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# Effect of initial emergency room imaging choice on time to hip reduction and repeat imaging

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ABSTRACT

*Objectives:* Hip dislocations are highly morbid injuries necessitating prompt reduction and post-reduction assessment for fracture and incarcerated fragments. Recent literature has questioned the need for initial pelvic radiographs for acute trauma patients, resulting in computed tomography (CT) scans as the initial evaluation. This study investigates the relationship between choice of pre-reduction imaging and treatment of acute hip dislocations.
*Design:* Retrospective Case-Control.
*Setting:* Single Academic Level I Trauma Center.
*Methods:* All acute hip dislocations from 2011 to 2016 were reviewed. Exclusion criteria were diagnosis of dislocation at another facility, death prior to reduction, emergent surgical or ICU intervention, and periprosthetic dislocation. Patients were grouped by those with only a radiograph prior to reduction, Group I, versus those with a pre-reduction CT scan, Group II. The primary outcomes were time to reduction and the acquisition of a second CT scan.
*Results:* Of the 123 hip dislocations identified, 35 patients were excluded, mostly for transfer with a known dislocation. Group I included 29 patients and Group II included 59 patients. The mean time to reduction was 74 min in Group I and 129 min in Group II for a difference of 55 min ($p < 0.001$). The rate of repeat CT scan was 0 in Group I versus 48 (81%) in Group II ($p < 0.001$).
*Conclusion:* Initial trauma pelvic radiography prior to CT is still important in the setting of suspected hip pathology to decrease time to hip reduction and unnecessary radiation exposure.
*Level of evidence:* Prognostic Level III.



## Introduction

Hip dislocations are morbid injuries that commonly result from high energy trauma such as motor vehicle collisions. A thorough evaluation in the Emergency Department (ED) should be initiated according to Advanced Trauma Life Support (ATLS) guidelines. Pelvic radiography is an important part of the primary survey and helps guide initial management when hip pathology is present. Ideally, hip reduction should be performed immediately after x-ray diagnosis in a stable patient. Although a computed tomography (CT) scan following reduction of a hip dislocation may be helpful to evaluate associated fractures, intra-articular loose bodies, and articular congruity [1–8], there are few indications to obtain a CT scan for a suspected dislocation prior to reduction.

Recent literature has questioned the utility of initial pelvic radiographs for acute trauma patients, citing sensitivities ranging from 64% to78% compared to CT for the detection of pelvic fractures [9–12]. These studies have suggested that pelvic radiographs do not routinely add to the management of acute trauma patients and have advocated that ATLS guidelines exclude pelvic radiography in patients who will undergo CT scanning. In our institution, we have seen that the pelvic radiograph has been increasingly omitted from the initial trauma evaluation, potentially leading to inappropriate use of imaging, additional radiation exposure, and delayed hip reduction. This study investigates the relationship between initial choice of imaging in the management of acute hip dislocations and the time to reduction and need for repeat CT scanning.

## Methods

Institutional Review Board approval was obtained from our institution. A retrospective review was conducted of all acute hip

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dislocations at a level 1 trauma center from January 1, 2011 to December 31, 2016. The hospital's trauma database was used to search for patients coded as a hip dislocation based on the International Classification of Diseases (ICD) 9 or 10 diagnosis codes or with the procedure code for closed hip reduction. Clinical documentation and radiographs of all identified patients were reviewed. Criteria for study inclusion were acute, traumatic dislocation of a native hip in a patient evaluated through a trauma activation. Exclusion criteria were diagnosis of dislocation at another facility, death pronounced on initial assessment, delay due to emergent surgical or ICU intervention, chronic dislocation and periprosthetic dislocation.

The primary outcomes were time to reduction in the ED and the number of CT scans obtained. The time to reduction was assessed as the time from presentation to the ED until the documented procedure time-out or administration of conscious sedation. A patient was considered to have a repeat CT if more than one CT scan was obtained to evaluate the hip. Patients were stratified into two groups. Group I included all patients who had hip dislocation diagnosed on pelvic radiographs and underwent immediate closed reduction without an intervening CT scan of the dislocated hip. Group II included all patients who received a CT scan prior to hip reduction.

