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Acetabular fractures in elderly patients are associated with high rates of complications during the initial admission

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ABSTRACT

Background Acetabular fractures among the elderly are common. Identification of risk factors predisposing elderly patients to in-hospital complications is critical to mitigating morbidity and mortality.

Methods A retrospective cohort study was performed including 195 patients ≥60 years old who sustained acetabulum fractures treated at a single level 1 trauma center. Operative (n=110, 56.4%) or non-operative management was undertaken, and complications during the index hospitalization were defined.

Results Seventy-three patients (37%) developed a complication during their hospitalization. Most common complications were acute respiratory failure: 13.3%, pneumonia: 10.3%, urinary tract infection: 10.3%, cardiac dysrhythmia: 9.7%, and acute kidney injury: 6.2%. On multivariable analysis, factors associated with in-hospital complications were increased age (adjusted OR (AOR): 1.06, 95% CI: 1.01 to 1.11, p=0.013), more comorbidities (AOR: 1.69, 95% CI: 1.07 to 2.65, p=0.024), operative management (AOR: 0.3, 95% CI: 0.12 to 0.76, p=0.011), and increased length of stay (AOR: 1.34, 95% CI: 1.2 to 1.51, p<0.001).

Conclusions Acetabular fractures in the elderly are associated with high rates of in-hospital complications. Advanced age, more medical comorbidities and longer lengths of stay predicted higher risk of developing complications. Whereas operative management was associated with lower risk of developing complications during the initial admission, it is important to note the selection bias in which healthier patients with improved baseline functionality may be more likely to undergo operative management.

Level of evidence Level III therapeutic.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The number of elderly patients with displaced acetabulum fractures is increasing. However, mechanistically, these fractures differ from most acetabulum fractures in younger patients. Displaced acetabulum fractures in younger, more active patients are often treated surgically to prevent post-traumatic arthrosis. Treatment indications and complications associated with injury and treatment among elderly patients are evolving and unclear.

WHAT THIS STUDY ADDS

⇒ Advanced age, more medical comorbidities and longer lengths of stay predicted higher risk of developing complications. Surgical treatment was favored among healthier, often younger patients, but surgery in all groups of elders was not predicted to be favorable.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study may prompt prospective data collection in a larger group of patients, to determine better indications for treatment.

BACKGROUND

The population is aging, and the burden of medical comorbidities, declining physical function, and poor bone health which accompany aging confer increased risk for major orthopedic injury.[1] Consequently, elderly patients represent the fastest growing subgroup of those sustaining acetabular fractures.[2] Recent epidemiologic work has shown a 2.4-fold increase in the incidence of acetabular fractures among patients 60 years and older during the past three decades.[3] Among young patients, acetabular fractures commonly occur after high-energy trauma,[4 5] whereas among elderly patients, a greater proportion of acetabular injury results from low-energy falls.[3–8]

Fragility fractures portend future morbidity and mortality.[9–14] The associated 1-year mortality rate after acetabular fracture in the elderly is between 8.1% and 25%.[7 10 15] Prior study of acetabular fractures in elderly populations has largely dealt with treatment modality (eg, non-operative, open reduction internal fixation (ORIF), acute total hip arthroplasty (THA)), to identify strategies to reduce mortality, enhance outcomes and limit secondary procedures, including conversion to THA. Despite interest in how to properly manage the elderly with acetabular fractures, little consensus exists. Therefore, the goals of the present study were (1) to report the frequency of complications during the index admission after acetabular fracture in patients 60 years and older, and (2) to identify risk factors associated with complications. We hypothesized that patients with younger age and/or fewer baseline medical comorbidities would have fewer early complications, regardless of type of treatment.

METHODS

Patient identification

After Institutional Review Board approval, an institution-wide database at an urban level 1 trauma center was developed. Skeletally mature

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patients who sustained acetabular fractures from June 1999 until December 2016 were gathered, which identified 1189 consecutive patients. Of these, 975 had complete clinical and radiographic data related to their injury and 195 patients were 60 years of age or older at the time of injury, meeting criteria for inclusion.

