REVIEW ARTICLE

Richard P. Cambria, MD, Section Editor

Radiation exposure in endovascular repair of abdominal and thoracic aortic aneurysms

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Background: **Endovascular aortic repair has become increasingly popular the last years for the treatment of abdominal aortic aneurysms (EVAR) and thoracic aortic aneurysms. EVAR is less invasive compared with the classic open approach, related to a decreased immediate postoperative morbidity and mortality. Those beneficial characteristics of EVAR do not come without a cost, since EVAR requires that the patient will be exposed to a significant amount of radiation during preoperative planning, graft placement, and consecutive follow-up. This systematic review examines the periprocedural radiation exposure to patients and staff as well as ways to ameliorate it.**

Methods: **A systematic literature search was conducted using the MEDLINE electronic database. All articles reporting radiation exposure to alive humans during EVAR were eligible for review. Only studies publishing numerical data regarding radiation exposure were included in the Results section. Other relevant articles were used for further discussion.**

Results: **Twenty-four studies, both prospective and retrospective in nature, were included. These studies revealed that the radiation exposure depends on the specific type of procedure, with more complex procedures carrying greater radiation burden. Variations in the positioning and operating of the fluoroscopic unit may significantly alter radiation dose to both patients and staff. There was an apparent lack of education among vascular specialists and trainees in terms of radiation safety awareness. At follow-up, a significant number of patients needed additional procedures, and all required radiographic imaging, further increasing the radiation exposure to alarming levels.**

Conclusions: **Every effort should be made to decrease radiation exposure related to endovascular aortic procedures. Attempts must be directed towards maximizing the operator's awareness, welcoming new imaging technology emitting less radiation, and shifting to follow-up strategies that require minimal or no radiation. (J Vasc Surg 2015;62:753-61.)**

Throughout the last two decades, utilization of endovascular procedures has become progressively more popular. Endovascular aortic repair (EVAR) represents one of the most common endovascular procedures today. The most apparent benefit to EVAR vs open repair is seen in the immediate postoperative period. Patients have less blood loss, shorter hospital stays, and ultimately a threefold decrease in 30-day postoperative mortality.[1] However, EVAR exposes patients and staff to significant doses of ionizing radiation.[2-7] Medical imaging studies now represent the greatest man-made source of ionizing radiation to the general population, and patients undergoing EVAR are a prime example.[1] Virtually all patients undergoing EVAR have a preoperative computed tomography (CT) scan, intraoperative fluoroscopic imaging, and lifelong surveillance imaging.[1,8-10]

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Author conflict of interest: none.

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The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214

http://dx.doi.org/10.1016/j.jvs.2015.05.033

Variation in technique, screening, operator's experience, and surveillance protocol, along with the equipment used for patients undergoing EVAR, may affect the dose of radiation exposure to the patient and staff involved. The goal of this study was to review the current understanding of radiation exposure during EVAR and the most commonly used techniques to reduce the burden of radiation on all of those involved.

METHODS

Studies including endovascular procedures of the thoracic and abdominal aorta that have measured radiation exposure were included. EVAR was used as a collective term in this manuscript for both thoracic (TEVAR) and abdominal endovascular aortic repair. This study was performed according to the Preferred Reporting Items for Systematic review and Meta-Analysis (PRISMA) guidelines.[11]

Search strategy. A systematic electronic literature search was conducted using the MEDLINE database from 1991 (first report on EVAR) through September 2014. The search was based on the term "radiation exposure" in combination with the terms "aneurysm," "endovascular," "EVAR," "TEVAR," and "aortic." The search identified 975 articles. Also, individual articles were identified by searching reference lists of already selected articles. Systematic search flow chart is depicted in Fig 1.

