arrest	3 (10.3%)
Beta-Blocker	11 (37.9%)
Anti-arrhythmic	3 (10.3%)
Blood thinner	20 (69.0%)

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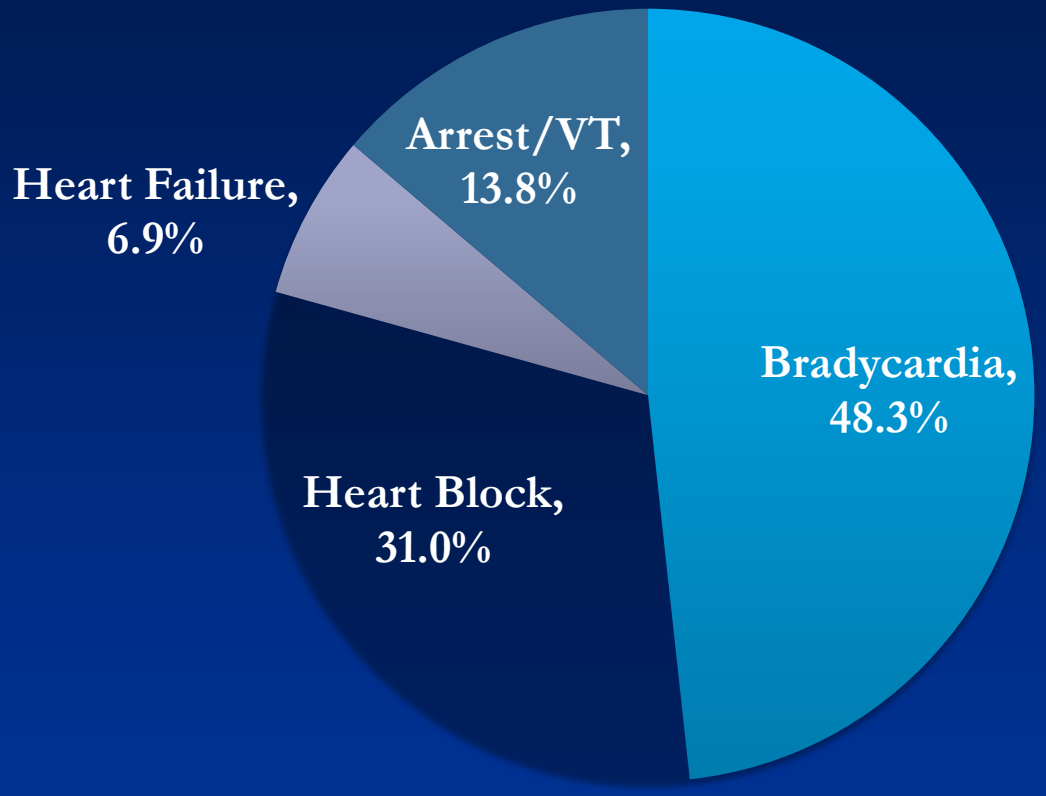
Device Indications



44.4% report pacemaker dependence.

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Weekly Cardiac Symptoms

- Chest pain – 3.7%
- Dyspnea – 25.9%
- Palpitations – 14.8%
- Presyncope – 40.7%

Note: none occurred during diving

Diving History

Characteristic	Median (25^{th}, 75^{th})
Years Diving	25.5 (18, 34)
Lifetime Dives	560 (195, 1163)
Dives Since Device	80 (15, 200)
Max Dives per Day	3 (2, 4)
Max Depth	100 (85, 110) Range 20-180

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Risky Diving Practices

Characteristic	Percentage
Decompression Diving	27.6%
Solo Diving	62.1%
Overhead Environments	27.6%
Distance from Hospital	
Up to 12 hours	75%
More than 12 hours	55%

Majority (69%) didn't change intensity of diving post-device.

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DAN Recommendations

Pacemaker

Each diver or dive student must be evaluated individually. The two most important factors to take into account are:

1. Why is the individual dependent on a pacemaker? and
2. Is the individual's pacemaker rated to perform at depths (i.e., pressures) compatible with recreational diving, including an added margin of safety?

Defibrillator is generally considered exclusion

- Defibrillator is usually set to allow a short period of unconsciousness before activation
- "…limited testing is reported to 40fsw. This is not considered to be an adequate testing depth for recreational diving".

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Manufacturer Recommendations

Boston Scientific — 33%

Table 1. Pressure Value Equivalencies

ATA	Sea Water* Depth (feet)	Sea Water* Depth (meters)	Pounds per Square Inch Absolute (psia)	Pounds per Square Inch Gauge (psig)†	Bar	kPa Absolute
5.0	130	40	72.8	58.1	5.0	500

Table 2. Testing Applicable to Boston Scientific Product Family and Models Listed

Product Type	Product Family	Model Numbers beginning with
Pacemakers	ADVANTIO® / INGENIO® / VITALIO™/ FORMIO™ EQUIO™ / ALTRUA®‡	J, K, L, S
CRT-Ps	INVIVE® / INTUA™/ INLIVEN™	V, W
ICDs and CRT-Ds	AUTOGEN™/ DYNAGEN™/ INOGEN™ / ORIGEN™ INCEPTA®/ PUNCTUA® / ENERGEN™ TELIGEN® / COGNIS®	D, E§, F§, G, N, P

St. Jude — 33%

Recommendations

Pacemakers

- Pacemakers should not be exposed to absolute pressures above 7 atmospheres or the equivalent depth of 198 feet of saltwater. (6 atmospheres above ambient sea-level pressure).

