

# Radiation dose reduction: comparative assessment of publication volume between interventional and diagnostic radiology

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## PURPOSE

We aimed to quantify and compare awareness regarding radiation dose reduction within the interventional radiology and diagnostic radiology communities.

## METHODS

Abstracts accepted to the annual meetings of the Society of Interventional Radiology (SIR), the Cardiovascular and Interventional Radiological Society of Europe (CIRSE), the Radiological Society of North America (RSNA), and the European Congress of Radiology (ECR) between 2005 and 2015 were analyzed using the search terms “interventional/computed tomography” and “radiation dose/radiation dose reduction.” A PubMed query using the above-mentioned search terms for the years of 2005–2015 was performed.

## RESULTS

Between 2005 and 2015, a total of 14 520 abstracts (mean,  $660 \pm 297$  abstracts) and 80 614 abstracts (mean,  $3664 \pm 1025$  abstracts) were presented at interventional and diagnostic radiology meetings, respectively. Significantly fewer abstracts related to radiation dose were presented at the interventional radiology meetings compared with the diagnostic radiology meetings (162 abstracts [1% of total] vs. 2706 [3% of total];  $P < 0.001$ ). On average  $15 \pm 7$  interventional radiology abstracts (range, 6–27) and  $246 \pm 105$  diagnostic radiology abstracts (range, 112–389) pertaining to radiation dose were presented at each meeting. The PubMed query revealed an average of  $124 \pm 39$  publications (range, 79–187) and  $1205 \pm 307$  publications (range, 829–1672) related to interventional and diagnostic radiology dose reduction per year, respectively ( $P < 0.001$ ).

## CONCLUSION

The observed increase in the number of abstracts regarding radiation dose reduction in the interventional radiology community over the past 10 years has not mirrored the increased volume seen within diagnostic radiology, suggesting that increased education and discussion about this topic may be warranted.

Over the past decade there has been an increase in scrutiny pertaining to radiation dose associated with medical procedures from both professional societies and the lay press. In 2006, a total of 4 million interventional procedures performed in the United States accounted for approximately 14% of the collective radiation dose from radiological procedures (1). In the same year, an estimated 67 million CT scans performed in the United States accounted for approximately 49% of the collective radiation dose from radiological procedures (1). Together, interventional radiology procedures and CT scans accounted for approximately 71 million examinations. In contrast, approximately 293 million diagnostic radiographic and fluoroscopic studies were performed in the United States in 2006 (1), but only accounted for approximately 11% of collective dose. Due to the disproportionate amount of ionizing radiation contributed by both interventional procedures and computed tomography examinations, dose reduction in these two modalities has become a particular focus of attention for professional societies and providers alike (2, 3).

Technical advances coupled with the increased interest in reducing radiation dose from medical procedures have resulted in a steady increase in the number of contributions to the radiological literature pertaining to radiation dose reduction over the past decade. Scientific contributions and educational sessions focusing exclusively on dose reduction have become fixtures at national and international radiology meetings. The aim of the current study is to quantify this increased interest and awareness by performing a systematic analysis of

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Received 15 April 2016; revision requested 19 May 2016; last revision received 20 August 2016; accepted 14 September 2016.

Published online 13 March 2017.  
DOI 10.5152/dir.2016.16196

scientific and educational contributions to the annual meeting of the Society of Interventional Radiology (SIR), the Cardiovascular and Interventional Radiological Society of Europe (CIRSE), the European Society of Radiology (ECR), and the Radiological Society of North America (RSNA) between 2005 and 2015. In addition, an analysis of scientific journal publications pertaining to dose reduction in the medical literature during that time period was performed.

