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ORIGINAL ARTICLE

Implanted cardiac devices are reliably detected by commercially available metal detectors

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Abstract

Objective. Explosions of Cardiovascular Implantable Electronic Devices (CIEDs) (pacemakers, defibrillators, and loop recorders) are a well-recognized problem during cremation, due to lithium–iodine batteries. In addition, burial of the deceased with a CIED can present a potential risk for environmental contamination. Therefore, detection of CIEDs in the deceased would be of value. This study evaluated a commercially available metal detector for detecting CIEDs. **Design.** Observational study including pacemaker patients ($n = 70$) and a control group without pacemaker ($n = 95$). The investigational device was a hand-held metal detector for detecting metal or electricity wiring. **Results.** The metal detector detected the pacemaker in all pacemaker patients and thus exhibited a sensitivity of 100%. The specificity of the metal detector was 86%, and the negative predictive value was 100%. Thirteen individuals without pacemakers were falsely identified as having an implanted device due to implanted prosthetic material or elements of clothing. **Conclusion.** A simple hand-held metal detector may detect CIEDs with a high sensitivity. It may be of value in detecting CIEDs in deceased persons before burial or cremation. Any signal detected by the metal detector should prompt further investigation of the body and patient files.

Key words: cardiovascular implantable electronic devices, metaldetector, pacemakers

Introduction

Cardiovascular Implantable Electronic Devices (CIEDs) are increasingly used in patients with various heart conditions. The number of implanted pacemakers and implantable cardioverter defibrillators (ICD) per year in Europe are 450,000 and 115,000, respectively (1). In the United States, the corresponding numbers are now exceeding 200,000 and 50,000, respectively (2). These numbers are increasing due to a demographic shift toward an elderly population but also due to changes in indications for ICDs and resynchronization devices (3). Furthermore, implantable loop-recorders are increasingly used for diagnostic purposes as part of a more aggressive strategy in the evaluation of syncope (4).

Most modern CIEDs use lithium–iodine batteries due to their longevity, reliability, and small size. However, when an individual with a CIED dies, the device has to be explanted before cremation, as the lithium–iodine battery poses a serious hazard for explosion in the crematory oven. This was first described in the 1970s with a pacemaker containing a zinc/mercuric oxide battery (5), but the explosion hazard is the same for modern lithium–iodine batteries during excessive heating due to rapid formation of hydrogen gas and subsequent breakage of the device casing. Such an explosion may lead to serious damage of the oven and economic losses as well as injury to crematorium staff (6). Further, there may be a risk of potential contamination of the environment

from the lithium–iodine battery if the deceased is buried.

Increasing awareness of the problem has resulted in a reduction in the number of explosions in the crematory ovens (7), but as CIEDs decrease in size they will become increasingly difficult to detect by physical examination. Pacemakers and ICDs can also be implanted at unexpected sites due to previous infection, specific wishes from the patient, or vascular abnormalities, and in some cases, an inactive pacemaker may have been left *in situ*. Also, the number of cremations is increasing in almost all countries due to both religious beliefs and practical considerations.

This study aimed at evaluating a simple method for detecting implanted cardiac devices by means of an electronic metal detector.

Methods

Study design

Observational study including pacemaker patients ($n = 70$) and a control group without pacemaker ($n = 95$) attending the outpatient clinic at Department of Cardiology, Aalborg University Hospital.

Study subjects

Study subjects with an implanted pacemaker and control subjects were asked to participate prior to inclusion. Pacemaker patients were included in connection with a planned out-patient visit. The pacemaker was tested before and after using the metal detector.

In the control group, we included persons without pacemakers scheduled for echocardiography in the outpatient clinic.

Investigational device

A commercially available hand-held metal detector, for detecting metal or electricity wiring in building walls, was used (Toolmate DT-908233). The metal detector can be operated both in the mode for detecting electric wiring and in the mode for detecting metal, but since the device was not able to detect the electrical current from pacemakers we used the “metal” mode for testing in the present study.

The detector was operated by choosing “metal detection mode” and by passing the detector over first a metallic object, then over the surface to be examined. When metal is detected it gives a signal in the form of a loud beep and a visual signal on the LCD display. The device measures $12 \times 25 \times 4$ cm ($4.7 \times 9.8 \times 1.6$ inches) and fits easily in the pocket

of a coat or gown. The retail price is approximately 17 Euros (21 US dollars).

It has previously been shown that metal detectors used for security purposes in airports do not interfere with the function of implanted pacemakers (8,9).

Study procedure

The metal detector was passed over the entire chest of the study person. In some patients, it was maneuvered directly on the skin whereas in others it was passed over a thin layer of clothing. Because pacemakers may have been implanted in atypical locations or can migrate subcutaneously, we passed the detector over the entire chest wall in a systematic approach. Any visible metal components such as pens or mobile phones in the chest pocket or zippers in cardigans or coats were removed before testing.

Ethics

The study protocol was forwarded to the local scientific ethics committee for Northern Jutland. The Ethics Committee concluded that the study did not need approval from the committee.

