Potential interference of small neodymium magnets with cardiac pacemakers and implantable cardioverter-defibrillators

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BACKGROUND Magnetic fields may interfere with the function of cardiac pacemakers and implantable cardioverter-defibrillators (ICDs). Neodymium-iron-boron (NdFeB) magnets, which are small in size but produce strong magnetic fields, have become widely available in recent years. Therefore, NdFeB magnets may be associated with an emerging risk of device interference.

OBJECTIVE We conducted a clinical study to evaluate the potential of small NdFeB magnets to interfere with cardiac pacemakers and ICDs.

METHODS The effect of four NdFeB magnets (two spherical magnets 8 and 10 mm in diameter, a necklace made of 45 spherical magnets, and a magnetic name tag) was tested in forty-one ambulatory patients with a pacemaker and 29 patients with an ICD. The maximum distance at which the magnetic switch of a device was influenced was observed.

RESULTS Magnetic interference was observed in all patients. The maximum distance resulting in device interference was 3 cm. No significant differences were found with respect to device manufacturer and device types.

CONCLUSION Small NdFeB magnets may cause interference with cardiac pacemakers and ICDs. Patients should be cautioned about the interference risk associated with NdFeB magnets during daily life.

KEYWORDS Magnet; Pacemaker; Implantable cardioverter-defibrillator; Electromagnetic interference; Neodymium

Interference of environmental factors with cardiac pacemakers and implantable cardioverter-defibrillators (ICDs) may cause temporary or permanent changes of device function. The vast majority of interactions in clinical practice may be attributed to electromagnetic interference, which may result from a wide spectrum of sources in everyday life and at the workplace.1 Common permanent magnets for household or office use are generally associated with low risk due to low magnetic field strength. However, very strong magnets made from neodymium-iron-boron (Nd$_2$Fe$_{14}$B) have recently become available. Because of high magnetic field strength and low production costs, NdFeB magnets are increasingly being incorporated into various articles for household and office use, for example, in toys, jewelry, and even clothes. The aim of this study was to determine the risk of magnetic interference caused by small commercially available NdFeB magnets in patients with cardiac pacemakers and ICDs.

Methods

Consecutive patients with pectorally implanted cardiac pacemakers or ICDs were recruited during regular device follow-up visits at the outpatient pacemaker service at the University Hospital of Zurich. Tests were performed using NdFeB magnets of different sizes and configurations, which included a single small (8 mm) and a larger (12 mm) spherical magnet, a necklace made of 45 spherical magnets of three different sizes, and a magnetic name tag (Figures 1 and 2).

After initial device interrogation, NdFeB magnets were placed in direct skin contact over the implanted device. Magnet position and orientation were varied systematically until magnet interference was noted. Then, starting from the center of the area of magnet interference during direct skin contact, magnets were elevated from the skin in 1-cm increments. The occurrence of magnet interference was evaluated at each distance until cessation of interference was observed. The same procedure was repeated using four different kinds of NdFeB magnets. In pacemakers, magnet effect documented by continuous electrocardiogram monitoring was used to evaluate magnet interference. In ICDs, interference was defined as emission of audible tones or annotation of magnet detection during marker-channel recording. Recording of marker channels was used in five devices, which could not be programmed to emit acoustic
signals. In these devices, programmer heads, which did not contain built-in magnets, were placed eccentrically to allow continuous telemetry during the test. No special programming of the device was performed before the test. After completion of all measurements, devices were reinterrogated to check for inadvertent programming during the test procedure, and regular testing and programming were performed as indicated clinically.

Data were analyzed with SPSS for Windows, version 13 (SPSS, Chicago, IL). Categorical data are presented as frequencies (%), continuous variables are presented as mean ± standard deviation (SD). Fisher’s exact test was used to compare rates. Continuous variables were compared using Student’s t-test or analysis of variance with post hoc analysis. Two-sided P-values <.05 were considered significant.

The study was conducted according to specific institutional and regional ethics guidelines. All participants provided written informed consent.