ICDs

- ICDs should not be exposed to absolute pressures above 7 atmospheres or the equivalent depth of 198 feet of saltwater. (6 atmospheres above ambient sea-level pressure).

Medtronic — 33%

Per Medtronic Labeling, Exposure to pressure exceeding 2.5 ATA (approximately 15 meters or 50 feet of seawater) may affect device function or cause device damage.

48.1% of respondents operated outside of manufacturer recommendations

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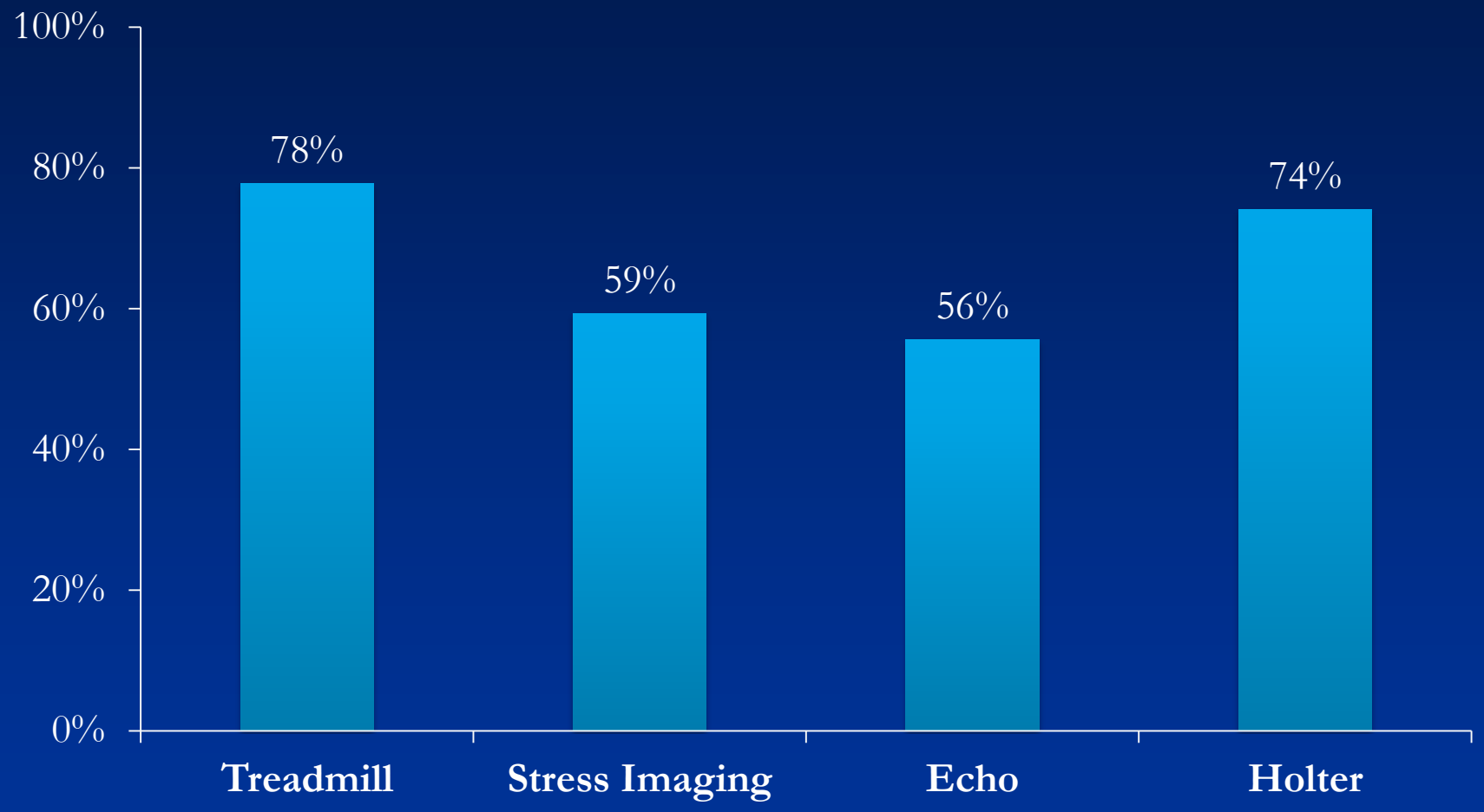
Workup Received



