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The effect of body mass index on fluoroscopy time and radiation dose in intra-articular glenohumeral joint injections

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ABSTRACT

Purpose: To determine the relationship between body mass index (BMI) and fluoroscopy time and radiation dose during fluoroscopy-guided glenohumeral joint injections.
Methods: This was a retrospective analysis of prospectively collected data. Physicians with board certification in Physical Medicine and Rehabilitation and/or Sports Medicine performed or supervised all injections. BMI was calculated within three months of the injection. Fluoroscopy time and radiation dose data were recorded by the fluoroscopy system and transcribed into the clinical database after each procedure.
Results: A total of 335 intra-articular GHJ injections were performed, 230 on the right shoulder and 105 on the left shoulder; none were bilateral. The mean fluoroscopy time for all injections was 18.8 ± 12.6 s, and the mean radiation DAP was 656 ± 1190 mGy-cm2. There was no significant difference in fluoroscopy time or dose between first-time and repeat injections ($P = .405$; $P = .011$) and no significant differences in fluoroscopy time or radiation dose when a trainee was involved ($P = .756$ for time and $P = .149$ for dose). Needle lengths of 1.5, 2.5, or 3.5 in. were used during the injection, and there was no significant difference in needle length selection between BMI groups ($P = .319$).
Conclusions: Intra-articular glenohumeral joint injection fluoroscopy time and radiation dose are not affected by body mass index, age, gender, trainee-involvement, first versus repeat injection, or needle length. This procedure is associated with a dose of radiation that likely has minimal to no clinical significance.

1. Introduction

Intra-articular glenohumeral joint injections (GHJ) injections are commonly performed for the diagnosis and treatment of shoulder pain [1–3]. Historically, these injections were performed blindly, but recent evidence demonstrates that use of anatomic landmarks alone is associated with inferior accuracy to image-guided modalities [4–6]. Even physicians with years of experience can have limited success when attempting an intra-articular GHJ injection without imaging [6]. Although blind injections are typically well-tolerated, less expensive, less time-consuming, and do not involve radiation, the needle position is not known during the injection, and this represents a serious disadvantage [7]. Misplaced injections pose several risks, including soft tissue damage, skin depigmentation, tendon weakening, and misinterpretation of imaging from contrast leakage into the extra-articular space [1,2,8].

Fluoroscopic guidance with contrast confirmation is currently the gold standard method for performing an intra-articular GHJ injection, though an ultrasound-guided approach has become a common alternative given its comparable accuracy rates and elimination of radiation exposure to the patient and practitioner [4,9–12]. However, this modality is dependent on operator experience, which limits generalized use [13], and the clinical significance of the reduction in radiation exposure compared to fluoroscopic-guidance has yet to be investigated. Additionally, with regard to shoulder arthrography, needle placement under ultrasound guidance can be unsuccessful due to technical challenges associated with obesity [14].

During fluoroscopic-guided injections, the radiation to which patients are exposed can have potential associated health risks, most notably various types of cancer [15–17], and minimizing exposure is an integral part of reducing associated health risks [16,17]. The effective dose of radiation, which represents the probability of cancer induction and genetic effects of ionizing radiation delivered to the body, is measured in Sieverts (Sv) [18]. One Sv represents a 5% chance of developing cancer and approximates to 1 Gray (Gy) [16,18]. The dose-area product (DAP) takes into account the area of tissue under examination and is reported as Gy-cm^2 or mGy-cm^2.

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Although BMI has previously been shown to correlate with increased fluoroscopy dose in several other interventional procedures [19–22], it cannot be assumed this will be the case with every interventional procedure. It stands to reason that variations in local tissue type/depths and variations in procedural techniques could affect radiation dose differently. Thus, the purpose of this study was to determine the relationship between body mass index (BMI) and radiation time and dose during fluoroscopy-guided intra-articular GHJ injection. This study also investigated the effects of patient age, trainee involvement, needle length, and first-time or repeat injection on radiation dose and time.

2. Methods

This study was approved by the local Institutional Review Board. A retrospective review of consecutive fluoroscopic injections between 2006 and 2015 at an academic orthopedic clinic was performed. This data was obtained by querying the institution's prospectively-collected clinical database. All GHJ injections were evaluated. Patients with missing fluoroscopic time or BMI data were not included in the analysis. Collected data included: age, gender, height, weight, involvement of a trainee (defined as resident or fellow), laterality of injection, needle length, first time versus repeat injection, fluoroscopy time (in seconds) and fluoroscopic dose-area product (DAP, either in mGy-cm^2 or mrad-cm^2, which was converted to mGy-cm^2). Fluoroscopy time and radiation dose data were recorded by the fluoroscopy system and transcribed into the clinical database after each procedure. Seven attending physicians with board certification in Physical Medicine and Rehabilitation and/or Sports Medicine performed or personally supervised all injections. BMI was calculated using the recorded height and weight within three months of the injection. Using the Center for Disease Control and Prevention (http://www.cdc.gov/obesity/adult/defining.html) definitions, obese BMI was defined as greater than 30 kg/m^2, overweight was between 25 kg/m^2 inclusive and 30 kg/m^2, and normal BMI was less than 25 kg/m^2.