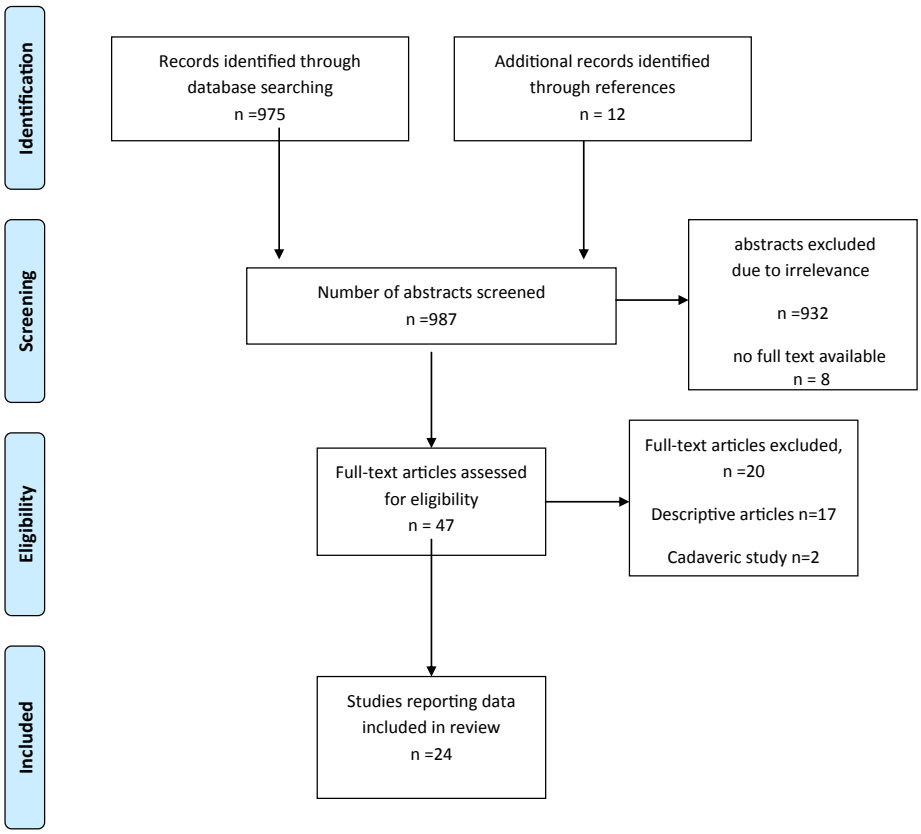

Fig 1. Systematic search flow chart based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[11]

Article selection. All articles reporting radiation exposure in alive humans during EVAR interventions were eligible for review. Both prospective and retrospective studies were included. Only articles published in the English language were screened. Case reports and duplicated data were excluded. Titles and abstracts were reviewed independently by two investigators to confirm relevance. Relevant descriptive articles, cadaveric studies, and surveys were also reviewed and used as reference for further discussion.

Data extraction and analysis. In the case where a study was reporting radiation exposure in both humans and phantoms, only the former were taken into account. In addition, multiple articles were reporting radiation exposure secondary to variable interventions necessitating fluoroscopy, aortic or not; of those, only data regarding the procedures of interest were extrapolated. Each article was reviewed in full text and the under-investigation data were extracted. That included the author, year of the study, type of study, number of patients, screening time (referring to fluoroscopy time during the procedure), and radiation dose to which patients were exposed. In addition, we report the radiation exposure of staff present during the procedure and preventative measures used against radiation when those were mentioned in the article. There was a significant discrepancy regarding the international units used to report the radiation exposure by several authors. That being a worth-mentioning limitation; quantitative analysis and interpretation of the data was not attempted.

RESULTS

The search revealed 975 articles. All case reports and irrelevant articles were excluded. A total of 45 articles were reviewed in full text and further evaluated; of those, 24 studies were finally included.

Type and size of study. The results table (Table I) is composed of 14 retrospective and 10 prospective studies. As mentioned previously, the radiation exposure published by several authors refers to a heterogeneous group of procedures, including a full gamut from simple infrarenal bifurcated graft placement to more complex fenestrated endograft placement with or without branch vessels coverage. Most of the studies are small in size, but the number of patients escalates throughout the first decade of the 21st century as EVAR is becoming increasingly more popular and long-term follow up becomes available. The mean number of patients included in those studies was 128 (range, 12-915 patients).

Radiation exposure to patients. There are two basic units for measuring radiation, the Gray (Gy) and the