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REVIEW ARTICLE

Airport detectors and orthopaedic implants

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As a result of the rising threats of terrorism, airport security has become a major issue. Patients with orthopaedic implants are concerned that they may activate alarms at airport security gates. A literature overview showed that the activation rate of the alarm by hand-held detectors is higher than for arch detectors (100% versus 56%). Arch detection rate has significantly increased from 0% before 1995 up to 83.3% after 1994. Reported factors which influence detection rates are implant mass, implant combinations, implant volume, transfer speed, side of implant, detector model, sensitivity settings, material and tissue masking. Detection rate has been improved by more sensitive devices and improved filter software. Doctors should be able to objectively inform patients. A form is presented which will easily inform the airport security staff.

Keywords : airport detectors ; orthopaedic implants.

INTRODUCTION

In recent years airport security checks have been intensified in response to the rising terror threats. Travel by plane as well as the number of individuals with orthopaedic implants have been increasing, and both are predicted to rise further in the future. This combination of increased security, growing air travel and rising number of travellers with orthopaedic implants will cause the problems associated with the detection of implants during airport security checks to rise significantly as well. Such problems affect passengers with implants but also all passengers in total, security staff and security in general. A passenger with an implant that is detected must bear the time loss, inconvenience or embarrassment of a body search. Even without the implant being detected, a patient might feel discomfort or even suffer from the fear of detection, as numerous phone call inquiries of patients to our clinics confirm. Some travelling patients even call the airport to gain information if they need a certificate to be allowed to pass the security gates in case the alarm is activated. Doctors should be able to objectively inform patients and relieve their concerns. All passengers must cope with long queues and delays that intensive searches after the true cause of a detected implant can cause. Security staff must deal with the impatience, stress and possible aggressive reactions of passengers while having to decide on the security relevance of the detection and search. This way security might be compromised if no clear information for travelling patients or security staff is available. The impact of

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the problems described depends on the detection rates or sensitivity level of airport metal detectors. However, only a limited number of studies have been published to investigate the detection rates of orthopaedic implants at airport metal detectors. In this study we present an overview of the literature concerning airport detectors and orthopaedic implants. This will give more clarity about the sensitivity of a variety of commonly implanted orthopaedic devices to airport metal detectors.

A patient information form is presented.

METAL DETECTORS – FUNCTION AND BACKGROUND

Metal detectors create an alternating electromagnetic field and as metal implants are capable of undergoing temporary magnetisation (permeability), an alternating eddy current is induced in the implant which is registered by the receiver (*3*). The magnetic permeability of the metal depends on its iron content and on the manufacturing method.

At the airport security gates, two types of detectors are utilised. Arch detectors are used compulsorily for each passenger and handheld detectors are employed if the arch detector gives a signal above threshold level or if demanded by increased security concerns. As shown by Boivin *et al* (*4*), the frequencies of the magnetic field signal for modern arch detectors vary between 0.1 kHz and 3.5 kHz while the wave-forms are saw-toothed or pulsed. The frequencies of hand-held detectors are sinusoidal and vary between 89 kHz and 133 kHz.

Older arch detector models consisted of a separate sender and a receiver panel left or right (single source unilateral detector), which created a non-uniform field mostly using a sinusoidal wave form. In 1976, the sensitivity of the detection equipment was improved with the introduction of pulsating electromagnetic field detectors. The newer models also comprise an all-around integrated sender/receiver unit and generate a near uniform field (bilateral arch detector). Sophisticated software filters can discriminate between different metal alloys and might help identify metals commonly used for orthopaedic implants. The detectors are calibrated and their minimum sensitivity must be preset to the Federal Aviation Authority-demanded levels for international travel.

Metal detectors distinguish between detection settings and alarm settings, both of which have a minimum required setting from the Federal Aviation Authority (FAA). These limits can be adjusted but remain above the minimum limit of the FAA. Some publications do not explicitly distinguish between detection and alarm settings and the corresponding detection or alarm rates.

LITERATURE OVERVIEW

We performed a search on Pubmed looking for all available data on this subject from 1970. The search terms were metal detectors, airport detectors, hand-held and arch detectors. Nine studies were found (table I). The studies investigated arch and/or handheld detectors and in some cases the influence of changed sensitivity settings was tested. In addition some patient surveys were performed. The implants studied were various common fracture and joint replacement implants, either individually or in combination, and either with patients and the implants *in situ* or with volunteers who had the implants taped or strapped on exteriorly or underneath some kind of wrap simulating the effect of soft tissue cover. Publication dates ranged from 1992 to 2002, with all but one study performed in Europe.

