Insertion of a Permanent Pacemaker in a Professional Diver

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Summary

Patients who require a permanent pacemaker are an increasingly diverse group and therefore the individual needs of the patient must be considered in detail. We report a female patient who has to dive on a regular basis as part of her profession and who required a permanent pacemaker for sinoatrial disease. To ensure that continued participation in diving would be appropriate, she undertook detailed assessment of her pacemaker function during a simulated "dry" dive in a hyperbaric chamber.

After being taken to a pressure equivalent to a depth of 50 metres, appropriate sensing and pacing behaviour was monitored whilst at rest, exercising on a static bicycle, and rocking to stimulate the accelerometer-driven rate response. This assessment was then repeated after returning to the "surface" to ensure that pacemaker function remained intact.

This case illustrates that care must be taken when choosing a pacemaker for an individual patient, but that having chosen appropriately it need not prohibit diving either as a recreational or professional activity.

Key words: sinoatrial disease, AAIR pacing, underwater diving, external pressure on pacemakers, hyperbaric pressure

Introduction

The sport of sub-aqua diving is becoming increasingly popular around the world. Although the age distribution of pacemaker patients largely differs from those who dive, there is likely to be an enlarging cohort of patients with permanent pacemakers who wish to participate. This raises concerns over pacemaker function under the influence of the pressure effects created by being at depth.

The medical standards of the British Sub-Aqua Club[1] state that pacemaker patients should not dive beyond a depth of 30 metres. This is, however, a blanket recommendation which is intended as a guideline for recreational divers and does not take into account the needs of the professional diver, nor does it make any distinction between the devices which are available. For the recreational diver these guidelines may give a false sense of security whilst they may impose unnecessary restrictions on the professional diver with undesirable consequences regarding employment. We report a patient with sinus node disease who, as a marine biologist, regularly has to dive to depths of 50 metres.

Case History

A 26 year old female presented in August 1994 with a 6 month history of light-headedness and presyncope associated with bradycardia. A resting ECG had shown sinus bradycardia with a rate of 40 beats per minute (bpm). The PR interval was normal and there was no depolarisation or repolarisation abnormality. A 24 hour tape had shown persistent sinus bradycardia with rates between 40 and 60 bpm;

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however, there was evidence of sinus arrest with a junctional escape rhythm of less than 30 bpm. On this basis, a diagnosis of sinus node disease was made and implantation of a permanent pacemaker recommended. Her occupation though as a marine biologist required her to dive to depths of 50 metres on a regular basis.

To ensure that an appropriate device, capable of withstanding the anticipated pressures, was implanted advice was sought from a number of pacing manufacturers. The tolerance levels of the devices varied dramatically between manufacturers. The recommended safe depth to which a pacemaker could be taken varied from 10 to 60 metres. Furthermore, it was emphasised that these depths were derived from simulated bench testing rather than on the basis of any in-vivo studies. Permanent pacemaker insertion was performed in September 1994 with an Intermedics Dash 292-03 SSIR generator (Intermedics, Angleton, USA). The manufacturers were prepared to certify it to a depth of 196 feet (60 metres). The device was connected to a Medtronic 5524M atrial lead (Medtronic, Minneapolis, MN, USA), positioned sub-pectorally (for aesthetic reasons). At implantation, the threshold was 0.4 V and the impedance was 480 Ohm. The pacemaker was programmed to AAIR mode with a base rate of 60 bpm and an upper rate of 130 bpm.

Although the device had been bench tested to a pressure equivalent to a depth of 196 feet (60 metres), there was no information available to confirm appropriate function in vivo. To support the patient's application for a licence from the regulatory bodies we decided to confirm its appropriate function at pressures equivalent to depths of 50 metres.

In December 1995 the patient underwent a controlled "dry" dive using a hyperbaric chamber at the Diving Diseases Research Centre in Plymouth, Devon, United Kingdom (Fig. 1). On entering the chamber the patient was connected to a cardiac monitor and continuously observed by a supervising doctor. Over a period of 10 minutes the pressure was increased to the equivalent of 50 metres depth. At this point the patient was in her normal sinus bradycardia with occasional paced beats compatible with appropriate sensing and pacing behaviour (Fig. 2). She then started exercising on a static bicycle and demonstrated an increase in sinus rate in excess of the sensor driven rate. The lack of pacing activity reflected the relative understimulation of the accelerometer by this type of exercise. Therefore, to enable assessment of the rate responsive element, the patient rocked back and forth whilst seated on the cycle. Under this stimulus, she began pacing with the rate increasing up to 101 bpm. She then returned to cycling resulting in an appropriate sinus tachycardia (Fig. 3). As the patient returned to the "surface", sinus node activity and rate response were both assessed as before and proved satisfactory. Once back under surface conditions, the pacemaker was checked and was found to be working normally with no change in parameters. The patient has remained asymptomatic since insertion of the pacemaker and has continued to dive on a regular basis within the limits of the sport`s governing bodies.

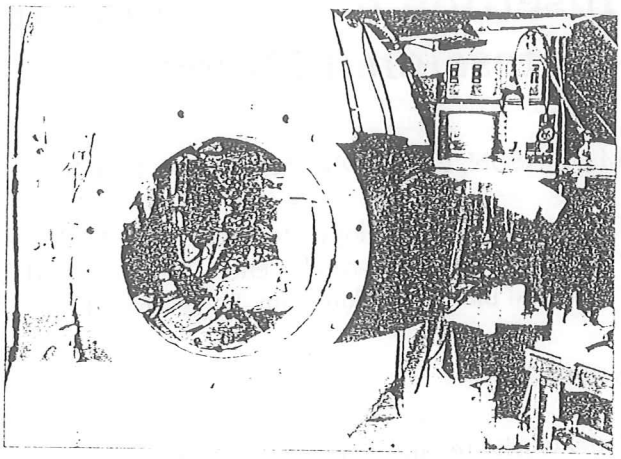

Fig. 1: Hyperbaric chamber at Diving Diseases Research Centre.

