Retrospective Evaluation

The Relationship Between Body Mass Index and Fluoroscopy Time During Intraarticular Hip Injection: A Multicenter Cohort Study

Zachary L. McCormick, MD[1], Meghan Bhave, MD[2], David T. Lee, MD[3], Paul Scholten, MD[4], Samuel K. Chu, MD[4], Ashwin N. Babu, MD[5], Mary Caldwell, DO[4], Craig Ziegler, MD[4], Humaira Ashraf, MD[4], Ryan Clark, DO[4], Claire Gross, MD[4], Jeffrey Cara, DO[4], Kristen McCormick, MD[4], Brendon Ross, DO[4], Joel Press, MD[4], David R. Walega, MD[2], and Daniel Cushman, MD[6]

From: [1]Department of Physical Medicine & Rehabilitation/Department of Anesthesiology, Northwestern Feinberg School of Medicine/The Rehabilitation Institute of Chicago, Chicago, IL; [2]Department of Anesthesia, Northwestern Feinberg School of Medicine, Chicago, IL; [3]University of Illinois College of Medicine, Chicago, IL; [4]Department of Physical Medicine and Rehabilitation, Northwestern Feinberg School of Medicine/The Rehabilitation Institute of Chicago, Chicago, IL; [5]Department of Physical Medicine and Rehabilitation, Harvard Medical School/Spaulding Rehabilitation Hospital, Boston, MA; [6]Division of PM&R, University of Utah, Salt Lake City, UT

Address Correspondence:
Zachary L. McCormick, MD
Department of Physical Medicine & Rehabilitation/Department of Anesthesiology, Northwestern Feinberg School of Medicine/The Rehabilitation Institute of Chicago, 676 N. St. Clair, Ste 17-200, Chicago, IL 60611
Email: zmccormi@gmail.com

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Background: Higher body mass index (BMI) is associated with difficulty in obtaining imaging studies. While there is a small body of literature regarding the relationship between fluoroscopy time and BMI during injections for pain management, this has not been studied for intraarticular (IA) hip injections. Further, in academic training centers, trainee involvement may affect this relationship.

Objective: To determine the relationship between BMI and fluoroscopy time during IA hip injections, both with and without involvement of a trainee.

Study Design: Multicenter retrospective cohort study.

Setting: Three academic, outpatient musculoskeletal and pain medicine centers.

Methods: Patients who underwent fluoroscopically guided IA hip injections with encounter data regarding fluoroscopy time during the procedure and BMI were included. Mean and standard deviation fluoroscopy time were recorded. Comparisons were made between BMI categories of normal (18.5 – 24.9 kg/m^2), overweight (25.0 – 29.9 kg/m^2), and obese (≥ 30.0 kg/m^2). Statistical significance was set at $P = 0.01$ due to multiple comparisons.

Results: A total of 559 IA hip injections are represented in this cohort. Patients had a mean age of 58 (standard deviation [SD] 14) years and 63% were women. There was no significant difference in fluoroscopy time when comparing BMI categories ($P = 0.02$). However, when trainees were not involved in the injection, fluoroscopy times were significantly shorter with decreasing BMI category, with normal weight patients requiring the shortest fluoroscopy times ($P = 0.01$).

Limitations: This study evaluated total fluoroscopy time, not radiation dose exposure per injection, which provides more direct and precise information with regard to provider and patient radiation exposure and overall safety. Future study of the impact of BMI on radiation dose during fluoroscopically guided IA hip injections is needed.

Conclusions: Fluoroscopy times during IA hip injections increase with higher BMI categories in a statistically significant manner when performed by experienced clinicians but this relationship is not observed when injections are performed with a trainee in a teaching institution. This finding appears to be related to longer fluoroscopy time required to complete an IA hip injection in patients with lower BMI when a trainee is involved.

Key words: Hip, injections, obesity, overweight, body mass index, fluoroscopy, radiation, pain

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Hip pain is a common complaint in primary care, musculoskeletal, and pain clinics, and is often related to osteoarthritis within the hip joint (1). When conservative management, including physical therapy and oral medications, is ineffective, intraarticular (IA) injections with corticosteroid or in some cases hyaluronic acid are performed (2). Additionally, the procedure can be used for diagnostic purposes to identify if a patient's pain is truly coming from the hip. Procedural technique varies by practitioner, including the means of image guidance during injection. Studies comparing blind IA hip injections using anatomical landmarks to those using ultrasound guidance or fluoroscopy have shown that image-guided IA hip injections improve the accuracy of needle placement and reduce the risk of damage to nearby neuromuscular structures (3-6). Ultrasound guidance during IA hip injection can be used in order to avoid radiation exposure to both patient and practitioner; however, ultrasound guidance may be more challenging in patients with higher body mass index (BMI).