Basic demographic data including sex, age and race were collected. Mechanism of injury and Injury Severity Scores (ISS) were identified. Additional injury characteristics including acetabular fracture, femoral head fracture, femur fracture, intracranial injury, pelvic disruption, significant abdominal organ injury and spinal fracture were recorded. The timing of ER admission was noted, differentiating between admission during day hours from 7 A M to 7 PM and night hours from 7 PM to 7 A M.

Means and standard deviations are reported unless otherwise stated. Categorical data were compared for statistical significance using the Chi-squared test or Fisher's exact test. Continuous data were compared using a *t*-test or the Mann Whitney test. All statistical procedures were done using SPSS software (Version 24; SPSS Inc., Chicago, IL). Statistical significance was set at $p < 0.05$.

## Results

Our institutional trauma database identified 137 patients with acute hip dislocations during the study period. 13 patients were excluded because they did not have a true dislocation or had an associated acetabular fracture that required open reduction. 12 patients were transferred from an outside hospital with known hip dislocations on imaging. These were excluded as the imaging was already completed and time to reduction estimates would be skewed. Nine patients had hip dislocations reduced at an outside hospital prior to transfer. Four patients were pronounced dead in the trauma bay. Four patients were directly admitted to the ICU for concurrent injuries prior to reduction. Four were taken emergently to the operating room for other injuries precluding prompt reduction of the hip dislocation. Two periprosthetic dislocations and one chronic dislocation were excluded.

88 patients met inclusion criteria with all reductions taking place within the emergency department. Group I included 29 patients with 30 hip dislocations who underwent closed reduction of the hip following initial pelvis radiograph. Group II included 59 patients with 60 hip dislocations who had CT scans completed prior to hip reduction. There was no difference between groups with respect to age, sex, race, ISS, associated injuries, or direction of dislocation (Table 1).

The mean time to reduction was 74 min in Group I compared to 129 minutes in Group II ($p < 0.001$) (Fig. 1). This represented an average delay of 55 min when a CT scan was obtained prior to reduction. With respect to number of CT scans obtained, all patients in Group I had 1 CT performed, which was after the closed reduction. In Group II, 48 of 59 (81%) patients had 2 CT scans in the ED ($p < 0.001$). Of the remaining 11 patients, post reduction CT was not performed in nine due to operative acetabular fractures and in one due to an operative femoral head fracture. With respect to timing of presentation, patients were more likely to have a pre-reduction CT scan if they presented at night ($p = 0.014$). Post hoc analysis demonstrated that with regard to timing of presentation, 58 patients who presented overnight trended towards having higher ISS scores (mean 13.1, 95% CI 10.7–15.4) as compared to the 30 daytime patients (mean 10.0, 95% CI 7.7–12.3) though this finding was not significant ($p = 0.091$).

## Discussion

The role of pelvic radiography in the evaluation of the acute trauma patients has become a subject of considerable debate. Although the anterior-posterior (AP) pelvis radiograph remains a component of the primary survey in ATLS algorithms, studies have questioned the utility of the AP radiograph and suggested that CT scanning better detects pelvic and sacral fractures [9–12]. While identifying these fractures may improve resuscitation efforts and uncover potential sources of occult bleeding, obtaining a CT scan necessarily introduces some delay compared to an AP pelvis radiograph in the acute trauma evaluation. The purpose of this study was to examine potential consequences of shifting away from routine pelvic radiography in the initial assessment of trauma patients. We chose to focus on hip dislocation as it represents a highly time sensitive injury requiring prompt diagnosis and reduction.

We found that hip reduction was delayed by almost one hour when a CT scan was obtained first. This represents an avoidable delay. Timely reduction decreases the ischemia time and may lead to improved survival of the femoral head. Multiple studies have examined the relationship between time to reduction and the development of avascular necrosis. Brav reviewed 262 hip dislocations with a minimum of 2 years follow up, showing a decrease in the rate of osteonecrosis from 52% to 22% when the time to reduction decreased from over 12 h to less than 12 h [13]. Sahin et al found that there was a significant improvement in outcomes if reduction was performed in under 12 h, although the osteonecrosis rates were too low to approach significance [14]. Hougaard et al reviewed 125 hip dislocations with a minimum of 5 year follow up and found that 58% of hips reduced after 6 h developed avascular necrosis compared to 4% reduced in less than 6 h [15]. Dreinhofer et al evaluated 50 hip dislocations reduced in under 3 h with a minimum of 8 year follow up and still found an osteonecrosis rate of 12% [16]. They noted no difference in hips reduced in under 1 h versus 1 to 3 h. In our study, the time to reduction was measured from the initial ED presentation. In all cases, there was additional time from injury to hospital presentation, which was not evaluated in this study. While the exact timing of reduction is controversial, additional delay of 1 h may contribute to poor outcomes.

