Surgeon's and Patient's Radiation Exposure Through Vertebral Body Cement Augmentation Procedures: A Prospective Multicentric Study of 49 Cases

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■ OBJECTIVE: **Vertebral body cement augmentation as a treatment option for osteoporotic or traumatic fractures has become increasingly popular during the past decade. However, these surgical procedures require numerous fluoroscopic examinations, resulting in high radiation exposure for the patient and the surgical team. The aim of this study was to evaluate the level of radiation exposure of the spine surgeon and the patient during these percutaneous procedures.**

■ METHODS: **Forty-nine patients admitted for single- or 2-level vertebral compression fracture were prospectively included and treated with vertebral body cement augmentation. For each procedure, radiation dose was measured on the surgeon's whole body, lens, and extremities as well as patient irradiation. Each surgeon wore 2 thermoluminescent dosimeters to measure lens and extremities radiation exposure and 1 electronic personal dosimeter. Patient clinical and surgical data, effective dose to patient, and surgeon were analyzed.**

■ RESULTS: **Mean operative time was 31.5 ± 11.7 minutes. The average fluoroscopic time was 61.0 ± 27.1 seconds. The average whole-body radiation dose per procedure was 1.4 ± 2.1 μSv. The average equivalent dose to lens and extremities were 44 μSv and 59 μSv, respectively.**

■ CONCLUSIONS: **Values of radiation doses for surgeon and patient were lower than those reported in the previous literature. The recommended annual dose limit is set to 500 mSv for extremities and 150 mSv for lens. According to our results, the exposure dose to the eye exceeds the annual limit after 3500 procedures. However, there is increasing concern among surgeons about radiation exposure, and there is still a need for solutions as preventive measures.**

INTRODUCTION

Minimally invasive procedures in spinal surgery have become increasingly popular during the past decade. Among them, the vertebral body cement augmentation (VBCA) procedure for compression fractures requires numerous intraoperative fluoroscopic examinations, resulting in high levels of radiation exposure.

With the progressive aging of the population, the challenge for treating vertebral compression fractures will become more and more prevalent. As a result, the number of cement augmentation procedures performed is continuously increasing; this minimally invasive percutaneous procedure is an accepted option in the first line or after failure of conservative treatment to reduce pain. Such treatment improves functional outcomes, reduces fracture incidence, and avoids posttraumatic kyphosis according to some studies.[1,2] These treatments require permanent control during surgery by fluoroscopy shots to avoid cement leakage. In parallel, concern about possible excessive x-ray exposure of the

Key words
- Fluoroscopy
- Fracture
- Radiation exposure
- Spine surgeon
- Vertebral body augmentation

Abbreviations and Acronyms
VBCA: Vertebral body cement augmentation
ICRP: International Commission on Radiological Protection
TLD: Thermoluminescent dosimeter
EPD: Electronic personal dosimeter
DAP: Dose-area-product

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operator and the patient is being raised as shown by the increased number of studies about radiation exposure and associated risks.[3,4]

Recent studies showing how to reduce x-ray exposure during spinal procedures have been reported.[5-8] However, only a few data concerning fluoroscopy time during surgery or radiation exposure to both the patient and the surgeon are available.[9-11]

Depending on the patient, the experience of the performing surgeon, and the level of the fractured vertebra, the average patient-effective radiation dose during a balloon kyphoplasty procedure can be more than 12 mSv.[4] Thus, this level of exposure is comparable with the effective dose delivered during a full computed tomography body scan.[12,13] The International Commission on Radiological Protection (ICRP) has established the standards for radiation protection, including dose limits. The maximum annual permissible effective dose is 20 mSv for the body; the maximum equivalent dose to the thyroid and lens is 150 mSv and 500 mSv to the extremities (International guidelines, ICRP). However, the dose limit for nonclassified staff (eg, orthopedic surgeons) is only 30% of these limits (ie, 150 mSv for the hands). The hands, eyes, and thyroid are often unprotected, and these organs show increased sensitivity to radiation exposure. It is particularly the case for the lens: recent studies reported that cataracts might occur at doses lower than previously recognized. As a result, the ICRP recommend reducing the previous dose limit from 150 mSv to 20 mSv.[13] In addition to the use of lead garments, previous studies have shown that the distance from the radiation source is also a critical factor in reducing surgeons' radiation exposure.