Results

Before the study the metal detector was tested with explanted pacemakers showing no signs of interference from the metal detector with respect to programming and battery status.

The metal detector was tested both in the mode for detecting electricity and in the mode for detecting metal. As the metal detector did not detect the electrical current in the pacemakers, we applied the mode for detecting metal in the study.

In the study, pacemakers were tested before and after examination with the metal detector showing no change in programming or measured values.

The performance of the metal detector for correctly identifying implanted pacemakers is displayed in a 2×2 table (Table I). The metal detector correctly identified the pacemaker in all pacemaker patients and thus exhibited a sensitivity of 100% ($p < 0.001$). The specificity of the metal detector

Table I. 2×2 table displaying diagnostic performance for detection of implantable pacemakers showing a sensitivity of 100% and a specificity of 86%.

	Pacemaker	No pacemaker	Total
Signal by metal detector	70	13	83
No signal	0	82	82
Total	70	95	165

was 86%, and the negative predictive value (NPV) was 100%.

Thirteen individuals without pacemaker were falsely identified as having an implanted device. In all cases this could be attributed to implanted metallic material or clothing elements (hangers in brassieres) (Sternal cerclage: $n = 11$; elements of clothing: $n = 2$).

In one patient it was possible to register separate signals from an artificial heart valve and a pacemaker. And in two female patients separate signals were registered over the brassiere and over the pacemaker. In two patients, a signal was registered over knee prostheses and in one patient over a hip prosthesis.

Discussion

This study shows that a commercially available metal detector is capable of identifying implanted cardiac pacemakers with great reliability, that is, a sensitivity of 100%. In the control group, 14% were falsely identified by the metal detector as having an implanted device, but in all cases this could be explained by clothing or other forms of implanted material. The number of falsely positive control subjects is likely to be higher in this study compared to the average population of deceased individuals due to a larger number of persons with previous heart surgery and sternal cerclage attending the echocardiography department.

In many countries, the physician signing the death certificate is obliged to secure the removal of CIEDs (10). However, in some cases the device is not identified and removed before burial or cremation. In Denmark, 10-year data from the Danish Crematory Association indicate that 7–29 explosions occur each year (7). It is likely that the proportion of deceased persons being buried with an undetected CIED is as least as high.

It has previously been shown that a hand-held metal detector can effectively detect cardiac pacemakers in deceased individuals (11). However, in the quoted short publication no data were given with respect to how many subjects were studied and there were no controls. Furthermore, the authors gave no information concerning false positive results.

Our study shows that a signal from the metal detector may derive from other sources than lithium battery devices, for example, clothing, artificial heart valves, cerclage in the sternum, and probably shoulder prostheses as we saw a signal over knee and hip prostheses. If the metal detector gives a signal in deceased persons, it is therefore necessary to inspect the chest region to look for relevant scars and subcutaneous devices or to examine hospital records,

unless clothing that may explain the signal can readily be identified.

The use of a simple, portable device for screening-deceased persons for potentially hazardous medical equipment may be economically important but also confers benefits to crematoria staff, which might otherwise be subject to injuries due to battery explosions. A very high NPV of 100% could make the metal detector useful in hospitals or at undertakers before the coffin is sealed and transported to the crematoria.

Alternatives to an electronic screening could include an X-ray examination of the chest of all deceased persons to detect CIEDs. This would however be both troublesome, expensive, and give rise to ethical considerations. Transportation of the deceased and delay in the time before cremation or burial.

Other alternatives include granting undertakers access to patient files or mandatory national device registers. However, opening patient files and registers to nonhealthcare professionals interferes with the patient—doctor confidentiality which is a fundamental ethical principle. Further, some devices are likely to be missed, as device registers are country specific and not accessible, if the patient dies in a foreign country.

Limitations

In this initial study, the observer using the metal detector was not blinded as to which patients had pacemakers and which had not.

All pacemakers were readily identified, and it was thus not possible to evaluate whether performance of the metal detector was related to the size or type of pacemaker (single, dual chamber, or CRT device) or the manufacturer. Also, the study did not include patients with ICDs and implantable loop recorders. However, in the case of ICDs, similar findings are to be expected due the larger size of the device.

The results were obtained in patients and controls who were alive. However, there is no reason to doubt that similar results could be obtained in deceased persons, due to the fact that the investigational device detects metallic objects and is not dependent of a normal functioning body.

Conclusion

A simple hand-held, commercially available metal detector can reliably be used to exclude implanted cardiac pacemakers. A signal can however be of other causes and warrants further investigation of hospital records and physical inspection to rule out implantable

cardiac devices. The results suggest that these devices should be considered used by undertakers or by medical doctors who write the death certificate to assure that an CIED is not in the body of a deceased individual. This will be advantageous for environment and for the security of persons working with cremation of bodies.

Declaration of interest: The authors report no declarations of interest. The authors alone are responsible for the content and writing of the paper.

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