Data collection

Medical records were queried for demographics, injury characteristics and treatment parameters. Patient age, sex, tobacco smoking status, body mass index (BMI) and comorbid medical diagnosis were collected. Injury characteristics were similarly recorded including Injury Severity Score and mechanism of injury, which included both high-energy mechanisms (eg, falls from a height, motor vehicle collisions (MVCs), and pedestrians struck by moving vehicles) and low-energy mechanisms (eg, ground-level falls). Additional injuries sustained were collected. These were subclassified as those to the head, chest, abdomen, spine, pelvis and upper or lower extremities. Fractures were classified by Letournel and Orthopaedic Trauma Association/Arbeitsgemeinschaft fur Osteosynthesis classification systems as determined by a fellowship-trained orthopedic trauma surgeon based on available plain radiography and CT scans.[16 17]

Patients were treated both operatively or non-operatively, with decision of management strategy and surgical approach at the discretion of the treating surgeon. All patients treated surgically underwent ORIF via standard anterior or posterior approaches based on fracture pattern. Complications during the index hospitalization were collected based on documentation and imaging available within the electronic medical record. These included acute respiratory failure, acute kidney injury (AKI), pneumonia, urinary tract infection (UTI), ileus, electrolyte imbalances, cardiac dysrhythmia, deep vein thrombosis (DVT), pulmonary embolism (PE), sepsis, cerebrovascular accident (CVA), and cardiac arrest. DVTs were described as positive findings proximal to the knee on venous duplex scanning and PEs were diagnosed by positive spiral CT of the chest or positive ventilation/perfusion scan. Patients were followed for a minimum of 3 months after the index hospitalization.

Statistical analysis

Reporting bias was minimized by using the query function in the electronic medical record to reduce potential for missing data elements. These queries include assessment of clinical documentation and diagnostic coding. Statistical analysis was performed by a trained expert not involved in data collection or patient care to minimize analytical biases.

Univariate analysis was performed based on development of in-hospital complications. Categorical variables were assessed using Fisher's exact tests or X^2 tests, where appropriate. For all continuous data, normality tests were conducted before any testing of significance. Age, comorbidities, and length of stay were not normally distributed and were compared via Mann-Whitney U testing. Other continuous variables were compared using Student's t-tests; these were reported as the average value and SD. Subgroup analyses were performed for patients treated operatively and non-operatively. Subgroups were also developed for patients aged 60–70, 70–80, and greater than 80 years of age. Lastly, subgroups were developed for patients based on mechanism of injury. Variables with p value of <0.2 on univariate analysis and treatment modality (operative vs. non-operative) were entered into a backward stepwise logistic regression model to identify independent predictors of in-hospital complications during the index admission. Regression results were reported as the adjusted OR (AOR) with the associated lower and upper limit 95% CIs. Statistical significance was set at p<0.05.

RESULTS

During the study period, 195 patients aged 60 years or older were treated for acetabular fractures. The mean age was 71 years (SD=8.6) and 70.3% were male (table 1). Seventy-three patients (37%) developed complications during their index hospitalization. Comorbid medical conditions were pervasive with diabetes mellitus: 24.6%, coronary artery disease: 15.4% and chronic kidney disease (CKD): 5.6%, being the most common. A preponderance of patients sustained injuries secondary to MVC (41.5%), followed by ground-level falls (30.8%) and falls from a height (22.6%). Patients who developed complications were more often older, when compared with patients who did not develop complications (72.9 vs. 69.8 years, p=0.024). Patients who developed complications also had more associated diabetes (32.9% vs. 19.7%), prior CVA (11% vs. 1.6%) and CKD (11% vs. 2.5%), when compared with patients who did not develop complications (all p<0.05). Falls from a height were less associated with development of in-hospital complications, compared with those without (11% vs. 29.5%, p=0.003). There were no differences between groups in terms of sex, tobacco smoking status, or BMI.