2.1. Injection procedure

The intra-articular GHJ injection procedure was completed in the following manner: With the patient in a supine position, the skin of the anterior shoulder was prepped in a sterile manner with povidone-iodine or chlorhexidine, followed by standard sterile draping. The superomedial quadrant of the humeral head was identified with the use of the fluoroscopic C-arm in an anterior-posterior view (see Fig. 1). Local anesthetic (1% lidocaine) was administered for skin and soft tissue anesthesia followed by insertion of a 22-gauge needle ranging from 1.5 to 3.5 in., depending on physician selection for each particular patient. Using fluoroscopic guidance, the needle was advanced to the anteromedial GHJ intra-articular space. Proper needle tip placement was confirmed by the injection of contrast through microbore tubing under live fluoroscopic observation (see Fig. 2). After confirmation of an appropriate intra-articular contrast pattern and lack of vascular flow, a combination of steroid and local anesthetic was injected. The injectate consisted of a corticosteroid (betamethasone, methylprednisolone, triamcinolone, or dexamethasone), mixed with a local anesthetic (lidocaine, ropivacaine, or bupivacaine). The injectate composition was selected at the discretion of the attending physician. The patient was asked to rate his or her shoulder pain on a visual analog score (VAS) between 0 and 10, both immediately prior to and immediately after the injection (within approximately 10 min).

2.2. Statistical analysis

Visual analysis of demographic variable frequency distributions was used to identify the possibility of erroneously entered data. Data were reported as means and standard deviations (SD) or number (n) and percentage. Analysis of variance testing was used to analyze relationships between numerical data, and chi-square testing was used for comparison of categorical data. The percentage improvement in VAS score was calculated as the difference between the patient's post-injection score and pre-injection score, divided by his or her pre-injection score, multiplied by 100. A Bonferroni correction was implemented due to multiple comparisons, defining statistical significance at $P < .01$. Data were analyzed with PSPP software, version 0.8.4 (Gnu Project, Boston, MA).

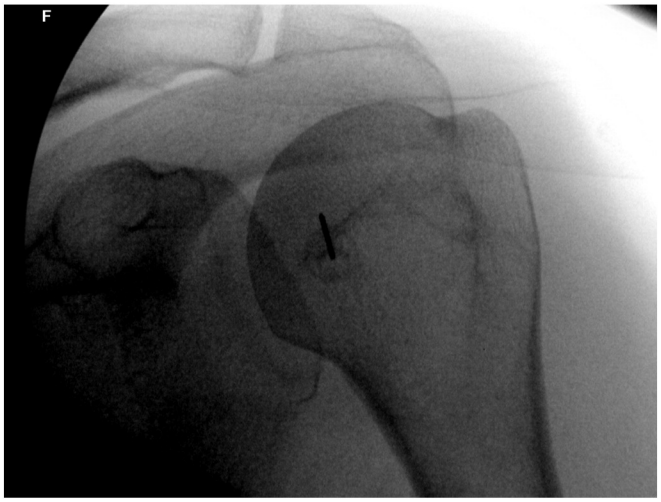

Fig. 1. Fluoroscopic image showing an anterior approach into the supero-medial quadrant of the glenohumeral joint space.

3. Results

A total of 335 intra-articular GHJ injections were performed, 230 on the right shoulder and 105 on the left shoulder; none were bilateral. The study sample was comprised of 163 (48.7%) male and 172 (51.3%) female patients, with a mean age of 58.2 ± 14.7 years. The distribution of patient BMI consisted of 73 normal, 77 overweight, and 68 obese patients, respectively. There were 283 (84.5%) first-time injections and 52 (15.5%) repeat injections. A trainee was involved in 245 (73.1%) of the injections performed and no complications occurred in any injection. The complete demographic and procedure information for the analyzed injection encounters is provided in Table 1.

The mean fluoroscopy time for all injections was 18.8 ± 12.6 s, and the mean radiation DAP was 656 ± 1190 mGy-cm^2. Fig. 3 and Fig. 4

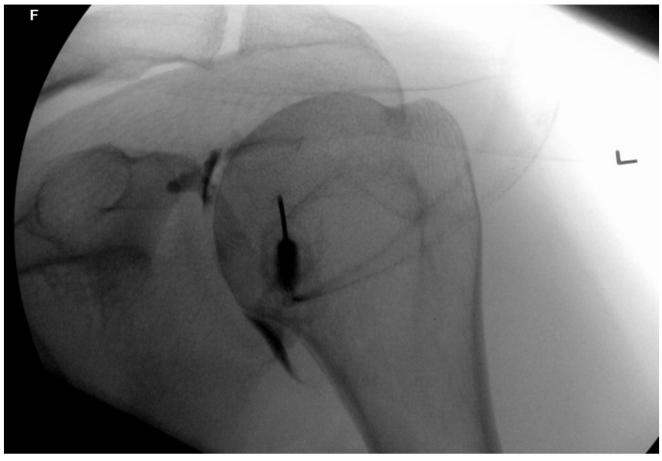

Fig. 2. Fluoroscopic image showing proper needle placement within the glenohumeral joint space as evidenced by the spread of contrast.