Another aim of this study was to assess the number of CT scans as a surrogate for radiation exposure. As described above, multiple studies support the use of post-reduction CT scan to assess for fracture, incarcerated fragments, and concentric reduction [1–8]. When a CT scan is obtained before the reduction, it is typically our current practice to obtain a second CT to assess for new fractures, fragments introduced to the joint during reduction and concentricity of the hip. In our study, none of the patients in the pre-reduction x-ray group received more than one CT scan, whereas 81% of the patients who received a pre-reduction CT scan had a repeat study.

**Table 1**
Summary of patient characteristics.

| | GROUP I (%) Pre-reduction Radiograph | GROUP II(%) Pre-reduction CT scan | Statistical Test used | Significance |
|---|---|---|---|---|
| **TOTAL** | **29 pts** | **59 pts** | | |
| SEX | | | Chi squared | p = 0.749 |
| Female | 6 (21) | 14(24) | | |
| Male | 23 (79) | 45(76) | | |
| RACE | | | Chi squared | p = 0.493 |
| Black/African American | 7 (24) | 15 (25) | | |
| Hispanic/Latino | 13 (45) | 34 (58) | | |
| White/Caucasian | 8 (28) | 9 (15) | | |
| Other | 1 (3) | 1 (2) | | |
| DIRECTION OF DISLOCATION | | | Chi squared | p = 0.616 |
| Anterior | 2 (7) | 6 (10) | | |
| Posterior | 27 (93) | 53 (90) | | |
| ER ADMISSION TIME | | | Chi squared | p = 0.014 |
| 7AM-7PM | 15(52) | 15(25) | | |
| 7PM-7AM | 14(48) | 44(75) | | |
| ASSOCIATED INJURIES | | | | |
| Acetabular fracture | 17(57) | 42(70) | Chi squared | p = 0.210 |
| Femoral head impaction or fracture | 3(10) | 15(25) | Chi squared | p = 0.094 |
| Femur fracture | 0(0) | 1(0) | Fischer exact | p = 1.0 |
| Intracranial injury* | 3(10) | 1(2) | Fischer exact | p = 0.106 |
| Pelvic ring disruption | 2(7) | 9(15) | Fischer exact | P = 0.324 |
| Significant organ injury** | 4(13) | 11(18) | Chi squared | p = 0.546 |
| Spine fracture | 7(23) | 7(11) | Fischer exact | p = 0.216 |
| INJURY SEVERITY SCORE | | | Mann Whitney | p = 0.086 |
| Mean | 12.0 | 12.2 | | |
| Interquartile range | 4-14 | 8-17 | | |
| Range | 4-41 | 4-34 | | |
| TIME TO REDUCTION | | | *t*-test | p<0.0005 |
| Mean | 74 | 129 | | |
| Interquartile range | 39-100 | 82-165 | | |
| Range | 16-218 | 51-292 | | |
| AGE | | | *t*-test | p = 0.345 |
| Mean | 34.0 | 30.3 | | |
| 95% confidence interval | 29.3-38.8 | 27.4-33 | | |
| Range | 18-70 | 18-65 | | |

* Denotes intracranial injury denotes any intracranial hemorrhage or contusion, or diffuse axonal injury.
** Denotes renal, liver or spleen lacerations grade II or higher, bladder rupture, or great vessel injury.

Multiple studies have sought to quantify the risk of radiation induced cancers. According to Wiest, the radiation dose from a pelvis CT is 10mSv compared to 0.7 mSv for a radiograph [17]. Smith-Bindman et al estimated the average radiation dose for non-contrast CT of the pelvis to be 10–20 mSv [18]. Based on their calculations for 20 year old patients receiving a single scan, there was an estimated risk of radiation induced cancer of 1 in 500 for women and 1 in 660 for men. In a similar study looking at CT scan protocols in femoracetabular impingement, Wylie et al calculated a number needed to harm as low as 564 for females and 952 for males with respect to lifetime attributable cancer [19]. Another important consideration in trauma patients with hip dislocations is that they often receive multiple CT scans for other injuries. Efforts to minimize radiation exposure from unnecessary repeat CT scans would lower the cumulative radiation dose.

