Airport metal detector activation is rare after posterior spinal fusion in children with scoliosis

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Abstract

Purpose Since the September 11, 2001 terrorist attacks on the World Trade Center in New York City, travel security has become an ever-increasing priority in the United States. Frequent parent and patient inquiry and recent literature reports have generated interest in the impact of heightened security measures on patients with orthopaedic implants, and have indicated increasing rates of metal detector triggering. There are no reports to date, however, evaluating children and adolescents who have undergone posterior spinal fusion for scoliosis, so responses to patient and parent inquiries are not data-driven. The purpose of this study is to determine the frequency of airport metal detector triggering by patients who have had posterior-only spinal fusion and to characterise any potential predictors of metal detector activation.

Methods A cross-sectional study was performed by interviewing 90 patients who underwent posterior-only spinal fusion for a diagnosis of juvenile or adolescent idiopathic scoliosis and have travelled by air in the past year. Demographic, clinical and surgical instrumentation data were collected and evaluated, along with patients' reports of airport metal detector triggering and subsequent screening procedures.

Results Five patients with stainless steel instrumentation (5.6 % of the cohort) triggered an airport walkthrough metal detector, and an additional five patients who did not

trigger an airport detector triggered a handheld detector at a different venue. All patients who triggered an airport metal detector had stainless steel instrumentation implanted prior to 2008, and no patient with titanium instrumentation triggered any detector in any venue. All trigger events required subsequent screening procedures, even when an implant card was presented.

Conclusions In this cohort of children and adolescents with posterior spinal instrumentation, airport walkthrough metal detector triggering was a rare event. Therefore, we advise patients and families with planned posterior scoliosis fusions using titanium instrumentation that airport detection risk is essentially non-existent, and only rare for those with planned stainless steel instrumentation. We no longer issue implant cards postoperatively, as these did not prevent further screening procedures in this cohort.

Level of evidence Prognostic level 2. Study design: cross-sectional.

Keywords Adolescent idiopathic scoliosis · Spinal instrumentation · Hardware · Stainless steel · Titanium · Air travel · Metal detector · Security screening

Introduction

Since the September 11, 2001 terrorist attacks on the World Trade Center in New York City, travel security has come to the forefront as a priority in the United States. Restrictions have been placed on travellers, which have included comprehensive screening and increased sensitivity of archway (walkthrough) metal detectors at airports. This has led to several reports in the orthopaedic literature discussing the implication of these heightened security

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measures on orthopaedic patients. While pre-9/11 series have shown that orthopaedic implants infrequently triggered metal detectors [1–3], many post-9/11 reports of increased screening procedures on travellers with orthopaedic instrumentation are available and have indicated increased detection frequency (of up to 88 %) and burden of security checkpoint stress on patients with orthopaedic implants [4–9].

In addition to heightened security measures, previous studies have indicated that both metallurgy [9, 10] and implant mass [2, 4, 6, 8, 10] also affect detector activation. To date, however, nearly all of these reports have been in adult patients with trauma instrumentation (e.g. nails, plates, screws) or total joint arthroplasties. Only one recent British study [5] evaluated a variety of anterior and posterior spinal instrumentation; however, all implants were titanium and no detectors were triggered. It still remains unclear as to how common posterior spinal instrumentation used in children and adolescents with scoliosis might affect airport metal detector activation in the post-9/11 era. Furthermore, with variable metallurgy and differing total implant mass depending on the degree of pathology, it is currently unknown if and how metal composition and/or amount of instrumentation affected airport metal detector triggering. Given the potential for increased psychological and physical stress on a child or adolescent who becomes separated from his or her parents and family members for further screening by a uniformed officer, this data is important in guiding surgeons, patients and families with regard to expectations surrounding postoperative air travel.

To that end, we designed and report herein a cross-sectional interview questionnaire study of a cohort of children and adolescents who underwent posterior-only scoliosis fusion. The purpose of this study was to provide information to surgeons and patients about a commonly asked question, for which there are very limited data in the orthopaedic literature. Our primary research question was: what is the rate of airport metal detector triggering from posterior spinal instrumentation? We secondarily asked: (1) what, if any, additional screening procedures took place? and (2) of those who triggered airport metal detectors, was there any predictive value of implant metallurgy, the number of implants per vertebral segment (so-called “implant density”) or body mass index (BMI)?