## Methods

### Abstract evaluation

To evaluate the contributions to the annual meeting of the SIR, CIRSE, ECR, and the RSNA, annual meeting programs from 2005–2015 were analyzed. Abstracts pertaining to radiation dose were grouped for the interventional radiology meetings (SIR and CIRSE) and the diagnostic radiology meetings (RSNA and ECR). Abstracts with a primary topic pertaining to radiation dose or radiation dose reduction were included. Abstracts were excluded if the content of the scientific contribution was not evident (e.g., abstract withdrawn, missing text). The present study assumed that abstracts submitted to the SIR, CIRSE, ECR, and RSNA annual meeting accurately reflect the current state of knowledge of radiology, that the published abstracts contain the pertinent findings and conclusion, and that any subject not mentioned in the abstract was in fact not the primary focus of the investigation.

### Literature evaluation

To evaluate the contributions to the radiological literature regarding radiation dose secondary to interventional procedures and

diagnostic CT, a search was performed using the terms “interventional” AND “radiation dose” OR “radiation dose reduction”; as well as “computed tomography” AND “radiation dose” OR “radiation dose reduction” utilizing PubMed to search the records of the US National Library of Medicine. The number of abstracts from 2005–2015 at the time of the literature search (06/2016) were recorded. Due to the disproportionate amount of ionizing radiation contributed by computed tomography (CT) examinations, CT was used as a surrogate for diagnostic radiology radiation dose. PET-CT was not included as a search term due to its primary association with nuclear medicine.

### Percent change

To account for the unequal distribution in the amount of abstracts and publications between diagnostic and interventional radiology, a yearly percentage change was calculated to allow for comparison. The amount of abstracts and publications of the baseline year was subtracted from the amount of abstracts in each following year and the results divided by the baseline year (i.e., (2006–2005) / 2005) and compared.

### Statistical analysis

All values are reported as mean ± standard deviation, with a *P* value of less than 0.05 considered statistically significant. Normal distributions for the abstract contributions were determined using the Shapiro-Wilk Test. Differences in the numbers of abstract contributions were assessed using a chi-square test, while the number of publications derived from the PubMed query were assessed using a paired *t* test. Statistical analysis was performed using Excel for Mac (14.1.2; Microsoft).

## Results

A total of 14 520 scientific contributions were presented at the annual meeting of the SIR and CIRSE between 2005 and 2015, while a total of 80 614 scientific contributions were presented at the RSNA and ECR during the same time period. All abstracts were eligible for inclusion. The average number of scientific contributions to the interventional radiology meetings (SIR and CIRSE) and the diagnostic radiology meetings (RSNA and ECR) were 660±297 and 3664±1025, respectively. Of these contributions, an average of 15±7 abstracts (range, 6–27) pertaining to radiation dose associated with interventional procedures were presented at each interventional radiology meeting, while an average of 246±105 abstracts (range, 112–389) pertaining to CT radiation dose were presented at each diagnostic radiology meeting. A total of 162 abstracts related to radiation dose associated with interventional radiology were presented at the interventional radiology meetings between 2005 and 2015, accounting for 1% of contributions, while the 2706 abstracts pertaining to CT dose reduction presented at the diagnostic radiology meetings between 2005 and 2015 accounted for 3% of contributions (*P* < 0.001; Fig. 1).

The PubMed search for published manuscripts related to CT in general yielded a total of 177 798 abstracts between 2005 and 2015, of which the search for CT dose reduction abstracts accounted for approximately 8% with a total number of 14 792 abstracts between 2005 and 2015. The search for interventional radiology manuscripts in general yielded a total of 16 644 between 2005 and 2015, of which

### Main points

- The overall amount of abstracts related to radiation dose presented at interventional and diagnostic radiology meetings and published in the literature have steadily increased over the past ten years, demonstrating increased attention to radiation safety by the interventional and diagnostic radiology community.
- The observed increase in the number of abstracts regarding radiation dose reduction in the interventional radiology community over the past 10 years has not mirrored the increased volume seen within diagnostic radiology, suggesting that increased education and discussion about this topic may be warranted.

