Airport Full-Body Scanners

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Question: Are there any radiation risks from airport full-body scanners?

"Full-body scanners," also known as "whole-body scanners" or "people scanners," are used to screen travelers at airports. They can be classified as either "millimeter radio wave technology" or "backscatter technology" systems. Millimeter radio wave full-body scanners scan travelers by bombarding them with radio waves (the energy projected is tens of thousands of times lower than the radio waves generated by cell phones) and collecting the reflected waves via antennae to generate images [1]. This technology does not use x-rays.

Backscatter full-body scanners use low-intensity x-rays to scan travelers. In backscatter x-ray systems, unlike transmission x-ray systems (as in medical radiography), the bounced off x-rays or backscattered x-rays are captured by detectors to create images (Figure 1). Backscatter systems use narrow x-ray beams to scan subjects at high speed in a raster pattern. The dwell time of relatively small diameter x-ray beam is extremely short. Large detectors on the same side as the x-ray source (Figure 1) capture the backscattered x-rays from subjects and create images in a few seconds. X-rays are relatively low energy, can penetrate through the clothing, and a few may even transmit through the body. However, the majority bounce off of the skin surface and are therefore useful for imaging objects hidden under clothing[2]. These systems are useful for detecting objects hidden under clothing and taped to the skin. However, they are not useful for detecting objects hidden deep inside the body. For that task, transmission x-ray systems are used [2]. The entire process takes 8 to 15 seconds, and a typical backscatter scan includes two images, front and back [2]. Full-body scanners are currently used as secondary screening devices in airports across the United States and in other countries, and travelers have the choice to opt out, although with increased emphasis on airport security, mandatory screening of travelers using full-body scanners will become routine in the near future.

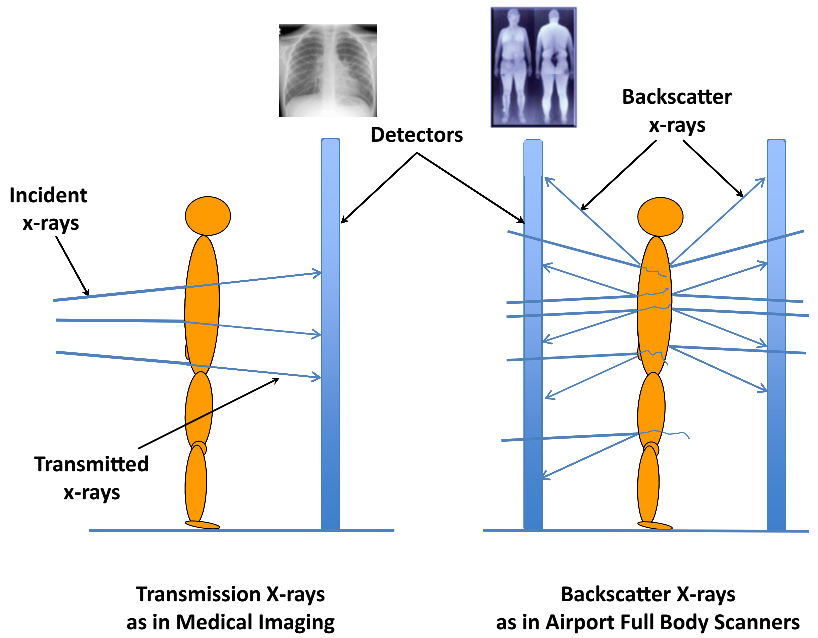

Fig 1. Basic principles of transmission x-ray systems (medical x-rays) and backscatter x-ray systems (airport full-body scanners).

The principal aims of this article are to discuss the radiation exposure from backscatter x-ray full-body scanners and to provide a comparison with regard to medical x-rays and other standard dose limits.

The radiation exposure for an individual undergoing a security scan using a backscatter system is quite low. The backscatter systems in general use are recommended to yield effective doses <0.10 μSv (10 μSv = 1 mrem) [2]. In fact, the effective dose measurements reported on the basis of the standard methodology [3] for different backscatter systems are as low as 0.05 μSv [2].

For comparison purposes, the radiation doses from backscatter x-ray systems are considered to be on the order of 0.05 to 0.10 μSv per scan. A traveler must undergo nearly 1000 to 2000 backscatter scans before receiving a dose equivalent to that of a medical chest x-ray (100 μSv) [4].