3.7% no workup

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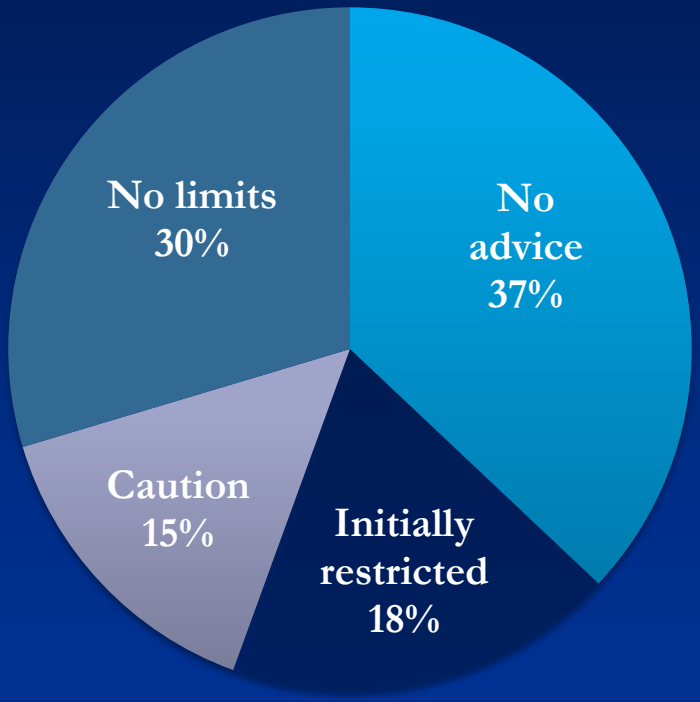
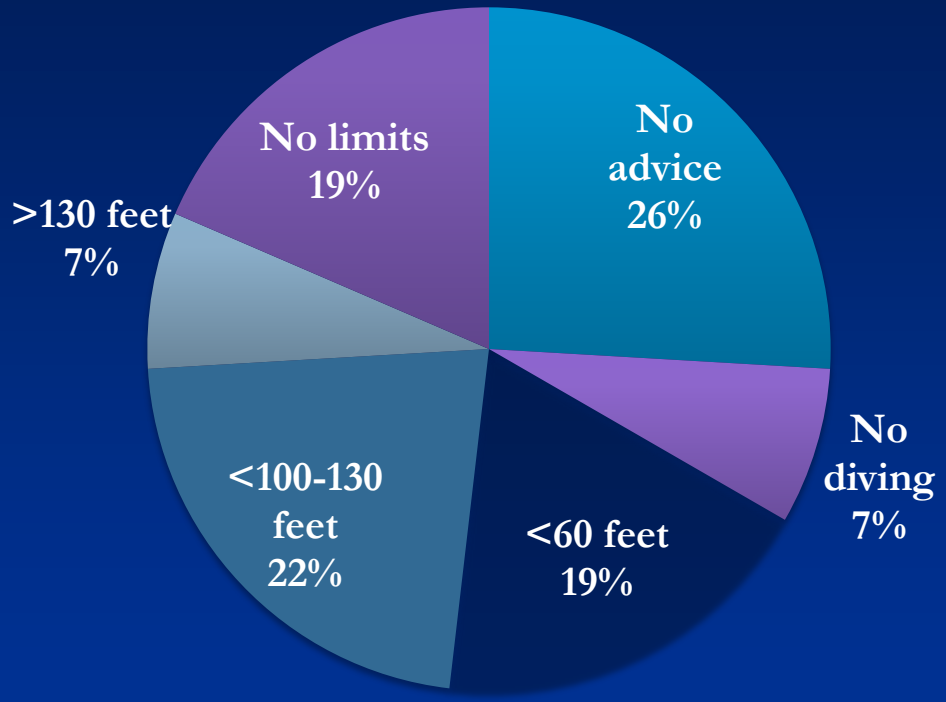
Advice Given

Physical Activity



Diving Activity



50% take no precautions currently

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Complications

Symptoms Shortly after Diving

- 1 patient each with occasional shortness of breath, weakness, and device site discomfort

Events Post-Diving

- MI (within 30 days of diving) – 1 patient
- ED visit for heart issue (immediately post-diving) – 2 patients (7.4%)
- DCI (immediately post-diving) – 1 patient
- No symptoms while underwater

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Conclusions

- Subjects who dive with implantable cardiac devices:
  - Self-selected group
  - Have substantial cardiac histories & rates of self-reported pacemaker dependence
  - Frequently possess ongoing cardiac symptoms
  - Pursue aggressive diving practices with maximal depth often below manufacturer recommendations
  - Receive heterogeneous or no physician advice
  - Have a risk for ongoing cardiac complications, though there is no evidence these are linked to diving

Future Directions

- Further research
  - Registry of divers with devices and long-term follow-up
  - Research of effects of devices on rates of typically-infrequent complications
  - Download ICD memory and review for recorded events while diving
- Guidelines
  - Standardization of physician advice
  - Communication of manufacturer recommendations

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THANK YOU.
QUESTIONS?