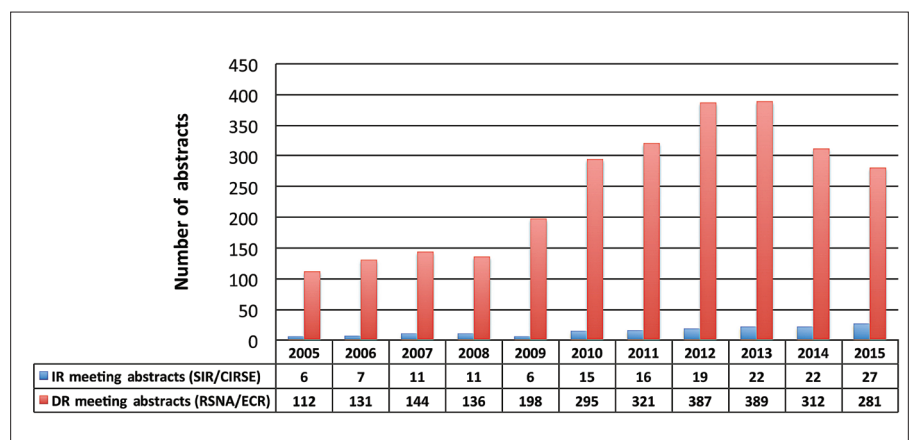
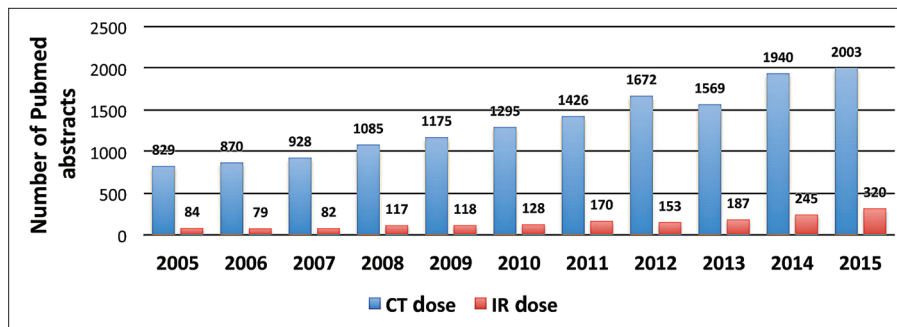
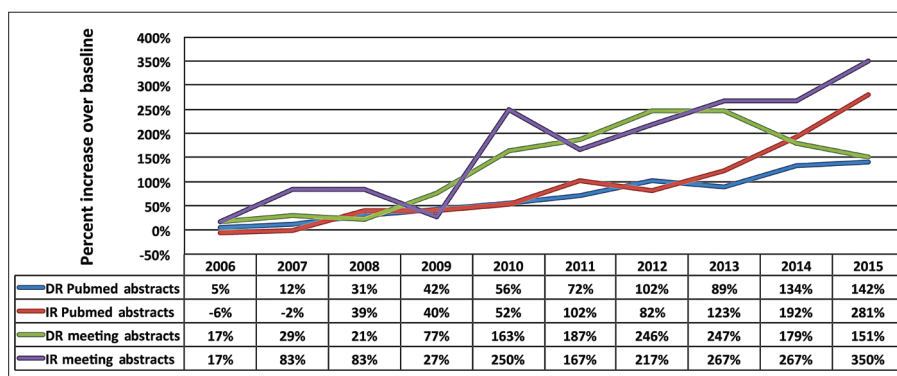


Figure 1. Number of abstracts pertaining to radiation dose reduction submitted to the annual meeting of the SIR/CIRSE (IR meeting abstracts) and the RSNA/ECR (DR meeting abstracts) between 2005 and 2015.



**Figure 2.** Number of abstracts published in the radiology literature pertaining to radiation dose reduction associated with diagnostic computed tomography (CT dose) and interventional procedures (IR dose) between 2005 and 2015 as retrieved from a PubMed query.