Higher BMI is associated with difficulty in obtaining imaging studies (7,8). Although some authors have examined the relationship between fluoroscopy time and BMI during injections for pain management (9-13), this has not been studied in IA hip injections. In academic training centers, trainee involvement may affect the efficiency of medical care (14) including procedures that utilize fluoroscopic guidance (15), but this relationship has not been determined during IA hip injection. We investigated the relationship between BMI and fluoroscopy time during IA hip injections both with and without trainee involvement in the procedure. This work has safety implications with regard to radiation exposure to patients and providers, and health risks of cumulative radiation exposure.

Methods

Our Institutional Review Board approved this multicenter retrospective cohort study. Electronic medical records from the Rehabilitation Institute of Chicago (RIC) Sports and Spine Rehabilitation Center, the RIC Sports and Spine Center at River Forest, and the Northwestern Memorial Faculty Foundation (NMFF) Anesthesiology Pain Medicine Center were surveyed using the current procedural terminology code 27096 with subsequent confirmation of IA injection in the procedure note. There was less than 25% overlap between attending physicians and trainees between these various institutions.

Patients treated at these sites between April 2007 and February 2015 were included if they met the following inclusion criteria: (1) underwent a fluoroscopically guided IA hip injection; (2) had a documented fluoroscopy time from the procedure; and (3) had a documented height and weight measurements or a BMI calculation. Patients undergoing IA hip injections that did not meet these criteria were excluded from the analysis.

All attending physicians who performed or supervised IA hip injections were either board-certified in anesthesiology, with additional subspecialty board certification in pain medicine, or physical medicine and rehabilitation, with additional subspecialty board-certification in either pain medicine or sports medicine. A total of 16 physicians with 6 to 38 years of clinical experienced performed the IA hip injections. Trainees in an ACGME-accredited physical medicine and rehabilitation residency, anesthesiology residency, sports medicine fellowship, or multidisciplinary pain medicine fellowship participated in the injection procedure in 80% of cases.

Demographic and procedural data were collected from the electronic medical record including: age, gender, BMI, procedure side, unilateral or bilateral procedure, needle length used, trainee involvement, and fluoroscopy time. Involvement of a "new trainee" was defined as involvement of a trainee during the first 2 months of the academic year (July and August).

Procedures

At all 3 study sites, IA hip injections were performed as follows: the patient was positioned supine on a fluoroscopy table and the inguinal region/proximal thigh was prepped with chlorhexidine and draped in a standard sterile manner. One percent lidocaine, 2 – 3 mL, was used for local anesthesia to the skin and subcutaneous tissues. Using fluoroscopic guidance, a sterile, 22 or 25-gauge Whitacre needle (2.5, 3.5, or 5 inch length) was positioned at the junction of the femoral head and neck, inferior to the acetabular lip. Appropriate needle placement was confirmed in anterior-posterior fluoroscopic views following negative aspiration and injection of approximately 1 – 3 mL of contrast (Omnipaque, Iohexal 180 mg/mL, GE Healthcare Inc., Princeton, NJ). A combination of steroid and local anesthetic of variable volume, typically 3 – 5 mL, was administered.

Table 1. *Patient characteristics and procedure details for fluoroscopically guided IA hip injections; stratified by normal body mass index (BMI 18.5 – 24.9 kg/m^2), overweight (BMI 25.0 – 29.9 kg/m^2), and obese (BMI between ≥3 0.0 kg/m^2). P values denote differences between BMI groups for each variable.*