One hundred and forty-five patients (74.3%) sustained associated injuries (table 2). These were often additional orthopedic injuries (58.5%), most often to the pelvis (27.7%), spinal column (19.5%), and upper extremities (18.5%). Concomitant chest wall injuries were present in 27.7% of patients. Associated both column (24.1%), anterior column posterior hemitransverse (16.9%), and posterior wall (16.4%) were the most common acetabular fracture patterns. Patients who developed complications during their index hospitalization had more associated spine fractures (32.9% vs. 11.5%) and chest wall injuries (39.7% vs. 20.5%) when compared with patients who did not develop in-hospital complications (both p<0.05). There were no statistically significant differences between groups in terms of Letournel fracture classification, concurrent hip dislocation, femoral head injury or marginal impaction.

Mean hospital length of stay was 8.3 days. Patients who developed complications had longer lengths of stay when compared with patients who did not develop complications (14.4 vs. 6.9 days, p<0.001). The most common in-hospital complications were acute respiratory failure: 13.3%, pneumonia: 10.3%, UTI: 10.3%, cardiac dysrhythmia: 9.7%, and AKI: 6.2% (table 3). No patients died during their hospital stay. On multivariable analysis, independent predictors of risk of developing in-hospital complications were increased age (AOR: 1.06, 95% CI: 1.01 to 1.11, p=0.013), number of comorbidities (AOR: 1.69, 95% CI: 1.07 to 2.65, p=0.024), operative management (AOR: 0.3, 95% CI: 0.12 to 0.76, p=0.011), and increased length of stay (AOR: 1.34, 95% CI: 1.2 to 1.51, p<0.001) (table 4).

One hundred and ten patients (56.4%) underwent operative management, and the mean time to surgery was 28.3 hours after presentation. These patients were more often younger (69.1 vs. 73.4 years) and more often male (76.4% vs. 62.4%) when compared with non-operative patients (both p<0.05) (table 5). There were no statistically significant differences in medical comorbidities based on treatment modality. However, operative patients were less often injured via low-energy ground-level falls (19.1% vs. 45.9%) but sustained more injuries secondary to high-energy MVC (52.7% vs. 27%) when compared with

Table 1 Demographics, medical history, and mechanism of injury stratified by presence of complications during the index hospitalization

	All patients (N=195)	Patients without in-hospital complications (N=122, 63%)	Patients with in-hospital complications (N=73, 37%)	P value
Age, years	71.0±8.6	69.8±7.9	72.9±9.3	**0.024**
Male	137 (70.3%)	85 (69.7%)	52 (71.2%)	0.82
Smoking status*				
Current	39 (20%)	17 (16.5%)	12 (18.2%)	0.78
Former	47 (24.1%)	25 (24.3%)	22 (33.3%)	0.20
Never	93 (47.7%)	61 (59.2%)	32 (48.5%)	0.17
BMI*	28.7±6.2	28.4±6.0	29.1±6.5	0.50
Comorbidities				
Average	0.6±0.8	0.4±0.7	0.8±0.1	**0.001**
Diabetes mellitus	48 (24.6%)	24 (19.7%)	24 (32.9%)	**0.038**
CAD	30 (15.4%)	16 (13.1%)	14 (19.2%)	0.26
COPD	9 (4.6%)	4 (3.3%)	5 (6.8%)	0.25
CVA/TIA	10 (5.1%)	2 (1.6%)	8 (11%)	**0.006**
CHF	4 (2.1%)	1 (0.8%)	3 (4.1%)	0.15
CKD/ESRD	11 (5.6%)	3 (2.5%)	8 (11%)	**0.021**
Mechanism of Injury				
Fall—ground level	60 (30.8%)	35 (28.7%)	25 (34.2%)	0.42
Fall—height	44 (22.6%)	36 (29.5%)	8 (11%)	**0.003**
MVC	81 (41.5%)	48 (39.3%)	33 (45.2%)	0.42
Pedestrian struck	8 (4.1%)	2 (1.6%)	6 (8.2%)	0.054
Crush/industrial	2 (1.0%)	1 (0.8%)	1 (1.4%)	1.00

Bold entries denote statistical significance.
*n=26 and n=41 patients with missing tobacco smoking and BMI data, respectively. P values represent comparisons made between patients with and without in-hospital complications.
BMI, body mass index; CAD, coronary artery disease; CHF, congestive heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; ESRD, end-stage renal disease; MVC, motor vehicle collision; TIA, transient ischemic attack.