Results
A total of 280 measurements were performed in 70 consecutive patients. Baseline characteristics of the study patients and devices are listed in Table 1. The NdFeB magnets used for the tests are depicted in Figure 1, and physical characteristics are presented in Table 2. The necklace was made of 20 small, 20 medium-sized, and five larger spheres. Magnetic interference was observed in all patients. Occurrence rates of magnetic interference at various distances are shown in Figure 3. The maximum distance of interference was 3 cm. Pacemakers were affected at greater distances [mean distance (SD), 2.1 (0.6) cm] compared with ICDs [1.7 (0.6) cm; \(P = .007\)]. There was no significant difference between single-chamber [1.9 (0.7) cm] and dual-chamber devices [2.0 (0.6) cm; \(P = .6\)] or between manufacturers \((P = .4)\). Magnetic interference was dependent on the size, configuration, and shape of the magnets (Table 3). While the larger sphere and the chain of spheres caused magnetic interference with virtually all devices, the name tag interfered with 57% of the devices. No patient experienced any symptoms during magnet testing. All devices resumed regular function immediately after magnet removal.

Discussion
The findings of this study suggest that small, commercially available NdFeB magnets may cause interference with modern cardiac pacemakers and ICDs. All devices were susceptible to interference within a distance of up to 3 cm. Notably, only small magnets weighing up to 8 g were tested. Larger NdFeB magnets are likely to cause interference at greater distances, but no such magnets were investigated because those magnets have to be handled with care on account of their strong adhesive force.

Interference may occur if the magnetic switch of an implanted device is affected by an external magnetic field. Reed switches incorporated in many pacemakers and ICDs are typically closed by a 0.9 mT magnetic field and reopen at 0.7 mT. In recent years, Hall sensors or semiconductor-based magnetic switches are increasingly being used, in which opening and closure occur at the same field strength. Magnet switch closure results in temporary asynchronous pacing in pacemakers and in temporary suspension of tachyarrhythmia detection in most ICDs, whereas bradycardia pacing functions remain unaffected in most ICDs.
During daily life, transient magnet reversion has been reported to occur at a rate of 11% per patient per year. Most patients with cardiac devices are unlikely to recognize short-lasting magnetic interference. Many individuals with an implanted pacemaker remain asymptomatic during asynchronous pacing, and brief episodes of asynchronous pacing seem to be associated with very low clinical risk, although competitive pacing during spontaneous rhythm may result in stimulation of the ventricle during its vulnerable period and may induce ventricular arrhythmias, especially in high-risk patients, such as those with ischemia. Initiation of reentrant pacemaker tachycardia, atrial flutter, or fibrillation by magnet application to a pacemaker has also been described. Some ICDs emit alarm tones during the occurrence of magnet interference. If this function is unavailable or deactivated, magnet effects may be identified by use of a programmer and recording of the marker channel, but this will not be recognized by the patient.

All devices tested in the current study resumed normal function after removal of the magnetic field. However, permanent or recurring magnetic influence might be caused by prolonged exposure to magnetic name tags, brooches, or other jewelry or apparel with magnetic closures. In Guidant devices, ICD functions may be permanently disabled by a magnet applied for 30 seconds if the “change tachy mode with magnet” feature is programmed “on.” Unintentional

Table 1  Baseline characteristics of 70 study patients and devices.

| Age (years) | 65 (17) |
| Male sex | 50 (71%) |
| Body mass index (kg/m²) | 27 (4) |
| Pacemakers | 41 |
| - Single chamber | 7 |
| - Dual chamber | 34 |
| ICDs | 29 |
| - Single chamber | 15 |
| - Dual chamber | 14 |
| Device manufacturer | |
| - Guidant | 25 |
| - St. Jude Medical | 22 |
| - Pacesetter | 3 |
| - Medtronic | 19 |
| - Vitatron | 1 |
| Time since implantation (months) | 27 (28) |

Numbers are counts or mean (SD).

Table 2  Physical characteristics of tested magnets.

<table>
<thead>
<tr>
<th>Size/Diameter (mm)</th>
<th>Weight (g)</th>
<th>Adhesive Force (kg)</th>
<th>Remanence (T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small sphere</td>
<td>8</td>
<td>2.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Medium sphere</td>
<td>10</td>
<td>4.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Large sphere</td>
<td>12</td>
<td>8.1</td>
<td>2.9</td>
</tr>
<tr>
<td>Name tag</td>
<td>40 × 11 × 4</td>
<td>8.3</td>
<td>NA</td>
</tr>
</tbody>
</table>

Adhesive force and remanence values were obtained from the distributor of the magnets. NA = information not available.

