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Original research

Location of Initial Closed Reduction Attempt Significantly Increases Cost and Length of Stay in Total Hip Arthroplasty

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ABSTRACT

Background: Prosthetic hip dislocation remains one of the most frequent complications following total hip replacement. Dislocations are predominantly managed by a closed reduction in the emergency department (ED) or the operating room (OR). This study aimed to evaluate how the location of an initial closed reduction attempt impacts a patient's course of care including length of stay (LOS) and cost of care.

Material and methods: A retrospective chart review was performed on all patients presenting to a single ED with a unilateral prosthetic hip dislocation from 2009 to 2019. A total of 108 patients were identified. Data collected included patient demographics, ED/hospital course, and hospital charges.

Results: Seventy-four patients (69%) had initial reduction attempted in the ED (65/74, 88% were successful), while 34 patients (31%) went directly to OR (100% successful with closed reduction). Failed closed reduction in ED or direct to OR resulted in a greater LOS and rate of placement to a skilled nursing facility following discharge. Median hospital charges for successful ED reduction were $6,837, while failed ED closed reduction or direct to OR resulted in median charges of $27,317 and $20,481, respectively.

Conclusion: Many patients successfully underwent closed reduction in the ED, and there was no difference in complications, independent of where the reduction was first performed. Patients undergoing reduction in the OR had greater LOS and cost of care, independent of whether a reduction attempt was performed and failed in the ED, than those successfully reduced in the ED.

Introduction

The incidence of total joint replacements has continued to increase over the past 2 decades [1], such that primary total hip arthroplasty (THA) is projected to increase by 71%, resulting in 635,000 procedures annually by 2030 [2]. As the number of THAs continues to rise, so does the volume of THA dislocations [3-17]. The incidence of dislocation has been reported to vary between 0.2% and 7% in primary THA and between 10% and 25% in revision THA [13,18,19]. THA instability continues to be a devastating and potentially costly complication that can lead to the need for revision, especially when it becomes recurrent. With rising health-care costs and ongoing initiatives to reduce the cost of care, numerous studies have evaluated the cost-utility of orthopedic surgical interventions, with THA being the most studied [20]. Prior studies have reported that the added cost for a primary THA that required a single closed hip reduction was increased by 27%, while cases of THA instability where a revision was required resulted in a 148% increase in the cost of care [21]. Cost of care associated with the index procedure has been previously evaluated, but there is very little information on costs associated with the management of THA instability.

Most hip dislocations following THA occur in the community and present to the emergency department (ED) where a radiograph

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is used to confirm the dislocation. While most of these patients can be managed with sedation and closed reduction in the ED, closed reduction is not always successful. Closed reduction in the ED is often preferred for multiple reasons: lower cost, quicker time to reduction, quicker patient disposition, and avoidance of intubation or general anesthetic. However, closed reduction in the ED is not always possible for a variety of reasons and are not always successful when attempted. The success of reduction in the ED has been estimated to be 71%-91% [22,23], indicating that while many hip dislocations can be conservatively managed, a subset of patients will require an open reduction or revision THA to manage the hip dislocation.

While prior studies have compared outcomes of reduction performed by ED physicians vs orthopedic physicians, no study has examined which factors influence the choice of location of the reduction [22,23]. The primary aim of this study was to evaluate the impact of where patients underwent their initial attempted closed reduction on the course of care. Specifically, this study evaluated patients who underwent initial closed reduction attempts in the ED compared with those who were sent directly to the operating room (OR) for reduction following a THA dislocation and examined the success rate of reduction, rate of complications, and course of care including length of stay (LOS), need for assisted care following discharge, and cost of care.

Material and methods

Following institutional review board approval, a retrospective chart review was performed on all patients presenting to a single-institution ED with a unilateral prosthetic hip dislocation during a 10-year period from July 1, 2009, to July 31, 2019. Potential study candidates were identified by Current Procedural Terminology codes 27265 and 27266. A total of 162 patients with a closed prosthetic hip dislocation were identified. For this study, only patients experiencing dislocation following primary THA were included, while those experiencing dislocation following a revision THA were excluded (N = 45). Dislocations that were incidentally discovered on the hospital floor and did not come through the ED (N = 6) or patients who ultimately elected to not undergo reduction or revision (N = 3) were excluded from the study (Fig. 1). A retrospective chart review was performed to gather patient demographics, procedural data points, as well as each patient's ED/hospital course for a total of 108 patients.