non-operative patients (both p<0.001). Differences among the groups regarding the energy of injury appear associated with the types of fracture patterns and by features of fractures dependent on mechanism and energy of injury. Operative patients had more associated posterior wall posterior column (17.3% vs. 2.4%), more transverse with posterior wall (10% vs. 1.2%) and fewer transverse (2.7% vs. 20%) and associated both column (17.3% vs. 32.9%) fractures when compared with non-operative patients (all p<0.05). Operative patients also had more associated hip dislocations (48.2% vs. 9.4%), femoral head injuries (11.8% vs. 1.2%) and marginal impaction (32.7% vs. 4.7%) (all p<0.05). There were no differences in overall rates of associated injuries. This included similar associated rates of vertebral column fractures (17.3% vs. 22.4%) and chest injuries (30% vs. 24.7%) when comparing operative and non-operative patients, respectively. Operative patients had fewer associated pelvic ring fractures (21.8% vs. 35.3%) compared with non-operative patients, reaching borderline statistical significance (p=0.052). Operative patients developed complications during the admission hospitalization 35.5% of the time, compared with 40% for non-operative patients (p=0.55). When comparing operative and non-operative patients, this included similar rates of acute respiratory failure (14.5% vs. 11.8%, p=0.67), UTI (7.3% vs. 14.1%, p=0.15), pneumonia (10% vs. 10.6%, p=0.89), and AKI (4.5% vs. 8.3%, p=0.37), respectively.

DISCUSSION

Despite advancements in the management of complex acetabular fractures in the elderly, the 1-year mortality rate remains as high as 25%.[7 10 15] This says nothing of the complications which frequently occur after injury, negatively impacting the recovery trajectory of these patients and often contributing to worse outcomes. Much prior work regarding acetabular fractures in elderly populations has pertained to treatment modality. We noted 37% of patients developed at least one complication. Advanced age, more comorbid medical conditions, and longer lengths of stay are each independently associated with higher risk of in-hospital complications, whereas operative management of the acetabulum fracture conferred a lower risk. Inherent difficulty persists in treating these patients secondary to their osteoporotic bone, worse baseline functional status and limited physiologic reserve, which makes minimizing the high rates of morbidity and mortality challenging. To date, a limited study of the morbidity of acetabular fractures in the acute period, particularly as it relates to the initial admission hospitalization, has been undertaken. There has been sparse investigation as it relates to hospital course after elderly patients sustain acetabular fractures and what factors influence the progression of their recovery. Identification of modifiable factors is paramount to mitigating morbidity and mortality in this patient population.

In recent years, an increasing number of elderly patients are sustaining acetabular fractures secondary to low-energy trauma such as a fall from body height or chair level.[4 5] In patients with osteopenia, a fall onto the posterolateral hip drives the femoral head into the acetabulum with an anteromedially directed force, often leading to fracture of the anterior column.[3 18 19] Subsequently, some authors note associated both column and anterior column posterior hemitransverse patterns to be common among elderly populations with reported rates of 23% to 26% and 15% to 19%, respectively. For our patients, 24.1% of patients

Table 2 Injury characteristics stratified by presence of complications during the index hospitalization