Figure 2  NdFeB magnets forming a necklace (A), a triangle (B), and a row (C). Shape and extension of the magnetic field resulting from the assembly of multiple magnets are demonstrated with iron powder.

Figure 3  Percentage of devices exhibiting magnetic interference during exposure to NdFeB magnets at various distances.
ICD deactivation with potentially fatal consequences has been reported.\textsuperscript{5–10} In newer devices, magnet application is being used to trigger specific functions, including storage of event markers and electrograms. Thus, in these devices, magnet interference may lead to eccentric, although innocuous, device behavior.\textsuperscript{11}

Because of higher magnetic field strength, NdFeB magnets are much smaller in size than conventional permanent magnets. The field strength of a specific magnet, as well as the extension and shape of the magnetic field of multiple magnets that have been put together, may not be easily predicted without performing B-field measurements. Our measurements demonstrated that the necklace, which was made of 25 spheres, did not cause interference at greater distance than the one observed with a single sphere. However, changes in the configuration of the magnets result in very different shape and extension of the magnetic field (Figure 2). Furthermore, various coatings or incorporation into pieces of jewelry or apparel may make these magnets less recognizable, and the risk of interference may be underestimated by patients. Although magnet interference may only cause fixed-rate pacing in pacemaker patients, such interference may suspend tachycardia detection in ICDs with potentially life-threatening consequences. Therefore, the use of name tags, jewelry, or reading glasses containing NdFeB magnets should generally be considered to be contraindicated. Magnetic toys and NdFeB magnets for home and office use should be handled with caution in patients with pacemakers and ICDs.

**Conclusion**

Small NdFeB magnets may cause interference with modern pacemakers and ICDs. Patients should be cautioned about the interference risk associated with NdFeB magnets during everyday life, and product declarations should include information on the potential hazard that may be associated with the use of these magnets.

**References**

Fridge magnets 'can be a killer'

Fridge magnets and decorative jewellery could be a killer if you have a weak heart, experts warn.

A strong type of magnet used in many new commercial products can interfere with pacemakers and implanted heart devices with deadly consequences.

Close contact - within about 3cm - with a neodymium magnet is enough to destabilise these life-saving heart devices, Heart Rhythm journal reports.

The authors suggest manufacturers include a health warning on products.

Ordinary iron or ferrite magnets, which are a dull grey colour with a low magnetic strength, are of little concern.

Very strong magnets made from neodymium-iron-boron, which are shiny and silver in colour, have only recently become available.

But because of their high magnetic field strength and low production costs, they are being used in computer hard drives, headphones and hi-fi speakers, as well as toys, jewellery and even clothes.

Swiss researchers at the University Hospital of Zurich tested the effect of neodymium magnets in 70 heart patients - 41 with pacemakers and 29 with implantable cardioverter defibrillators.

Magnetism

The small 8g magnets tested interfered with all of the patients' devices, regardless of their make or type, when they were in a maximum range of 3cm.

The researchers said larger neodymium magnets would be likely to cause interference at greater distances than this.

There is a real danger. These magnets are everywhere

Ian Asquith, director of Neodymium Magnets UK

Although the devices worked normally again once the magnet was removed, the authors warned permanent damage might occur with prolonged exposure - if someone were to wear a magnetic name badge, for example.

Lead researcher Thomas Wolber said: "Physicians should caution patients about the risks associated with these
magnets.
"We also recommend that the packaging includes information on the potential risks."

**Warnings**

Ian Asquith, director of Neodymium Magnets UK, a supplier of neodymium magnets to product manufacturers, said his company was aware of the risks and sends warnings out with every magnet.

But consumers were generally unaware, he said, and manufacturers had a responsibility to warn consumers of any risks.

"There is a real danger. These magnets are everywhere. They are in lots of badges, fridge magnets and mobile phones. If you were on a busy bus and someone you are squashed up against had a magnet in their top pocket you could easily come within 3cm of it.

June Davison, of the British Heart Foundation, said anyone with concerns should contact their pacemaker clinic.