Complication data

Periprocedural complications surrounding the prosthetic reduction were collected from the electronic medical record. Complications of the sedation as defined by Jacques et al. were used including systolic blood pressure less than 90 mmHg or requiring vasopressors, oxygen desaturation (<90%), apnea, vomiting, aspiration, and cardiac arrest, in addition to other events that were deemed complications by the ED faculty physician [24]. Procedural complications related directly to the closed reduction were recorded and included skin tearing, knee injury, periprosthetic fracture, new neurologic deficit, or implant complication not previously identified.

Location of reduction

All patients in this study presented to the ED for initial evaluation and were evaluated by ED physicians. The attending physician in the ED determined which patients were candidates for ED sedation and attempted reduction or deemed them unfit for sedation. Reasons cited for not sedating in the ED included American Society of Anesthesiologists (ASA) Class > II, difficult airway, a history of requiring a prior OR reduction, or other active medical problems (Table 2).

Time to reduction

The time of the first ED radiograph demonstrating a prosthetic dislocation was recorded. Outside hospital imaging was not available for review for patients who initially presented with dislocation to another hospital and were transferred to this institution for definitive management. Timing of reduction was judged by the timestamp of the radiograph showing interval reduction, regardless of where the reduction took place. The length of time to reduction was then quantified as the difference between these two time points.

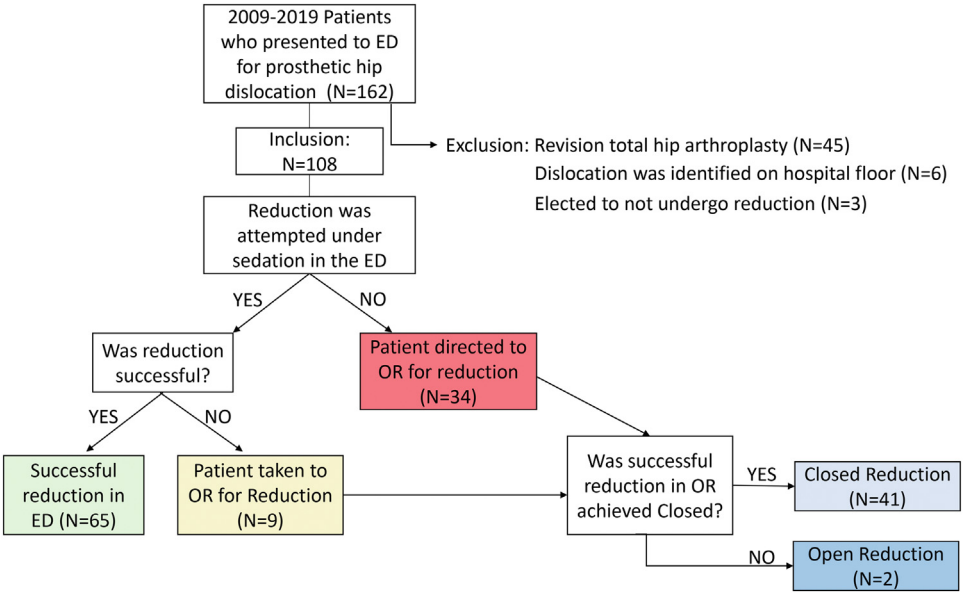

Figure 1. Flow chart with breakdown of patients with associated exclusion criteria.

Cost analysis

Total hospital and professional charges associated with each encounter were obtained from institutional databases.

Data analysis

Study data were collected and managed using REDCap electronic data-capture tools hosted at the Vanderbilt University Medical Center [25,26]. REDCap (Research Electronic Data Capture) is a secure, web-based software platform designed to support data capture for research studies, providing (1) an intuitive interface for validated data capture; (2) audit trails for tracking data manipulation and export procedures; (3) automated export procedures for seamless data downloads to common statistical packages, and (4) procedures for data integration and interoperability with external sources.