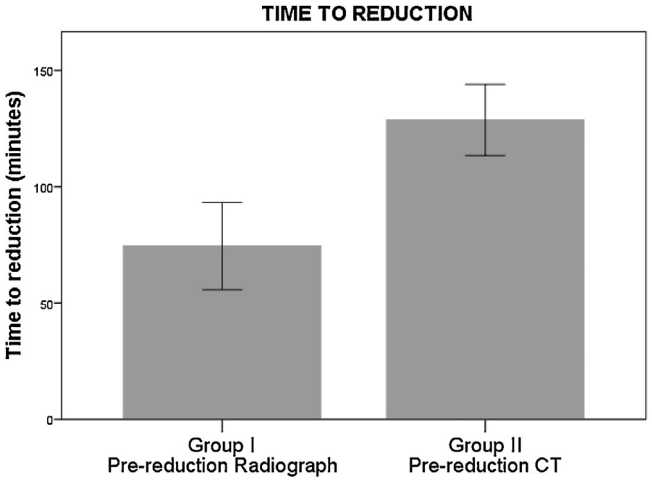


**Fig. 1.** Histogram showing the average time to reduction for Group I, with pre-reduction radiograph only, and Group II, with pre-reduction CT scan. The error bars demonstrated the 95% confidence interval.

Multiple studies have questioned the need for routine pelvic radiographs in blunt trauma patients. Kessel et al reviewed 129 stable blunt trauma patients who underwent pelvic radiographs and CT scans [12]. They found CT diagnosed 35.6% more pelvic fractures than x-ray. Guillamondegui et al reviewed 686 blunt trauma patients and found a sensitivity of 68% for pelvic radiograph compared to CT [10]. Soto et al reviewed 153 patients with pelvic fractures who had both radiographs and CT, with the finding that 67% more fractures were identified on the CT [9]. They specifically note that x-ray did not change management in the ED, although they do not discuss the management of hip dislocations. Obaid et el reviewed 174 patients with both imaging modalities and showed a sensitivity of 78% for x-ray [11]. Hilty et al reviewed 68 blunt trauma patients with both imaging studies and found missed pelvic fractures in 3 cases (4%) with none of the patients requiring immediate intervention due to the x-ray results [20].

Based on their results, the above authors suggest that pelvic radiographs are likely unnecessary in stable blunt trauma patients

with negative pelvic or hip exams. During the time of the study results, our institution had not adopted a guideline against using pelvic radiographs according to ATLS protocol and the choice of imaging was left to the discretion of the trauma or emergency medicine physician directing the initial trauma evaluation. Despite this, 59 out of 88 (67%) of our patients had CT scans with hip dislocations, which led to 48 of these patients receiving a second CT scan. All patients had trauma activations and thorough examinations by the trauma team. Rigorously following current ATLS guidelines regarding pelvic radiograph use would have prevented these inappropriate imaging studies and delays in joint reduction.

An unexpected finding of this study was the difference in initial imaging modality based on the timing of patient presentation to the emergency department. This may be related to potential confounding patient factors as may be suggested by the trend to higher ISS scores amongst the night-time group. Prior studies have demonstrated differences in potential confounding factors such as patient age and injury mechanisms based on time of presentation. [21,22] On the other hand, the differences in initial imaging modality may be represent nighttime physician practice variation as has been described in the non-trauma setting [23].

The limitations of this study include the retrospective nature. The sample was relatively small compared to other hip dislocation studies; however, significant differences were still found between the groups. Another limitation was using medication administration time as recorded in the electronic medical record as a surrogate for reduction. The actual reduction time would likely be within 10 min, but this introduces some error. However, the magnitude of such error is far less than the effect we measured between groups. Additionally, there may be other factors that affect time to reduction that were not captured. Lastly, this data represents information from only a single level 1 trauma center, which affects the generalizability of the study. Time to reduction and imaging protocols are likely to vary across institutions.

## Conclusion

The shift toward initial CT scanning at our institution has led to avoidable delays in hip reduction and increased radiation exposure from repeat CT scans. We recommend that the pelvic radiographs should remain part of the initial trauma assessment, consistent with current ATLS protocol.

## Conflicts of interest

The authors have no conflicts of interest to declare.

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