Airport metal detectors and orthopedic implants

The responses of arch and hand-held devices

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8 subjects with a variety of orthopedic implants were examined by the security staff at an international airport using arch and hand-held metal detectors. None of the subjects caused activation of the alarm on the arch, although the presence of metal was registered in 2 at a level below the alarm threshold. The hand-held detectors alarmed over the larger superficial implants. A substantial tissue screening effect was noted.

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Patients often ask what effect metal implants will have on airport security devices, and until recently there was no published data on the subject.

In 1992, Pearson and Matthews reported their findings on the response of 3 airport metal detectors to a variety of implants which were strapped to a normal subject. Their paper made the assumption that there was no screening effect of body tissues, it made little allowance for variations in the sensitivity of metal detectors, and it did not include the responses of hand-held detectors which are frequently used to perform more thorough examinations. We undertook a study addressing these issues.

Subjects and methods

8 adults with a variety of orthopedic implants (Table 1) took part. After removing metal objects, such as coins, keys and jewellery, which might interfere with the detectors, they were screened by 3 members of the security staff at an international airport in 2 ways.

1. Each subject walked through a metal detector arch (IAL Pin Point Series) 4 times. The response of the detector, registering on a scale from 0 to 15, was recorded, as also was triggering of the alarm at a previously set threshold.

2. The subjects were examined using hand-held metal detectors (IPD 5) concentrating on the region of the implant.

3 members of the security staff performed all the examinations. They were aware that all of the subjects had metal implants, but when using the detector arch they were unaware of the nature or site of the implants. When using the handheld detectors, the staff were informed of the site of the metalwork and thus were able to concentrate on these areas.

Results

None of the subjects caused activation of the alarm on the metal-detecting arch. However, 2 caused a registration signal below the alarm threshold on each passage.

The hand-held detectors alarmed in 4 of the 8 cases. In the case of the stainless steel intramedullary nail, the detectors alarmed when held over the knee at the point of introduction and at the fracture site (where union was incomplete), but not where the nail was enclosed by the tibial shaft above and below the fracture.

Discussion

Our results for the metal-detecting arch are in general agreement with those of Pearson and Matthews (1992). The threshold at which the alarm is triggered, however, is adjusted depending on the security risk perceived at the site of operation. The IAL Pin Point Series machine can function at any 1 of 10 settings, the threshold in this study being that used for routine international flights from the United Kingdom. Our observation that the 2 subjects with the largest amounts of metalwork were registered by the arch suggests that, at the lower thresholds used in high-risk situations, passengers with a number of implants may trigger the alarm.

Table 1. Response of the metal detectors. The arch detector alarm was set at a level higher than 4

Implant	Metal	Arch detector maximum display 0–15	Hand-held detector alarm
Screw in tibia	stainless steel	0	–
8-hole tibial plate	stainless steel	0	+
Intramedullary tibial nail	stainless steel	0	+
Unilateral total knee arthroplasty	CoCrMo and Ti–6Al–4V	0	+
Bilateral total knee arthroplasty	CoCrMo and Ti–6Al–4V	1	+
Unilateral total hip arthoplasty	CoCrMo and Ti–6Al–4V	0	–
Unilateral total hip arthroplasty	stainless steel	0	–
Bilateral total hip arthroplasty	stainless steel	4	–

The response of the hand-held detectors shows that there is a tissue screening effect; superficial implants, with the exception of the single screw, were all identified, but deep implants (the total hip replacements) were shielded. The response to the intramedullary tibial nail implies that the greatest screening is provided by mature cortical bone.

Pearson and Matthews (1992) explained their findings on the basis that "Contemporary orthopedic implants are made of highly refined alloys such as titanium, cobalt-chromium-molybdenum alloy and stainless steel. They contain little if any iron." Stainless steel, however, contains approximately 66 percent iron and thus the failure to detect these prostheses in their study cannot be explained entirely on this basis.

Metal detectors use 2 electromagnetic phenomena; eddy current generation and electromagnetic field distortion. In all devices an electromagnetic field is created, either in wave or pulsed form, by a transmitter winding and is analyzed by a receiver winding. In some devices 1 winding serves both functions. When a conductor is placed within the field, eddy currents form on its surface at the expense of field power. Then the power reduction is sensed by the detector circuits. The eddy currents themselves form electromagnetic fields which, in pulsed induction detectors, are sensed by the receiver winding. Ferrous metals with low conductivity create a distortion in the electromagnetic field and upset the "balance" of the transmitter and receiver windings resulting in power being induced into the receiver windings (Garrett 1991).

Eddy current generation depends on conductivity and surface area thus, for non-ferrous metals, detection is facilitated by low resistivity and a large surface area. Cobalt-chrome-molybdenum alloy, however, has a high resistivity similar to stainless steel (0.89 and 0.75 uohm.m, respectively), whilst that of the titanium alloy Ti-6Al-4V is greater still (1.66 uohm.m). The sensitivity to metal type differs between detectors according to the mode of operation and, on more modern machines, adjustments can be made which allow discrimination on the basis of metal type and object size. All these factors may interact to determine the response of an individual machine to a particular implant.

From this study we believe that, with present security routines, passengers with orthopedic implants are unlikely to be identified for individual examination. Should other factors prompt closer examination with hand-held detectors, then many superficial implants will indeed be identified.

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References

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