Methods

Prior approval was obtained from the hospital institutional review board (IRB) and participation did not affect patient care in any way. A list of 147 consecutive patients was generated from a database of children who underwent posterior spinal fusion for a diagnosis of juvenile or

adolescent idiopathic scoliosis (JIS and AIS, respectively) by one of three surgeons at a single metropolitan tertiary care orthopaedic referral centre. The inclusion criteria were: diagnosis of JIS/AIS, posterior-only spine fusion by one of three surgeons and date of surgery between June 1997 and August 2011. These dates were chosen in order to include all patients of record from the inception of the current operative database until 1 year prior to the study analysis in order to ensure that all patients had at least 1 year to have flown after the implantation of spinal instrumentation. Patients were excluded for primary or supplemental anterior instrumentation, or if they reported no air travel since surgery.

Of the original 147 patients, 119 (81.0 %) were able to be contacted after three rounds of phone calls. Of the 119 contacted patients, 90 patients (75.6 %) had reported flying in the previous year, and were questioned further and included in the final analysis. Some families had moved and their contact information did not yield current addresses, phone numbers or email addresses, including patients who had graduated from college and moved out of the family home. No contacted patient refused to participate in the study, and no patient had subsequent spine surgery outside of our institution. Included patients were interviewed by phone by trained study staff about their experience with airport security. Specifically, how many travel segments, number of flight segments and where (e.g. USA vs. international) an airport metal detector was triggered, and any additional procedures requested by security officers (e.g. wandering, patdown, documentation, showing scar) were recorded.

Demographics and spinal instrumentation variables were retrieved from the medical records and are reported in Table 1. Date of surgery, age at surgery, gender and BMI were retrieved from office charts. BMI as measured at the time of surgery was used as a predictor variable for metal detector triggering. To ensure no significant changes in BMI over the follow up interval, height and weight at the time of follow up questioning were collected and a current BMI was calculated. All BMIs at the time of follow up were within 15 % of the BMI recorded at the time of surgery. Implant material was retrieved from the operative record; number and type of implants were retrieved from the operative record and confirmed on the most recent postoperative radiographs. Type and metallurgy of implants used did not change over the study period. The number and material of each type of implant (e.g. screw, hook, wire, rod, crosslink) as well as the number of fusion levels were recorded; an “implant density” variable was created for each patient by dividing the total number of spinal implants by the number of fusion levels.

Data were collected using Microsoft Excel (Microsoft Corp., Redmond, WA, USA) and analysed using STATA

Table 1 Demographic, clinical and surgical implant data

Variable	Mean $\pm$ SD or no. of patients	Range or percent
Age at surgery (years)	15.2 $\pm$ 1.79	12.1–21.0
Gender		
Male	29	32.2 %
Female	61	67.8 %
Body mass index (BMI)	20.6 $\pm$ 3.9	14.6–38.7
No. of fusion levels	9.5 $\pm$ 2.2	3–16
Material		
Stainless steel	74	82.2 %
Titanium	16	17.8 %
Implants		
Pedicule screws	80	92.0 %
Hooks	76	87.4 %
Wires	47	54.0 %
Crosslinks	60	69.0 %
Total implants	19.0 $\pm$ 3.6	11–32
Implant density	2.0 $\pm$ 0.3	1.1–2.9
Air travel (no. of screenings)	4.8 $\pm$ 3.0	2–20
Airport detector triggers	5	5.6 %

Table 2 Clinical details of the five patients who triggered airport metal detectors

Patient	DOS	Age (years)	Gender	BMI	Material	No. of fusion levels	Implant density	Triggers (%)	Location	Additional procedures
1	July 1999	13.8	Female	21.49	SS	10	1.10	100	USA	Wand, patdown
2	Dec 2001	17.1	Male	27.81	SS	10	1.80	50	USA	Wand
3	Feb 2006	13.2	Female	19.48	SS	7	2.43	50	International	Wand, patdown
4	June 2006	15.8	Female	14.61	SS	7	2.43	16.7	USA	Wand, patdown
5	July 2007	15.9	Male	17.54	SS	11	2.27	50	USA and international	Wand, patdown, documentation

SS stainless steel

v12.1 (StataCorp, College Station, TX, USA) by a member of the research team with advanced training in epidemiology and biostatistics. Descriptive analyses for normally distributed data were reported as means and standard deviations, while non-parametric data were reported using medians and ranges. The Wilcoxon rank sum test was used to compare non-parametric continuous variables between patients who triggered an airport metal detector and those who did not. This investigation was designed as a question-driven descriptive cross-sectional study, with a primary research question that did not test differences between groups; therefore, an ad-hoc power calculation was not appropriate [11]. Statistical significance was set at 0.05 (two-tailed) for all analyses.