The radiation dose from a backscatter scan is equivalent to the dose one receives from approximately <30 minutes of background radiation [5,6]. Air travelers are also exposed to radiation from atmo-

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Table 1. Radiation doses from backscatter systems and number of backscatter scans equivalent to doses from various sources of radiation

Radiation Dose From Backscatter Systems (μSv/scan)*	Number of Scans Equivalent to Doses From Other Sources				
	Chest X-Ray†	Annual Dose Limit for Public‡	1 Day of Natural Background Radiation (~10 μSv/d)§	Negligible Individual Dose‖	Average Dose From Air Travel¶
0.1	1000	2500	100	100	40
0.05	2000	5000	200	200	80

Note: A dose of 0.1 μSv from backscatter scan is equivalent to about 10 minutes of background radiation and about 2 minutes of radiation received from average air travel. A dose of 0.05 μSv from backscatter scan is equivalent to about 20 minutes of background radiation and about 4 minutes of radiation received from average air travel.
*10 μSv = 1 mrem.
†Typical chest x-ray dose is about 100 μSv [4].
‡Annual permissible dose to the general public from a single source is about 250 μSv [9].
§Annual natural background radiation dose is about 3100 μSv [5] or about 2400 μSv [6].
‖Negligible individual dose is about 10 μSv [8].
¶Average radiation exposure during air travel is about 4 μSv/h [7].

spheric and other sources, and these dose levels vary with respect to flight altitude, flight path, and many other factors. The radiation doses from backscatter systems are approximately equivalent to 2 to 10 minutes of average flight [7].

The National Council on Radiation Protection and Measurements, an advisory body to the federal government that routinely publishes reports on various topics related to radiation measurements and radiation protection, uses the concept of "negligible individual dose" (NID), which is "an effective dose corresponding to the level of average annual excess risk of fatal health effects attributable to radiation exposure below which effort to further reduce the exposure to an individual is not warranted." The NID is set at an annual effective dose of 10 μSv (1 mrem) per source or practice [8]. With comparison with the NID, in individual would have to undergo 100 to 200 backscatter scans, yielding 0.10 to 0.05 μSv of dose per scan.

The Nuclear Regulatory Commission (and other regulatory agencies) recognizes an annual limit on doses to the public of 1000 μSv (100 mrem) from all sources and practices combined and has recognized an annual limit on doses to the public of 250 μSv (25 mrem) from any single source or practice [9]. At a dose of 0.05 to 0.10 μSv from backscatter scans, the limit of 250 μSv (25 mrem) per year is realized if an individual undergoes 2500 to 5000 scans per year (10 to 20 scans per day, 5 days per week, 50 weeks per year), which is highly improbable for any single traveler. Table 1 lists dose levels of backscatter systems and the number of backscatter scans needed to yield doses equivalent to chest x-rays [4], to the annual dose limit to the general public [9], to typical background radiation exposure [6], to the NID [8], and to typical air travel exposure [7].

With regard to radiation dose, another concern is the long-term stability of these scanners to deliver low dose but yield images of sufficient quality. This is a key concern especially in countries where the infrastructure for periodic checks is poor at best, or even nonexistent. As performed on any medical x-ray imaging system, it is key to establish routine maintenance and quality assurance programs and involve trained individuals such as health physicists or medical physicists to verify the radiation dose delivered by backscatter systems [10,11].

Apart from radiation dose, the other important issue with full-body scanners is privacy because the images created by full-body scanners reveal anatomic details of the individuals scanned. This has led to the use of terms such as *virtual strip search* and *personal intrusion search*. The privacy issues are to a large extent handled by setting up the image viewing stations at remote locations rather than adjacent to the scanners [12] and also assuring travelers that the systems do not have the mechanism to save the images once they are reviewed and deemed to have met the criteria for safety. In addition, many software programs have been developed to modify backscatter images (modesty filtering) to render the images less intrusive and more like "chalk outline" images, with fewer personal details.

Overall, the backscatter systems complying with American National Standards Institute [3] standards deliver low radiation dose per scan. One would have to undergo 1000 to 2000 scans before reaching a dose equivalent to that of medical chest x-rays. Current calculations indicate that the backscatter systems are safe for general use, even in infants and children, pregnant woman, and people with genetically based hypersensitivity to radiation. When considered in the context of a potential increase in security, the benefits outweigh the potential for harm [13].

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