	All patients (N=195)	Patients without in-hospital complications (N=122, 63%)	Patients with in-hospital complications (N=73, 37%)	P value
Any associated injury	145 (74.3%)	87 (71.3%)	58 (79.5%)	0.21
Any orthopedic injury	114 (58.5%)	66 (54.1%)	48 (65.8%)	0.11
Upper extremity fracture	36 (18.5%)	18 (14.8%)	18 (24.7%)	0.085
Spine fracture	38 (19.5%)	14 (11.5%)	24 (32.9%)	**<0.001**
Pelvic fracture	54 (27.7%)	37 (30.3%)	17 (23.3%)	0.29
Femur fracture	16 (8.2%)	10 (8.2%)	6 (8.2%)	1.00
Tibia/fibula fracture	17 (8.7%)	7 (5.7%)	10 (13.7%)	0.057
Foot/ankle fracture	9 (4.6%)	6 (4.9%)	3 (4.1%)	1.00
Any non-orthopedic injury	71 (36.4%)	38 (31.1%)	33 (45.2%)	**0.048**
Head/neck	17 (8.7%)	11 (9%)	6 (8.2%)	0.85
Chest	54 (27.7%)	25 (20.5%)	29 (39.7%)	**0.004**
Abdominal	10 (5.1%)	6 (4.9%)	4 (5.5%)	1.00
Letournel classification				
Posterior wall	32 (16.4%)	22 (18%)	10 (13.7%)	0.43
Posterior column	1 (0.5%)	0 (0%)	1 (1.4%)	0.37
Posterior wall+posterior column	21 (10.8%)	11 (9%)	10 (13.7%)	0.31
Transverse	20 (10.3%)	15 (12.3%)	5 (6.8%)	0.23
Transverse+posterior wall	12 (6.2%)	7 (5.7%)	5 (6.8%)	0.77
T-type	13 (6.7%)	9 (7.4%)	4 (5.5%)	0.77
Anterior wall	3 (1.5%)	2 (1.6%)	1 (1.4%)	0.88
Anterior column	13 (6.7%)	7 (5.7%)	6 (8.2%)	0.56
Anterior column posterior hemitransverse	33 (16.9%)	21 (17.2%)	12 (16.4%)	0.89
Associated both column	47 (24.1%)	28 (23%)	19 (26%)	0.63
Hip dislocation	61 (31.3%)	37 (30.3%)	24 (32.9%)	0.71
Femoral head injury	14 (7.2%)	11 (9%)	3 (4.1%)	0.20
Marginal impaction	40 (20.5%)	21 (17.2%)	19 (26%)	0.14

P values represent comparisons made between patients with and without in-hospital complications.
Bold entries denote statistical significance.

sustained an associated both column pattern, followed by anterior column posterior hemitransverse: 16.9%, and posterior wall: 16.4%. Some authors have noted decreased joint survivorship for acetabular injury after low-energy trauma, possibly secondary to higher rates of non-anatomic reduction among patients with associated both column patterns.[20] In our study, we found no associations between fracture classification, hip dislocation, femoral head injury or marginal impaction and the development of complications during the admission hospitalization.

Table 3 In-hospital complications during the index hospitalization

	Number of patients (%)
Any complication	73 (37%)
Acute respiratory failure	26 (13.3%)
Pneumonia	20 (10.3%)
Urinary tract infection	20 (10.3%)
Cardiac dysrhythmia	19 (9.7%)
Acute kidney injury	12 (6.2%)
Electrolyte imbalance	8 (4.1%)
Ileus	7 (3.6%)
Deep vein thrombosis	4 (2.1%)
Cerebrovascular accident	3 (1.5%)
Cardiac arrest	3 (1.5%)
Sepsis	2 (1.0%)
Pulmonary embolism	1 (0.5%)

However, the effects of fracture pattern and treatment type or quality on radiographic outcome were not included in this study.

Postoperative complications after acetabular fracture have been well documented. Various authors have noted deep infection in 0.9% to 6.8%,[21–24] DVTs in 4.7% to 7%,[22 25 26] PEs in 1.1% to 3.6%,[23 24] nerve injury in 2.5% to 7.7%,[26–28] and symptomatic heterotopic ossification (HO) in 2.1% to 21.9%.[26 27] Despite that complications have been well investigated, several important limitations persist. None of these studies distinguish between complications developed during the initial admission hospitalization versus those occurring after hospital discharge. These studies also include patients of all ages, and the results are therefore not generalizable to an elderly population. There is also a limited documentation of complications that are not

Table 4 Independent predictors of risk of in-hospital complications on stepwise logistic regression

Variables	Adjusted OR	Lower limit 95% CI	Upper limit 95% CI	P value
Age (years)	1.058	1.012	1.105	**0.013**
Number of comorbidities	1.685	1.071	2.649	**0.024**
Marginal impaction	2.529	0.962	6.644	0.06
Operative management	0.299	0.118	0.757	**0.011**
Length of stay (days)	1.342	1.197	1.505	**<0.001**

Bold entries denote statistical significance.