"Pacemakers are manufactured to the highest standards, are rigorously tested, and most have a protective case to shield them from outside interference. Problems are rare."
Livsfarlige koleskabsmagneter

Koleskabsmagneter kan koste menneskeliv, lyder advarslens fra schweiziske forskere

Michael Winther-Rasmussen - 16.29 - 02. dec. 2006

En meget stærk type magnet, der blandt andet kan bruges i koleskabsmagneter, kan have fatale konsekvenser for personer med pacemaker. Kort afstand - hvilket vil sige op til tre centimeter - mellem magnet og pacemaker kan få det livsvigtige apparat til at svigte.

Sådan lyder advarslens fra en gruppe forskere ved universitetshospitalet i Zürich i Schweiz. Det skriver BBC med baggrund i en artikel i fagbladet 'Heart Rhythm'.

Forskerne har undersøgt en ny kraftig type magnet, der er farlig. De er billige at lave og der blandt andet indeholder neodym, der er farlige. Forskerne har undersøgt ikke de nye kraftige magneter, der er farlige. Forskere har undersøgt ikke de nye kraftige magneter, der er farlige.

- Læger bør advarle patienter om de risici, der er forbundet med disse magneter, siger forskerholdets leder, Thomas Wolber, der også opfordrer til, at der placeres advarslser på produkter, der indeholder magnetene.

Det er ikke alle magneter, der er farlige. Forskerne har alene fundet en negativ effekt ved de nye kraftfulde neodym-magneter.

SENESTE NYT

16:13 > FCK’er på svensk landshold
15:47 > Myndige sine forældre for at få fred
15:47 > Morten ‘Duncan’ klar til opstart
15:40 > Britney dater Federlines producent
15:30 > Iraniere frifundet for terroranklage
15:18 > Carey kæmper mod pornoprisen

MEST LÆSTE ARTIKLER

1. Den bedste sitcom
2. Myndige sine forældre for at få fred
3. Carey kæmper mod pornoprisen
4. Britney dater Federlines producent
5. Krigen umler på Nørrebro
6. Skuespiller fik otte år for narkohandel

MEST SENDETE

1. Gå en tur på Grand Canyons glasbro
2. Bredahl-overfald: Voldsmand på fri fod
3. 15 måneder for fængsling under graviditet
4. Tamme chiller,
5. Hvordan rør det
6. Arkitekten kan være smeltet i 2040

MEST LÆSTE I BAR

1. Bredahl-overfald: Voldsmand på fri fod
2. 19-årig anholdt for Bredahl-overfald
3. Begravelse endte i nævekamp
4. Kvinde valdt i sin lejlighed
5. Hun elsker at vise måsen frem
6. Så fjern hende dog fra skærmen
Magnets 'threat to heart patients'
By PA
Last Updated: 1:48am GMT 02/12/2006

Magnets used in toys, jewellery and office equipment may pose a serious risk to patients fitted with pacemakers and other heart implants, according to researchers. A study has found they can interfere with the operation of devices such as pacemakers and implantable cardioverter defibrillators (ICDs).

Ordinary iron or ferrite magnets, like those used to stick messages and badges on fridges, are of little concern. But researchers found that more powerful magnets made from neodymium-iron-boron (NdFeB) may present a real problem. NdFeB magnets are increasingly being used in homes and offices. They can be found in the hard drives of computers, "in-ear" headphones, and certain hi-fi speakers, as well as toys, jewellery and even clothing.

Scientists in Switzerland tested two spherical NdFeB magnets of 8mm and 10mm diameter, and a necklace made from 45 magnetic beads, on 70 heart patients. Forty-one of the volunteers were fitted with pacemakers and 29 with ICDs.

In all cases, being close to the magnets caused interference which disrupted the functioning of the devices. Normal operation was resumed as soon as the magnets were removed.

Dr Thomas Wolber of the University Hospital of Zürich, who led the study, said: "Physicians should caution patients about the risks associated with these magnets. We also recommend that packaging include information on the potential risks that may be associated with these types of magnets."

The findings were reported in the journal Heart Rhythm.

In an accompanying commentary, Dr Huagui Li, a US cardiologist at the Minnesota Heart Clinic in Edina, Minneapolis, wrote: "This study is timely and important to attract the attention of both the public and the medical profession about the potentially serious health consequences of magnets used in decoration productions ... for an ICD patient, the magnetic interference can be fatal."

He said manufacturers who used magnets should be required to place warning labels on their products.