Results

Of the 90 analysed patients, 5 (5.6 %) reported triggering an airport security alarm an average of 1.6 times, which ranged from 16.7 to 100 % of airport screening interactions (Table 2). Three patients triggered detectors in the USA only, one patient triggered an international detector only and one patient triggered detectors both in the USA and abroad. All initial screenings were performed using walk-through metal detectors. All patients underwent subsequent examination with a handheld wand, and four patients (80 %) underwent an additional patdown. Only one patient was asked for any documentation of the implants, which he provided (an implant card); however, he was still subjected

Table 3 Comparisons between patients who triggered airport metal detectors and those who did not

	Variable	Median (range)		<i>p</i> -Value ^a
		Trigger	No trigger	
No significant differences were noted between groups for any variable	BMI	19.48 (14.61–27.81)	19.44 (14.61–38.65)	0.71
	No. of fusion levels	10 (7–11)	10 (3–16)	0.33
	Total implants	17 (11–25)	20 (11–32)	0.22
	Implant density	2.27 (1.1–2.43)	2.08 (1.09–2.9)	0.58
	Travel segments	4 (2–8)	4 (2–20)	0.65

BMI body mass index

^a Wilcoxon rank sum test used for non-parametric analyses

to additional screening procedures. All patients reported minor inconvenience with these additional screening procedures, and no patient was required to show their scar. With regard to metallurgy, all triggering implants were stainless steel (6.8 % of the 74 patients with stainless steel instrumentation). Five additional patients (5.6 % of the cohort) who reported not triggering an airport metal detector did report triggering handheld wand detectors at other locations, including parties (three patients), a government building (one patient) and a museum (one patient). All five of these patients also had stainless steel instrumentation.

The most recent date of implantation in those who triggered any detector was in July 2007. Neither titanium instrumentation nor any instrumentation implanted later than mid-2007 triggered any airport metal detector. All metal detector triggering events in this cohort took place after September 11, 2001.

Due to the fact that metal detector triggering was a rare event in this series of patients, medians and ranges of predictor variables for those who triggered detectors and those who did not are reported in (Table 3), alongside non-parametric Wilcoxon rank sum analysis comparing these subgroups. There were no differences noted between groups with respect to BMI, number of fusion levels, total number of implants, implant density nor the number of airline travel segments. There were no significant differences in the rates of type of metal implanted over each year of the study period (1997–2011), eliminating time and metallurgy as potential interaction or confounder variables with respect to the association of each with positively triggering metal detectors.

Discussion

In this series of children and adolescents with posterior spinal instrumentation, airport walkthrough metal detector triggering was a rare event, affecting only 5.6 % of the study cohort. All of these patients underwent further screening, but reported only minor inconvenience with these additional procedures. With regard to the predictive

value of metallurgy, the only alarm triggers in our cohort had stainless steel implants. Furthermore, the five additional patients who did not trigger an airport metal detector but did trigger a handheld metal detector at another location all had stainless steel instrumentation. This is most probably due to the ferromagnetic (attracted to a magnetic field) properties of stainless steel versus the diamagnetic (not attracted to a magnetic field) nature of titanium [12], and confirms previous orthopaedic research indicating that titanium implants have the lowest rates of metal detector triggering [4–10]. We did not show that an increased implant density was associated with more frequent airport metal detector triggering events, which is likely due to the rarity in metal detector triggering coupled with the small variation in the range of implant density in this cohort. While all metal detector triggers were in patients who had surgery prior to mid-2007, it is unclear why this was the case, and is likely multi-factorial in nature. It is possible that the evolution of metallurgy and slight changes in manufacturing and processing could have contributed to this finding, though it is impossible to be certain.

The exact reason for the triggering of non-airport metal detectors by five patients in this cohort is unknown, especially in light of the fact that these patients did not set off the more sophisticated, expensive, standardised equipment used in airports. It is possible that the non-uniform screening methods (e.g. method of wand, how close the detector is held to the body, sensitivity setting of the wand or machine) all likely play a role. This highlights the variability of metal detectors and other unknown factors involved in implant triggering of metal detectors, even in the setting of individuals with less formal training using less expensive technology.