Table 5 Comparison of patients stratified by operative vs. non-operative treatment

	Operative (N=110, 56.4%)	Non-operative (N=85, 43.6%)	P value
Demographics			
Age, years	69.1±7.6	73.4±9.2	**<0.001**
Male	84 (76.4%)	53 (62.4%)	**0.04**
Medical comorbidities			
Diabetes mellitus	26 (23.6%)	22 (25.9%)	0.74
Coronary artery disease	19 (17.3%)	11 (12.9%)	0.43
COPD	6 (5.5%)	3 (3.5%)	0.73
CVA/TIA	6 (5.5%)	4 (4.7%)	1.00
Congestive heart failure	2 (1.8%)	2 (2.4%)	1.00
CKD/ESRD	4 (3.6%)	7 (8.2%)	0.22
≥2 comorbidities	17 (15.5%)	8 (9.4%)	0.28
Mechanism of injury			
Fall—ground level	21 (19.1%)	39 (45.9%)	**<0.001**
Fall—height	26 (23.6%)	18 (21.2%)	0.73
Motor vehicle collision	58 (52.7%)	23 (27%)	**<0.001**
Pedestrian struck	4 (3.6%)	4 (4.7%)	0.73
Crush/industrial	1 (0.9%)	1 (1.2%)	0.85
Any associated injury	80 (72.7%)	65 (76.5%)	0.62
Any additional orthopedic injury	63 (57.3%)	51 (60%)	0.77
Letournel classification			
Posterior wall	22 (20%)	10 (11.8%)	0.17
Posterior column	0 (0%)	1 (1.2%)	0.90
Posterior wall+posterior column	19 (17.3%)	2 (2.4%)	**<0.001**
Transverse	3 (2.7%)	17 (20%)	**<0.001**
Transverse+posterior wall	11 (10%)	1 (1.2%)	**0.025**
T-type	8 (7.3%)	5 (5.9%)	0.92
Anterior wall	1 (0.9%)	2 (2.4%)	0.82
Anterior column	7 (6.4%)	6 (7.1%)	0.85
Anterior column posterior hemitransverse	20 (18.2%)	13 (15.3%)	0.70
Associated both column	19 (17.3%)	28 (32.9%)	**0.018**
Hip dislocation	53 (48.2%)	8 (9.4%)	**<0.001**
Femoral head injury	13 (11.8%)	1 (1.2%)	**0.01**
Marginal impaction	36 (32.7%)	4 (4.7%)	**<0.001**
Any complication	39 (35.5%)	34 (40%)	0.55

Bold entries denote statistical significance.
CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; ESRD, end-stage renal disease; TIA, transient ischemic attack.

directly related to the acetabular injury but are a consequence of the prolonged hospitalization and protracted recovery necessitated by this injury in elderly patients.

Complications which occur during the admission hospitalization pose a substantial hurdle after acetabular fracture. In a study of 645 consecutive patients with mechanically unstable pelvic ring and acetabular fractures, 17% of patients developed complications during the initial hospitalization, which included pulmonary complications, DVTs, sepsis, organ failure and death.[22] Arroyo *et al* studied 41 297 cases of pelvic and acetabular fractures from the National Sample Program of the National Trauma Databank.[29] The authors also noted a 17% complication rate with a breakdown of cardiac events in 2%, venous thromboembolism in 4% and infections in 3%.[29] In a retrospective study of 106 adult patients with operatively managed acetabular fractures, Fairhurst *et al* noted a 34.9% complication rate.[30] Although the authors did not include the specific complications these patients developed, they did note that 60% were Clavien-Dindo score 1 indicating no need for pharmacologic, surgical, or radiological intervention.[30] These studies have made headway through reporting of complications which portend protracted hospitalization and possible death, particularly among elderly patients with decreased physiologic reserve. However, none reported an exhaustive list of the hospital-related complications that occur. Possibly this is because certain complications may not pose an increased morbidity or mortality risk, although they may contribute to longer hospital stays and greater economic cost, in addition to impacting ability to participate in physical rehabilitation.