Subsequent data analysis was carried out using GraphPad Prism 9.1.2 (College Station, TX) and IBM SPSS 27 (Armonk, NY). The D'Agostino & Pearson test was used to test for the normal distribution of the data. Data not passing normality testing were evaluated using nonparametric assessments including Mann-Whitney U-test or Kruskal-Wallis test. Categorical data were analyzed with chi-squared or Fisher's exact test. A P value < .05 was considered significant. When appropriate, P values have been corrected to account for multiple comparisons.

Results

Demographics

The baseline demographics comparing patients for whom reductions were attempted in the ED (N = 74) to patients sent directly to the OR for reduction (N = 34) are shown in Table 1. Patients who had attempted reduction in ED were found to be significantly younger than those who were sent directly to the OR ($P = .001$), but no significant difference in gender ($P = .228$) or BMI ($P = .668$) was noted between cohorts. When considering ASA classification, a significant difference in the distribution of ASA class was noted among cohorts ($P < .001$). In patients for whom an ED reduction was attempted, a lower incidence of ASA Class III and IV (41.9%, 31/74) was noted, compared with patients sent directly to the OR for reduction (94.1%, 32/34) (Table 1). There was a significantly higher incidence of cardiovascular ($P = .021$) and pulmonary comorbidities ($P = .005$) in patients that were sent directly to the OR. No significant difference in diabetes incidence or status was found between cohorts ($P = .596$). These findings directly align with physician rationale for direct OR transfer for reduction, frequently citing ASA class > II (27/34, 79.4%) and the patients' medical status (11/34, 32.4%) (Table 2). Finally, the prior history of dislocation was compared between patients for whom reductions were attempted in the ED and patients sent directly to the OR for reduction (Table 2). No significant differences in the incidence of prior dislocation ($P = .832$; ED reduction attempted 46/74 [62.2%] vs no ED reduction attempted/direct to OR 20/34 [58.8%]) or the laterality of the dislocation ($P > .999$) were observed among cohorts.

Patient course of care

Of the patients for whom an initial reduction was attempted in the ED (N = 74), 87.8% (65/74) were successful, while 20.9% (9/43) were transferred to the OR following a failed reduction in the ED (Fig. 1). Of these 9 patients, 77.8% (7/9) successfully underwent closed reduction in the OR, while 22.2% (2/9) required open reduction/revision due to interposed soft tissue within the joint space or the need for revision to a constrained liner due to persistent intraoperative instability. Of patients requiring a reduction in the OR (N = 43), 79.1% (34/43) of patients went directly to the OR for reduction, without attempted reduction in the ED (Fig. 1). Of patients who underwent an initial reduction attempt in the OR (N = 34), all 34 (100%) underwent closed management with none requiring open management (Fig. 1).

Across all patients presenting to the ED for management of a hip dislocation following primary THA, the median time to identification of the dislocation was 38 minutes (range: 15 minutes to 366 minutes). Median time to the reduction in patients where the reduction was successful in the ED (N = 64) was 195 minutes (range: 102-588 minutes). As anticipated, time to reduction was significantly longer in patients for whom reduction failed in the ED ($P < .001$ compared with successful ED reduction, median: 579 minutes, range: 231-1272 minutes) or when patients were sent directly to the OR ($P < .001$ compared with successful ED reduction,

Table 1
Patient demographics.