In the first study (*9*) various implants were tested by three different arch metal detectors. Two machines were set for average sensitivity and one for the highest sensitivity. The implants were either fracture fixation implants or joint replacement implants. They were strapped by an adhesive belt to a subject in the appropriate anatomic position. The implants were tested individually, in combination of pairs, and as a whole in each of three different metal detectors. None of these implants activated the alarm, except the Moore fenestrated hip. The alarm was only activated when the high sensitivity detector was used. This detector was activated because the Moore hip is made of an older metal alloy with a high iron content.

In the study of Evans *et al* (*6*), 8 patients with a variety of orthopaedic implants were examined

Table I. — Studies showing the detection rates of orthopaedic implants at an airport

Authors, year	Implant type	Arch detector activated	Hand-held detector activated	Doctoral statement recommended by authors
Pearson *et al*, 1992	Fracture fixation, orthopaedic implants	No, except Moore fenestrated hip and combinations with highest sensitivity level only	N.I.	No
Evans *et al*, 1993	Orthopaedic implants	No	Yes ; large superficial implants	No
Van Rhijn *et al*, 1994	Fracture fixation, orthopaedic implants	No, except Lubinus prosthesis	Yes	Yes
Sperling *et al*, 1995	Fracture fixation, orthopaedic implants	Yes, prosthesis activated the alarm depending on sensitivity level	N.I.	Yes
Asch *et al*, 1997	Radiologic implants, orthopaedic implants	No	Yes, only metal containing ports	No
Basu *et al*, 1997	Fracture fixation, orthopaedic implants	Yes, especially > 1 prosthesis	N.I.	Yes
Grohs *et al*, 1997	Orthopaedic implants	Yes		Yes
Charitidis *et al*, 2000	Orthopaedic implants	Yes	Yes, only to taped-on implants	Yes
Kamineni *et al*, 2002	Fracture fixation, orthopaedic implants	Yes, failed to detect some implants	Yes	Yes

N.I. = not investigated.

with arch and hand-held metal detectors. Using the arch detector no alarm was activated and in case of the hand-held detectors the alarm was activated in two cases. The hand-held detectors gave alarm when large implants taped on exteriorly were tested.

Van Rhijn *et al* (*11*) asked 50 operated scoliosis patients by a questionnaire whether they had ever been checked with a metal detector at an airport. Forty-six questionnaires were returned and the activation rate of the alarm at the airport amounted to 14% (3/22 patients). They also performed an airport trial in which several implants were tested with an arch and hand-held detector. These implants were exteriorly attached to a volunteer. The arch detector was activated by the Lubinus-prosthesis depending on the walking speed and place on the body, and the Moore prosthesis. Using the hand-held detector, the alarm was activated in all cases.

Sperling *et al* (*10*) tested ten different prostheses for hip and knee arthroplasties and plates for internal fixation in two metal detectors. The plates were not detected, whereas the detection of the prosthesis depended on the sensitivity setting of the detector.

In the study of Asch *et al* (*1*), radiologic and orthopaedic implants were evaluated by three types of metal detectors at an international airport. The arch detectors were not activated at all, but metal-containing ports did set off the hand-held scanners.

Basu *et al* (*2*) assessed the effect of a variety of implants used in fracture fixation and joint replacement on the activation of metal detectors at airport security gates. An arch detector was used and in one group the implants were strapped to a healthy volunteer while the other group consisted of patients with implants *in situ*. Fracture implants, except the Richards cannulated screw, did not activate the alarm. Volunteers with one Austin-Moore prosthesis or three or four standard hip and knee replacements strapped on activated the alarm.

Grohs *et al* (*7*) studied the detection of joint replacements at airport security checks in relation to their weight using two different arch detectors : a single-source, unilateral detector and a bilateral arch detector. All implants weighing more than 145 g were detected by the single source detector. The degree of detection was directly related to the logarithm of the weight of the prosthesis in patients, with a linear correlation ($r^2 = 0.61$). The detection rate was also influenced by the transit speed and, with the single arch detector, by the side of the implant. The bilateral arch detected all prostheses weighing over 195 g.

In another study (*5*), 9 patients with orthopaedic implants and 9 volunteers with implants taped on were screened by arch detectors or hand-held detectors. All the implants activated the metal arch detectors but only a small number of these activated the alarm threshold. The hand-held detectors gave alarm for all taped-on implants.