Variable	All Patients n = 559	Normal Weight n = 177	Overweight n = 175	Obese n = 207	*P* value
Age, y; mean (SD)	58 (14)	55 (16)	61 (15)	57 (12)	< 0.01
Gender, n (%)					
Female Male	350 (63%) 209 (37%)	132 (75%) 45 (25%)	100 (57%) 75 (43%)	118 (57%) 89 (43%)	< 0.01
BMI, kg/m^2; mean (SD)	29 (7.6)	22 (2.2)	27 (1.4)	37 (6.6)	< 0.01
Procedure Side					
Left Right	233 (43%) 312 (57%)	70 (41%) 102 (59%)	66 (38%) 106 (62%)	97 (48%) 104 (52%)	0.13
Trainee Involvement	417 (80%)	138 (78%)	127 (73%)	152 (73%)	0.49
Repeat Injection	138 (25%)	38 (22%)	28 (22%)	62 (30%)	0.09
Length of needle (in)					
2.5 3.5 5.0	8 (1%) 488 (88%) 61 (11%)	3 (2%) 170 (97%) 3 (2%)	3 (2%) 168 (97%) 3 (2%)	2 (1%) 150 (72%) 55 (27%)	< 0.01

SD – Standard Deviation

Statistical Analysis

Statistical software was used to analyze the data (PSPP, Version 0.8.4; Gnu Project, Boston, MA). The distributional form of the data was checked using summary statistics and graphical displays. Data were stratified into 3 BMI categories: normal (BMI 18.5 – 24.9 kg/m^2), overweight (BMI 25.0 – 29.9 kg/m^2), and obese (BMI ≥ 30.0 kg/m^2). Groups were compared using analysis of variance testing for continuous variables and χ^2 tests for categorical variables.

A Bonferroni correction was used given multiple comparisons were performed, and the level of significance was set at 0.01.

Results

Demographic and procedural characteristics of the study population are shown in Table 1. A total of 597 IA hip injections were identified during the study time frame; 559 IA hip injections had both fluoroscopy time and BMI information documented and could be included for analysis. There were 233 injections performed on the left hip, 312 injections on the right hip, and 14 injection reports did not include a side specification. Patients had a mean age of 58 (SD 14) years, and 63% were women. Trainees were involved in 80% of the injections, and 25% were repeat IA hip injections. Practitioners were more likely to use a longer needle in obese patients (P < 0.01); however, 88% of patients received IA hip injections with the use of a 3.5-inch needle.

The relationship between fluoroscopy time during IA hip injection and BMI stratified by normal weight, overweight, and obese BMI is shown in Table 2. There was no significant difference in fluoroscopy time in the 3 different BMI categories (P = 0.02). For all patients, trainee involvement was not associated with an increased fluoroscopy time (P = 0.32). However, when attending physicians performed the injection without the involvement of a trainee, fluoroscopy time increased significantly with higher BMI categories. There were no serious adverse events.

Discussion

We identified a significant relationship between increased fluoroscopy time and higher BMI for IA hip injections. This relationship was seen when an attending physician performed the injection without a trainee. When a trainee was involved with the procedure, fluoroscopy times were relatively longer in lower BMI categories compared to attending physicians performing the injection. Although it is intuitive that less fluoroscopy time would be required to complete an IA hip injection in a patient with lower BMI, as there is less tissue depth to traverse in order to enter the hip joint capsule, it is not clear why this was not seen when trainees were involved in the procedure. We speculate that novice injectionists spend more time with initial needle positioning and basic needle manipulation and maneuvering in order to obtain a co-axial view of the

Table 2. *Fluoroscopy time during IA hip injection for normal body mass index (BMI 18.5 – 24.9 kg/m^2), overweight (BMI 25.0 – 29.9 kg/m^2), and obese (BMI between ≥ 30.0 kg/m^2) individuals. P values denote differences between BMI groups for each variable.*

Variable	n	Fluoroscopy time per injection, s; mean (SD)	Fluoroscopy time per injection, s; mean (SD)	Fluoroscopy time per injection, s; mean (SD)	*P* value
		Normal Weight	Overweight	Obese	
All injections	559	11 (8.3)	11 (6.4)	13 (12)	0.02
Repeat injections	138	12 (10)	11 (6.5)	11 (6.1)	0.86
Trainee involvement	420	12 (8.9)	11 (6.6)	12 (9.5)	0.32
No Trainee involvement	139	7.6 (4.3)	9.6 (6.0)	14 (16)	0.01
New trainee involvement	58	14 (11)	10 (8.6)	11 (5.7)	0.40

SD – Standard Deviation
New trainee – injection performed with trainee in July or August

needle superficial to the target site. Further, the novice who is unfamiliar with the "feel" of soft tissue versus periosteum of the joint capsule may also spend more time attempting to achieve satisfactory capsular entry or perform an arthrogram.