Demographic category	Total population (N = 108)	ED reduction attempted (N = 74)	No ED reduction attempted (direct to OR) (N = 34)	*P* value
Age, median (range)	61.8 (29.0-92.0)	60.7 (29.0-90.1)	71.4 (50.3-92.0)	.001
Male, N (%)	60 (55.6)	44 (59.5)	16 (47.1)	.228
BMI, median (range)	26.8 (17.9-64.1)	26.8 (18.0-43.8)	26.7 (17.9-64.1)	.668
ASA Class, N (%)				<.001
I	8 (7.4)	8 (10.8)	0 (0.0)	
II	22 (20.4)	22 (29.7)	0 (0.0)	
III	52 (48.1)	30 (40.5)	22 (64.7)	
IV	11 (10.2)	1 (1.4)	10 (29.4)	
V	0 (0.0)	0 (0.0)	0 (0.0)	
Not specified	15 (13.9)	13 (17.6)	2 (5.9)	
Comorbidities, N (%)				
Cardiovascular[a]	46 (42.6)	26 (35.1)	20 (58.8)	.021
Pulmonary[b]	36 (33.3)	18 (24.3)	18 (52.9)	.005
Diabetes				
No disease	82 (73.2)	57 (77.0)	25 (73.5)	.596
Diet controlled	10 (8.9)	5 (6.8)	5 (14.7)	
Oral medication	7 (6.3)	5 (6.8)	2 (5.9)	
Insulin dependent	9 (8.0)	7 (9.5)	2 (5.9)	

[a] Cardiovascular comorbidities include myocardial infarction, prior placement of a stent, congestive heart failure, coronary artery disease, or arrhythmia (with or without anticoagulation).

[b] Pulmonary comorbidities include chronic obstructive pulmonary disease, home O_2 use, history of asthma, prior history of pulmonary embolism, sleep apnea, pulmonary hypertension, and other chronic pulmonary conditions.

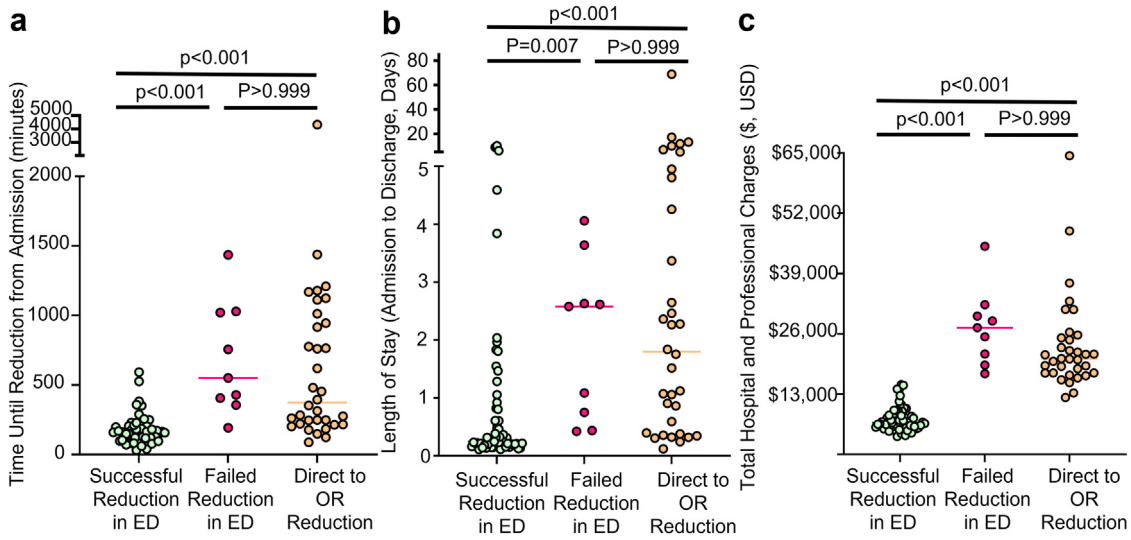

Figure 2. (a) Scatterplot showing time to reduction for all 3 cohorts (minutes). (b) Scatterplot showing length of stay (days). (c) Scatterplot showing cost of care for all 3 cohorts ($US).

median: 463 minutes, range: 155-940 minutes). When comparing patients who experienced failed ED reductions to those sent directly to the OR, no significant difference in time to reduction was noted ($P > .999$) (Fig. 2a).

Aligning with an increased time to reduction, patients who required OR reduction following either a failed ED reduction attempt or direct to OR transfer experienced significantly longer LOS than patients who underwent a successful reduction in the ED (Fig. 2b). Yet no significant difference in LOS was found among patients who required OR reduction independent of if a reduction was attempted in the ED ($P > .999$).