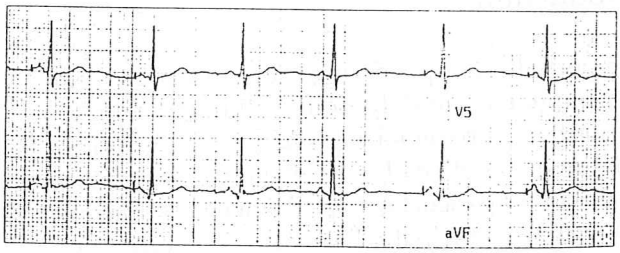

Fig. 2: At rest: appropriate sensing/pacing activity base rate.

Discussion

This case illustrates the need to consider potential interactions between implanted pacemakers and the patient's environment. Although we have demonstrated in vivo the safe and appropriate function of a selected pacemaker to a simulated depth of 50 metres, caution is advised in such cases. The pressure which a pacemaker will withstand varies dramatically between different manufacturers and even be-

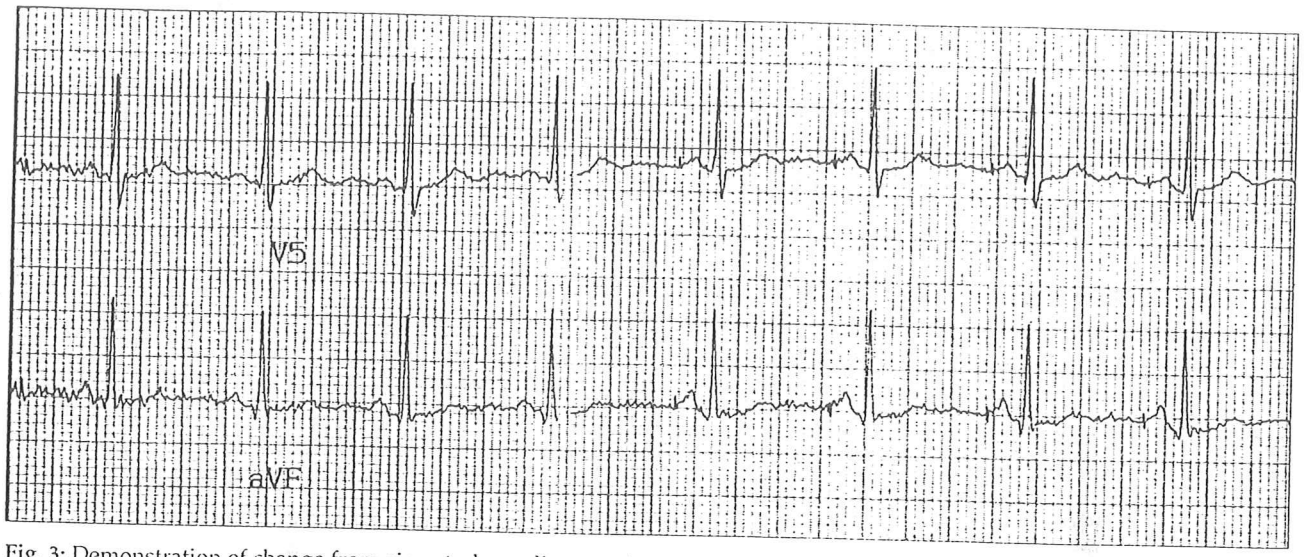

Fig. 3: Demonstration of change from sinus tachycardia to pacing at sensor driven rate at the cessation of exercise.

tween different models. Manufacturers recommended depth limits varied between 10 and 60 metres.

Pacemaker function under hyperbaric conditions was reviewed by Kratz et al.[2] in 1984. They demonstrated permanent pacemakers from five different manufacturers functioning normally at pressures of up to 100 pounds per square inch (psi), equivalent to a depth of approximately 60 metres. Since that time there have been significant changes in pacemaker construction. Contemporary pacemakers have thinner walls but a smaller surface area than older models and as such their ability to withstand pressure effects may differ. Rate adaptive pacemakers using canbonded sensors are sensitive to external pressure[3] and would be unsuitable for patients likely to dive.

The British Sub-Aqua Club sanctions diving in pacemaker patients to a depth of 30 metres. However, some pacemakers have only been tested in vitro to pressures equivalent to a depth of ten metres. Thus the current guidelines of BSAC would give an inappropriate clearance to some patients. A more considered approach is adopted by the Professional Association of Diving Instructors (PADI) who have a recreational dive limit of 130 feet (40 metres) and will allow pacemaker patients to dive to that depth if the patient can be issued with a Medical Fitness to Dive certificate by a Medical Examiner[4].

Whilst for the recreational diver, the criteria of the governing bodies do not seem to impede enjoyment of the sport, those individuals who dive regularly as part of their profession require a degree of flexibility taking into account their needs and the significantly different technology available compared with previous generations of pacemakers. We believe that the rigid application of a set maximum depth is neither fair to the individual nor relevant in the light of the great variation between current pacemakers. We suggest that the type of pacemaker be considered carefully for the individual concerned before implantation, and if there is any doubt about the pacemaker`s ability to function appropriately, that certification is then based on in vivo testing of the pacemaker.

References

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