Kamineni *et al* (*8*) hypothesised that a soft tissue shield and fast transit through archway detectors would decrease implant detectability, whereas greater implant mass would increase detectability. Twelve patients with 8 orthopaedic implants *in vivo* and 60 trauma and arthroplasty implants *in vitro* were subjected to standard airport security measures at an international airport. The implants were detected by arch and standard and non-standard hand-held detectors. Except one ankle arthroplasty, hand-held detectors detected all implants. Arch detectors failed to detect some implants. The detection rate in archway detection is related to the transit speed through the detection field and implant mass and volume. A wax shield had no influence on the detection rate.

In summary, in five out of nine studies the arch detector was activated by implants (*2, 5, 7, 8, 10*). In five studies hand-held detectors were used and in all cases the alarm was activated (*1, 5, 6, 8, 11*). Thus, the detection rate of hand-held detectors is higher than arch detectors (100% versus 56%). In six of the studies mentioned above (*2, 5, 7, 8, 10, 11*) (67%) it was recommended by the authors that patients with orthopaedic implants should carry a doctoral statement. In four out of nine studies (44%) the arch detector was not activated by the implants but from these studies three (75%) were done before 1995 (*6, 9, 11*).

Therefore, before 1995 the arch detection rate was 0% (0/3) and after 1994 the detection rate was 83.3% (5/6). This shows a clear correlation between study time and detection rates and/or sensitivity settings of arch detectors.

DISCUSSION

Detection rates of orthopaedic implants can be influenced by several factors. Reported factors are : implant mass, implant combinations, implant volume, transfer speed, side of implant, detector model, sensitivity settings, material and tissue masking (*1, 2, 4-11*). In general fracture implants with their typically low weight and small volume, and light joint implants do not activate the alarm detectors. Handheld detectors were more sensitive to detect orthopaedic implants.

Since contemporary and future orthopaedic implants use little, if any, ferrous metal, they might escape detection by airport metal detectors and save passengers from the inconvenience of a body search and discussion. However, the detection sensitivity has been increased and security settings have been tightened to overcompensate this development. However, more intelligent filter software which could identify the response signals of typical implant alloys might aid to reduce unnecessary alarms. So far the improved device sensitivity and tightened security settings which can vary widely between different airports have led to a continuously increasing detection rate with time. In the study of Grohs *et al* (*7*) many joint replacements were detectable already at their standard sensitivity settings. The exact data of the sensitivity levels are unknown and have been preset to the Federal Aviation Authority-demanded levels for international travel. As shown above the arch detection rate has increased significantly from 0% before 1995 to 83% in studies thereafter. The sensitivity levels might also have been tightened further after the terror attacks of 11th September 2001. The only

RECTO

Name, first name	Berger, Leopold	
Date of birth	02/03/1928	
Nationality	Dutch	*Photograph*
Passport number	184133778	
Gender M/F	male	

To whom it may concern,

I hereby declare that the above mentioned person is the bearer of (a) metallic orthopaedic implant(s), which may activate airport security metal detectors.

Surgeon	date 08/03/2005	Hospital Authority
…………….		……………………..

VERSO

IMPLANT ID-CARD

Number of implants :	1
Location of implant :	hip
Side of implant (L/R) :	left
Implant specifications :	titanium hip implant

IMPLANT MAY ACTIVATE METAL DETECTORS

Fig. 1. — Example of a patient information form, which can be used at the airport

study published after this date (*8*) showed a high detection rate by more sensitive devices and improved filter software. The disclosure of certain findings and more details regarding sensitivity levels and detection rates was prohibited by relevant state authorities and further studies and publications on the issue will not be allowed according to the authors.

In order to improve security and comfort of travelling patients with implants, as well as of other passengers and security staff at airport gates, we would make three recommendations.

1. Manufacturers should provide information on size, weight and material of the implant, to the makers of detector devices in order to enable calibration of the filter software to lower the detection rate of orthopaedic implants. In the future sophisticated filter software might be able to distinguish the alloys and locations of implants, from those used in weapons.
2. Implant carriers should pass all other metal objects, such as jewellery, through the x-ray machine in order to avoid pasitive arch detection and the inevitable further handheld detection.

3. In agreement with the recommendation made in six studies mentioned above (*2, 5, 7, 8, 10, 11*) we think patients should be produced an official and international accepted compact document providing a doctoral statement in English (the standard language in international aviation) mentioning the implant type and location (fig 1). The airport authorities should be informed about the prosthesis identification document and instruct the security staff. Since the sensitivity of arch detectors has improved, patients with orthopaedic implants have less chance to pass and to avoid questioning, additional searches and delays. A positive arch detector search is usually followed by a metal search with hand-held detectors and will lead to implant detection. In case of activation of the alarm, the document can be presented and reduce the burden for security staff and the fear of highly concerned patients.

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