Discharge location was classified as home or a skilled nursing facility (Table 3). Patients who underwent a successful reduction in the ED were significantly more likely to be discharged home, while patients who failed reduction in the ED or underwent a reduction in the OR were more frequently discharged to skilled nursing facility ($P = .007$). Within this overall patient population, 1 patient who successfully underwent reduction in the ED required inpatient admission for incidental finding of pneumonia and eventually left against medical advice during hospital admission. Additionally, 1 patient died during their hospitalization due to a sequela of complications related to metastatic bladder cancer, which were unrelated to the prosthetic dislocation that led to presentation to the ED.

Patient outcomes

Across the entire cohort (N = 108), there were no major medical complications noted, regardless of where patients underwent initial reduction. Among patients for whom the reduction was attempted in the ED (N = 74), minor anesthetic-related complications occurred in 7 (7/74, 9.5%). Of patients in whom ED reduction was successful, 4 (4/65, 6.2%) required a bag-valve mask, and 1 (1/65, 1.5%) experienced apnea requiring jaw thrust. No patients required intubation or use of vasopressors. Of the patients who failed ED reduction and successfully underwent reduction in the OR (N = 9), 2 (2/9, 22%) experienced oversedation/hypoxia associated with prolonged ED sedation, yet no operative complications were observed. In patients who were directly sent to the OR for reduction (N = 34), there were no operative complications.

Table 2
Reasons cited for needing OR reduction/unwilling to attempt in ED.

Reason for no sedation	No ED reduction attempted (direct to OR) (N = 34)
ASA Class > II	27 (79.4)
Difficult airway	1 (2.9)
History of requiring a prior OR reduction	2 (5.9)
Other[a]	10 (29.4)

[a] Included concomitant pelvic fractures, hypotension/vital sign instability, chronic obstructive pulmonary disease, suspected need for open reduction, history of pulseless electrical activity arrest from OR or prior sedation, heart transplant patient, or extensive/complex cardiac history or other active medical comorbidity.

Cost of care

Total hospital and professional charges were examined between cohorts (Fig. 2c). In patients for whom ED reduction of the hip dislocation was successful, the median cost of care was $6837 (range: $3850-$15,038). In patients for whom ED reduction failed, the cost of care was significantly greater with a median of $27,317 (range: $17,411-$44,873) ($P < .001$). In patients who were directly transferred to the OR for reduction, the accrued median cost of $20,620 (range: $12,256-$64,403) was not significantly different from that of patients who had undergone a failed attempt in the ED ($P > .999$).

Discussion

Despite a low incidence of instability following THA, the increased number of THAs being performed annually leads to an increased number of ED visits with prosthetic hip dislocation [3-17]. The cost of care can vary greatly depending upon where the patient requires inpatient admission for reduction or revision in OR vs discharge from ED following closed reduction. In a health-care climate with ongoing initiatives to reduce the cost of delivering care, physicians continue to evaluate areas of care that can be further optimized to reduce cost and the need for hospital resources. Early mobilization protocols, preoperative optimization, patient education, and the increase in the number of procedures performed in ambulatory surgery centers have all successfully reduced the LOS, and subsequent cost of care, without compromising patient safety [27-29]. While these prior studies have concentrated on improving the index procedure, further work

Table 3
Patient disposition from hospital.

Location of patient disposition	Total population (N = 112)	ED reduction successful (N = 65)	ED reduction failed (N = 9)	No ED reduction attempted (direct to OR) (N = 34)	*P*
Discharged to home, N (%)	91 (81.2)	60 (92.3)	6 (66.7)	24 (70.6)	.007
Discharged to SNF, N (%)	19 (17.0)	4 (6.2)	3 (33.3)	9 (26.5)	
Died during hospitalization, N (%)	1 (0.9)	0 (0)	0 (0)	1 (2.9)	
Left hospital against medical advice, N (%)	1 (0.9)	1 (1.5)	0 (0)	0 (0)	

SNF, skilled nursing facility.

optimizing care for complications such as instability remains. This study demonstrated a high success rate of closed reduction in all patients, unless closed reduction in the ED failed. LOS was significantly longer for patients requiring OR for either closed or open reduction. Financially, as expected, a successful closed reduction in the ED was significantly less expensive than going to the OR.