**Figure 3.** Yearly percent change in diagnostic radiology (DR) and interventional radiology (IR) abstract publications in the literature and submissions to the annual meeting of the SIR/CIRSE (IR) and the RSNA/ECR (DR) compared with 2005 baseline.

the search for interventional radiology dose reduction abstracts accounted for approximately 10% with a total number of 1683 abstracts. The PubMed query revealed an average of  $124 \pm 39$  (range, 79–187) and  $1205 \pm 307$  (range, 829–1672) publications related to interventional and diagnostic radiology dose reduction per year, respectively ( $P < 0.001$ ). Fig. 2 illustrates the yearly number of manuscripts in the radiological literature pertaining to radiation dose associated with interventional procedures and diagnostic CT between 2005 and 2015.

Fig. 3 illustrates the percent change in diagnostic radiology meeting (RSNA and ECR) and interventional radiology (SIR and CIRSE) abstract submission and published literature regarding radiation dose compared with the 2005 baseline. Diagnostic radiology meeting abstract contributions increased steadily each year and peaked in 2013 with an increase of 247% over the 2005 baseline. Interventional radiology abstract presentations peaked with an increase of 350% over the 2005 baseline in 2015.

Literature publications increased steadily, with an increase of approximately 281% and

142% noted by 2015 for interventional publications and diagnostic radiology publications related to radiation dose, respectively.

## Discussion

Our results demonstrate increased attention to radiation safety, evidenced by the steady increase in the number of abstracts related to radiation dose presented at interventional and diagnostic radiology meetings and published in the literature. While 112 abstracts related to CT dose reduction were presented at the RSNA and ECR in 2005, contributions peaked in 2013 with a total of 389 presented abstracts. However, interventional radiology attentiveness to the topic has not mirrored the increase seen in diagnostic radiology, as evidenced by the number of abstract presentations at the annual SIR and CIRSE meeting. The annual meetings of the SIR and CIRSE included six abstracts pertaining to radiation dose at the 2005 meeting, with the highest number of abstracts recorded in 2015 with a total of 27 presentations. While the number of contributions related to CT and interventional radiology dose reduction at the respective

meetings increased steadily each year, the overall relative amount of interventional abstracts related to dose reduction was significantly less compared with the relative overall amount of CT dose reduction abstracts.

The increase in the number of abstracts pertaining to radiation dose and dose reduction seen at the diagnostic and interventional radiology meetings is also mirrored in the radiological literature. The total number of publications focusing on CT dose reduction doubled between 2005 (829 abstracts listed in PubMed) and 2012 (1672 abstracts listed in PubMed), while the number of publications related to radiation dose in interventional procedures doubled between 2005 (84 abstracts listed in PubMed) and 2011 (170 abstracts listed in PubMed) as shown in Fig. 2. However, the discussion regarding the risks associated with CT and ionizing radiation were primarily debated in the radiological community. A 2007 article by Brenner et al. (4) in the *New England Journal of Medicine* about the risk of cancer induction associated with the use of CT propelled the topic from the radiological community to the broader medical community, with a subsequent increase in publications discussing the topic in non-radiological journals (5, 6). While there is an ongoing debate in the medical community about the accuracy of the risk models utilized to estimate cancer risks, the radiological community agreed that efforts to reduce the radiation dose of children and adults undergoing diagnostic and interventional imaging procedures had to be increased. As a result of this, the Alliance for Radiation Safety in Pediatric Imaging introduced the Image Gently campaign in 2008 (7). The campaign's web site provides patients and parents as well as healthcare providers with information on ways to decrease the exposure of children to ionizing radiation when undergoing diagnostic imaging. A joint effort by the Alliance for Radiation Safety and the SIR resulted in the "Step Lightly" campaign, which was introduced in 2009 (8). The Step Lightly campaign evolved from the Image Gently campaign with a focus on adhering to As Low As Reasonably Achievable (ALARA) principles in pediatric interventional procedures by providing easily applicable dose reduction steps to be taken in the interventional suite. While Image Gently and Step Lightly focused on reducing radiation exposure in the pediatric patients, in 2010 the American College

of Radiology and the RSNA launched the Image Wisely campaign (9). Similar to the aforementioned efforts, the Image Wisely campaign provides educational material to patients as well as to the general public in an effort to encourage radiologists to take personal responsibility to keep patients safe from inappropriate or excessive exposure to radiation dose.