Our study has limitations. The retrospective nature of this interview study is subject to limitations in recall by the patients; however, the stress of triggering a metal detector and being subjected to further screening is a memorable event, therefore minimising this risk. Because of this, our main conclusions were drawn from positive metal detector triggering events, rather than focusing on the number of negative screenings. Also, systematic recall bias is unlikely, as there were no significant changes in any of the

predictor variables (BMI, metallurgy etc.) over the study period. In other words, while those who had surgery earlier in the study period may, in fact, have more limitations in their ability to recall events or negative scans, there were no systematic differences between those patients and those who had surgery later in the study period that could potentially bias the results of the study. We were only able to contact 119 of the original 147 patients from the initial query list; however, this was expected due to the nature of the included patients. Many children and adolescents who have surgery move to college or a different address after several years. Despite this, we were still able to obtain a >80 % rate of patient contact. In evaluating metallurgy, our cross-sectional study did not include any cobalt chrome implants, so we are unable to draw any conclusions regarding the rate of metal detector activation by cobalt chrome implants. Finally, event rarity precluded a robust subgroup analysis. Despite this limitation, appropriate non-parametric analyses were performed and indicated no statistically significant differences in the predictor variables studied. While it would have been methodologically inappropriate to perform an ad-hoc power calculation, as all possible patients were identified, subgroup analysis yielded nearly identical median effect sizes for three of the five potential predictor variables (BMI, number of fusion levels and travel segments) and clinically insignificant differences in effect sizes in the other two (total number of implants and implant density). Therefore, even if they had reached statistical significance, when taken in clinical context, it would have been unlikely that these variables could be used to predict who will trigger an airport metal detector. Furthermore, the “implant density” variable is inherently imprecise, as we were unable to quantitatively account for differences in rod thickness or length. Finally, there are many factors that can contribute to triggering an alarm. While sidedness is not a consideration in spinal instrumentation, we are unable to control for variables such as walking speed and specific levels of detector sensitivity in this retrospective analysis. We do, however, offer a “real world” report of the experience of these 90 children and adolescents, thus providing information to surgeons and patients about a commonly asked question, for which very limited data exists.

Post-9/11 reports in the arthroplasty [4, 6–10] and trauma [8–10] literature have indicated triggering rates ranging from 32 to 84 % that is affected by metal composition and total implant mass. The only recent report of spinal instrumentation evaluated several types of titanium-only implants in 40 patients and noted no metal detector triggering in a British cohort [5]. The main strengths of the current study are that it is the largest report of metal detector activation by spinal instrumentation to date, including a variety of posterior spinal implants, metal

composition and dates of implantation. Additionally, it is the first report of the effect of heightened airport security in the post-9/11 era on children and adolescents. While due to the broad timeframe of included surgical dates the current patient age range extends beyond adolescence, these data still represent the travel experience of today’s children and adolescents moving forward with posterior spinal instrumentation. The widespread use of posterior spinal fusion for the surgical management of idiopathic scoliosis underscores the utility and applicability of these data.

One common question that arises during office consultation is the issuing of an “implant card” or means of documentation that the patient has had implantation of orthopaedic instrumentation. In our practice, these are not issued for several reasons. First, as we have shown here, the overall rate of metal detector triggering is rare. Second, patients who do trigger the alarm will undergo further screening procedures regardless of documentation (e.g. Table 2, patient 5); the Transportation Security Administration (TSA) does not exempt travellers who provide medical documentation from additional screening or pat-downs [13]. This is likely due to the fact that the issuance of implant documentation is neither uniform nor regulated by any government agency. It may be easy for any individual to obtain a card documenting metal implants, which may or may not be appropriately issued.

Finally, very recent additions to airport screening technology include the use of millimetre wave and backscatter advanced imaging technology (AIT) at certain major metropolitan airports [14]. It is currently unclear how the detection of posterior spinal fusion instrumentation (or orthopaedic implants in general) by this new technology will impact passenger screening and may be of interest for future study. Importantly, this new technology does not currently provide the security officer with detailed imaging or insight into the nature of a metallic object. Rather, in an effort to enhance privacy, passenger-specific images have been eliminated and replaced by a report of the screening test results (positive or negative) that direct the officer to allow the traveller to pass or undergo further screening procedures [14].

Conclusion

In this series of children and adolescents with posterior spinal instrumentation, airport walkthrough metal detector triggering was a rare event. Those that did trigger archway metal detectors had stainless steel instrumentation implanted prior to 2008. Therefore, from our series of patients, we have begun to advise patients and families with planned posterior scoliosis fusions using titanium instrumentation that airport detection risk is essentially

non-existent, and for those with planned stainless steel instrumentation that detection is rare and should not be expected with contemporary posterior spinal implants. In the future, as detection methods become updated and more refined [e.g. widespread implementation of advanced imaging technology (AIT) and/or full-body scans], it will be important to continue to revisit this question in order to be able to counsel patients and families preoperatively about the likelihood of these children and adolescents triggering airport security measures, and to what additional screening procedures they will be subjected.

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Conflict of interest None.

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