Across this retrospective cohort, closed reduction in the ED has a high success rate and low complication rate, aligning with prior reports [22,23]. Several factors can influence the success or ability to perform a closed reduction in the ED. For example, if soft tissue or bony fragments impede the return of the femoral head into the socket, surgical intervention with an open reduction may be required. Of patients who had failed reduction in the ED, the 2 patients who required open reduction/revision, one was due to interposed soft tissue within the joint space, and the other required revision to a constrained liner due to persistent intraoperative instability. In addition, patient comorbidities or ASA grade is often cited as a rationale for why a patient is not a candidate for sedation in the ED, as observed in the population (Table 1). Ultimately, of both patients who had failed reduction in the ED and those sent directly to the OR for reduction, most patients had a successful closed reduction, suggesting that few patients may need an open procedure that would necessitate going to the OR. Additionally, the number of medical complications in the ED vs OR was not different in our study cohorts, suggesting that sedation for closed reduction is a safe procedure. However, there remains limited literature regarding the safety of closed reduction in the ED vs the OR, specifically regarding patient comorbidities. Given the potential to reduce the cost of care and resources required to treat prosthetic hip dislocations, future prospective studies are warranted.

Benefits of reduction in the ED are shorter time to reduction, decreased need for inpatient admission, and consequently, decreased cost of care. Reduction in the OR ensures that the patient can have an adequate amount of relaxation to allow for reduction, with the ability to open reduce or revise if the hip is deemed unstable following closed reduction. Closed reduction in the ED under conscious sedation has the risk of developing airway compromise requiring bag-valve mask or intubation, hypotension, or cardiac events [24]. Importantly, reduction in the OR carries similar risks, yet the OR is generally deemed a more controlled environment with anesthesia providers specifically trained in management of these conditions.

The retrospective nature of this study introduces limitations including data availability and selection bias given that patients sent directly to the OR for reduction tended to have more medical comorbidities and were deemed unsafe for ED reduction by the ED attending provider. The ED did not follow a standard protocol for sedations, and medication dosing and patient selection for sedation are variables at the discretion of the ED provider performing the sedation. Given this selection bias and data available, it is unknown whether there would be a similar complication profile if all patients had ED reduction attempted prior to proceeding to OR. A future prospective study would be required to determine if attempting an ED reduction on every patient is safe from a medical perspective, which would eliminate selection bias of patients with medical comorbidities or other factors that precluded ED reduction attempts in our study. Furthermore, the development of a standard ED sedation protocol would aid in evaluating the success of closed reduction in the ED. Additionally, the development of a treatment algorithm for revision THA patients or those with constrained implants is necessary since this study only evaluated primary THA patients.

Finally, given the small number of patients who failed reduction in the ED and went on to successful reduction in the OR, as well as small number requiring an open procedure in the OR, a future, study with a larger cohort would be required to discern if there are differences in course of care, LOS, or cost of care in patients who had a failed ED attempt prior to successful reduction in the OR compared with those sent directly to OR, or differences between closed and open management.

Conclusions

The increasing incidence of THA inevitably leads to an increasing burden of dislocation, which is often initially identified in the ED. Our study has shown the location of where hips are currently reduced can markedly impact the patient's course of care and cost of care. This study illustrates that a high rate of success of ED closed reduction and associated cost reduction can be achieved, thus future prospective studies are warranted to safely increase the number of closed reduction attempts in the ED.

Conflicts of interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: J. R. Martin is a paid consultant for DePuy Synthes. G. G. Pollowski receives royalties from DJ Orthopaedics; is a paid consultant for DJ Orthopaedics and Bone Support; and is a board member in the American Association of Hip and Knee Surgeons.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2022.03.002.

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