While the aforementioned campaign efforts are primarily targeted at decreasing patient exposure, operator and medical staff exposure is a concern with interventional procedures (10, 11). Given the increasing complexity of interventional procedures and the subsequent increase in fluoroscopy time, operator safety is paramount. This has long been recognized by the SIR, which first incorporated educational workshops on radiation safety and exposure as part of their annual scientific meeting in 1992. Other prominent efforts by the SIR included the Radiation Safety Position statement released in 2003 (2), publication of studies related to skin dose in fluoroscopy guided procedures (12), as well as guidelines for patient radiation dose management (13).

Despite the ever-increasing number of scientific and educational contributions to the radiological and medical literature regarding radiation dose reduction (3, 14, 15), knowledge about radiation safety among medical residents is still limited regardless of specialty. In a study performed by Sadigh et al. (16), residents from 15 residency programs at a major academic teaching hospital in the US were questioned about their knowledge regarding radiation dose safety using a survey. While 47% of radiology residents were aware of the potential risk of developing a cataract in interventional personnel, only 27% of nonradiology residents were aware of this risk. Similarly, the greater radiosensitivity of children compared with adults as well as the relative radiation dose of an abdominal CT compared with a chest X-ray were only answered correctly by approximately 50% of the participating residents. These results underscore the importance of continued efforts aimed at educating both healthcare providers regardless of specialty as well as the general public regarding radiation dose and measures of radiation dose reduction. These limitations in awareness also apply outside of the radiology department and were addressed by the International Commission on Radiological Protection (ICRP) in the ICRP Publication 117 "Radiological protection in fluoroscopically guided pro-

cedures performed outside the imaging department" (17). The ICRP notes that an increasing number of medical specialties utilize fluoroscopy outside the imaging department, and notes a general neglect of radiation protection coverage of fluoroscopy machines in this regard. Procedures such as endovascular interventions, ureteric stent placement, therapeutic endoscopic retrograde cholangiopancreatography and bile duct stenting and drainage have the potential to impart skin doses exceeding 1 Gy. The ICRP therefore stresses patient dose monitoring whenever fluoroscopy is used, as well as targeted training programs in radiological protection for healthcare staff outside the radiology department. While the full range of recommendations is outside the scope of this article, the interested reader is referred to ICRP Publication 117 for further information.

Several limitations warrant further discussion. Radiation dose and dose reduction techniques for fluoroscopy and CT were utilized as a determinant of awareness. While these modalities have a large contribution to radiation dose, other sources including nuclear medicine studies as well as diagnostic radiography studies are also important contributors to overall radiation dose. One should refrain from generalizing awareness based on the number of articles published about fluoroscopy and CT radiation dose. Another limitation is the acceptance of published articles relating to radiation dose as representative of diagnostic radiology. Nuclear medicine studies and diagnostic radiographic studies contribute 26% and 11% to the collective procedure dose in the United States in 2006 (4), for a combined per capita dose of 1.1 mSv. In contrast, CT accounts for a per capita dose of 1.47 mSv and 49% of the collective procedure dose.

The inclusion of only four major society meetings is a limitation to this study. High-quality abstracts related to radiation dose may also be presented at numerous subspecialty society meetings. In addition, publications may not accurately reflect local practice patterns with regards to current efforts aimed at reducing radiation exposure.

In conclusion, the observed increase in the number of abstracts regarding radiation dose reduction in the interventional radiology community over the past 10 years has not mirrored the increased volume seen within diagnostic radiology, suggesting that increased education and discussion about this topic may be warranted.

## Conflict of interest disclosure

The authors declared no conflicts of interest.

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