In France, practices regarding x-ray exposure are heterogeneous and there is no accurate evaluation of radiation exposure to surgeons and patients. This prospective multicentric study aimed to determine the amount of radiation exposure to the spine surgeon and the patient that occurs during VBCA.

METHODS

Study Design

Forty-nine successive patients were prospectively included in this study, from November 2014 to April 2015, in 3 different spine centers. In these 3 centers, surgeons' experience exceeded 10 years. The number of VBCA procedures performed annually in centers 1, 2, and 3 is an average of 50, 65, and 35, respectively. Inclusion criteria were patients with single- or 2-level osteoporotic or traumatic vertebral fractures treated through a VBCA under fluoroscopic monitoring. For every patient, the surgical procedure was performed via a bilateral pedicular or extrapedicular (for the highest thoracic levels) approach using traditional surgical instruments: introducers, inflatable bone tamps or expandable devices, polymethylmethacrylate bone cement, and delivery devices. In each center, all the procedures were realized by 1 fluoroscopic technique.

Radiation Protocol

Two different dosimeters were used (Figure 1). The first, the thermoluminescent dosimeter (TLD), is a passive dosimeter used to measure exposure from ionizing radiation. When heated, it releases a light intensity proportional to the amount of radiation previously received. TLDs are usually placed under filters simulating different tissue equivalent depths to differentiate doses received at the surface (skin dose) and under a certain depth. Thus, the equivalent lens dose is given at a tissue depth of 3 mm (referred to as Hp(3)); the extremities surface dose is given at a tissue equivalent depth of 0.07 mm (Hp(0.07)). The other dosimeter used in that study is the electronic personal or operational dosimeter (EPD); this is a direct reading dosimeters based on electron-hole pairs creation in a solid state detector. It measures a personal dose equivalent at a 10-mm equivalent depth (Hp(10)); this value is considered as a conservative estimate of the effective dose E. Effective dose is the weighted sum of equivalent

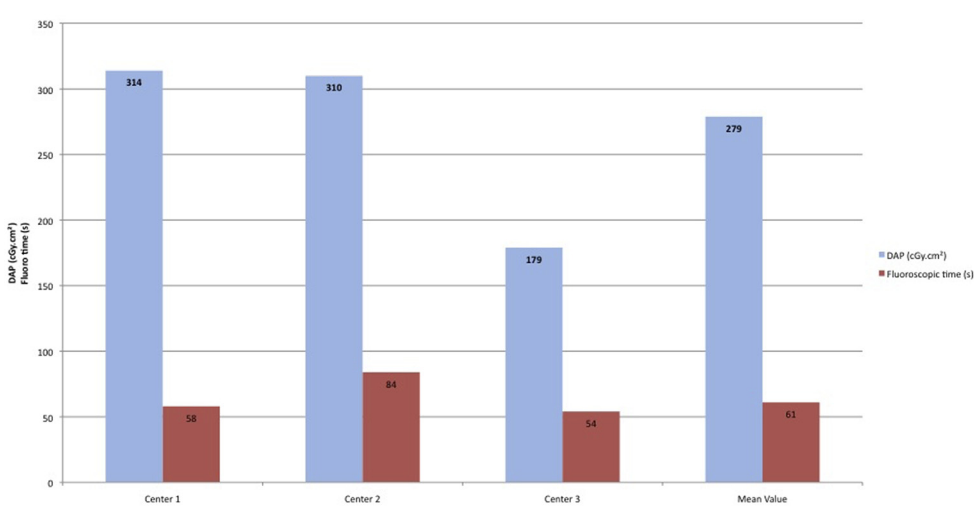

Figure 1. Comparison of dose-area-product (DAP) and fluoroscopic time to each patient for the 3 centers.