The present study suggests that when experienced clinicians perform IA hip injections in patients with high BMI, both patients and staff experience increased radiation exposure. Increased fluoroscopy time as a function of higher BMI has been identified in other pain management injection procedures including lumbar epidural injections, lumbar medial branch blocks, and IA facet joint injections (9,10). While there was no observed difference in fluoroscopy time between BMI categories when trainees were involved in the procedure, it is likely that both patients and staff still experience increased radiation exposure with increasing BMI of the patient due to a need for increased emitter current required to penetrate more soft tissue in order to achieve a suitable image. This concept is further supported by evidence from a study in fluoroscopically guided IA sacroiliac joint injections in which fluoroscopy time between BMI categories was not different, yet patients with higher BMI received a greater radiation dose (16).

Further, the present data suggest that when trainees are involved with IA hip injections, patients and staff are exposed to a greater degree of radiation exposure compared to procedures in which only attending physicians are involved. While this finding was expected, it does underscore the importance of optimizing radiation safety in all patients, regardless of BMI, particularly when a trainee is involved with the procedure.

Ionizating radiation can cause injury at a molecular level, resulting in cell injury and death that can lead to radiation burns, as well as structural changes in DNA, which increases the risk of cataract formation and various cancers (17,18). Practitioners should be mindful of the possibility of increased radiation exposure when treating obese patients and take additional precautions to minimize cumulative exposure: increase the distance from the radiation source, use lead shielding and eye protection (19). Additional precautions include the use of pulsed fluoroscopy, image magnification, dose spreading, dose level settings, and electronic collimation, and adjustment of beam quality should also utilized when feasible to further reduce radiation dose (19-24).

Given the risks of radiation exposure, decreasing cost of bedside-machines, and advances in the quality of imaging, the use of ultrasound-guidance by non-radiologists during injections for pain indications has recently increased (25). Ultrasound guidance for IA hip injections obviates the risks of radiation exposure to the patient and the practitioner. Several studies have established the safety and efficacy of ultrasound-guided IA hip injections as compared to landmark techniques (26-28). Currently, there is insufficient literature to determine superior efficacy of ultrasound- compared to fluoroscopic-guidance during IA hip injection for clinical outcomes (4,6), yet given the advantage of reducing radiation exposure, ultrasound-guidance has a role in improving safety to both patients and staff. However, ultrasound-guided injections can be technically challenging in obese patients, even in experienced hands. Thus, further investigation is needed to compare clinical outcomes of these 2 image-guidance techniques for IA hip injections specifically in obese patients, particularly given the increased health risks to patients in cases of higher BMI, as suggested by this study. This question is particularly relevant given the significant prevalence of obesity in patients with hip osteoarthritis (29,30), and the common use of IA hip injection for this indication (31).

Strengths of this study include a relatively large

number of injections performed at multiple centers, with minimal missing data, on a sample population that appears to reflect epidemiologic BMI data for the United States as a whole. Sixty-eight percent of all patients that received IA hip injections were overweight or obese, consistent with the National Health and Nutrition Examination Survey (Ogden 2012), which showed that 2 in 3 adults are overweight or obese (32). The strengths contribute to the generalizability of the presented finding to other academic practice settings in the United States.

Study Limitations

The findings of this study should be interpreted within the context of its limitations. Multiple physicians and radiology technicians of varying clinical experience were involved with the IA hip injections in this relatively large cohort, which may confound the data. Furthermore, this study evaluated total fluoroscopy time, not radiation dose exposure per injection, which provides more direct and precise information with regard to provider and patient radiation exposure and overall safety. Radiation dose was not recorded in this cohort. Future study of the impact of BMI on radiation dose during fluoroscopically guided IA hip injections is needed. Missing data, a potential problem with retrospective studies, was not a major issue here, as only 6% of IA hip injections had missing data and were excluded from analysis. This small percentage would not affect our results or conclusions. Given the nature of this study, and the data collected from 3 large practices, selection bias is less likely.

Conclusions

Fluoroscopy times during IA hip injections increase with higher BMI categories in a statistically significant manner when performed by experienced clinicians but this relationship is not observed when injections are performed with a trainee in a teaching institution. This finding appears to be related to longer fluoroscopy time required to complete an IA hip injection in patients with lower BMI when a trainee is involved.

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Author Contributions: All authors had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. All authors designed the study protocol. All authors managed the literature searches and summaries of previous related work and wrote the first draft of the manuscript. All authors provided revision for intellectual content and final approval of the manuscript.

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