In the present study, 37% of patients developed complications, indicating a high complication rate, likely due to patient age and comorbidities, consistent with our hypothesis. Most commonly identified were acute respiratory failure: 13.3%, pneumonia: 10.3%, UTI: 10.3%, cardiac dysrhythmia: 9.7%, and AKI: 6.2%. Severe complications were far less common including three patients (1.5%) with CVAs, three (1.5%) with cardiac arrest, and two (1.0%) with sepsis. Vallier *et al* observed that 9% developed pulmonary complications in their cohort, which included acute respiratory distress syndrome (ARDS), pneumonia, and PE.[22] The higher rate of pulmonary complications seen in the present study can likely be attributed to age: the mean age in their work was 40.3 years versus 71 among our patients.[22]

What places patients at increased risk of developing complications? Prior reports noted that early definitive fixation (<24 hours after injury) was associated with fewer complications including any pulmonary complication (pneumonia, ARDS, PE) when compared with patients who underwent later fixation.[22] With their model, Fairhurst *et al* found an increase in preoperative risk score by one unit increased the odds of developing a complication by a factor of 17.34.[30] Notably, their preoperative risk score included age, comorbid medical disease (severe heart or pulmonary disease, or diabetes mellitus), baseline functional status and American Society of Anesthesiologists (ASA) physiological status classification.[30] Neither of these studies specifically investigated elderly patients. For 78 patients ≥60 years with operatively managed acetabular fractures, Sanders *et al* reported a complication rate similar to ours, at 35.9%, including osteoarthritis: 20.5%, conversion to THA: 14.1%, deep infection: 5.1% and revision for fixation failure: 1.3%.[20] The authors noted that patients with injuries secondary to low-energy trauma were more likely to have complications after ORIF.[20] In the present study, low-energy injuries were more likely to be managed non-operatively. This may be due to lower-energy injuries resulting in more mechanically stable fractures, which may lend themselves to non-operative treatment. It may also reflect that with increasing frailty, patients are more likely to incur falls, and subsequently also more likely to sustain acetabular fractures secondary to a low-energy fall. In terms of complication risk, our study observed that older age, more comorbid medical conditions, and longer lengths of stay were associated with developing complications, whereas operative management of fractures conferred a lower risk, although the rates of any complication among the operative and non-operative patients were 35.5% and 40%, respectively. We propose that patients with high-energy injuries may be younger and healthier at baseline, thus more able to tolerate surgery, which is more often recommended for higher-energy fracture patterns. Subsequently, this group may be less likely to incur in-hospital complications.

Historically, some studies had reported satisfactory results with non-operative management. Spencer studied 25 patients >65 years with non-operatively managed acetabular fractures, noting 64% achieved satisfactory results.[31] More recently, in a cohort study comparing 37 patients with operatively managed acetabular fractures versus 49 patients with non-operative management, Walley *et al* noted no difference between length of stay, return to baseline ambulatory status, and 1-year mortality based on treatment modality.[32] In a case series of 27 patients (60 years and older) with displaced acetabular fractures meeting operative criteria which were managed non-operatively, satisfactory Western Ontario and McMaster Universities Arthritis Index (WOMAC) and Short Form 8 (SF-8) scores indicated less disability when compared with patients who underwent conversion to THA.[33] In 176 elderly patients with low-energy fragility fractures of the acetabulum, Wollmerstadt *et al* noted no differences in functional outcome scores between operatively and non-operatively managed patients.[34]

The findings of our current study seem to contradict the results of prior work. Some of this may be attributable to inherent selection bias. Wollmerstadt *et al* noted this in their work, whereby non-operative patients had worse baseline health and would likely not tolerate an extensive surgery.[34] In fact, they remarked that non-operative patients in their study tended to be older, more often female, and had higher ASA scores.[34] Therefore, the results of our study present a similar conundrum. Operative treatment alone may not confer a decreased risk of developing in-hospital complications. But rather, the patients who undergo operative management are better surgical candidates who have lower baseline risk of developing complications.

This study has several limitations. First, it carries all the limitations of a retrospective design, including recall and reporting biases. Second, selection bias is likely present with regard to treatment modality. This is a non-randomized study in which decision-making was left to the treating surgeon; thus, the ability of our analysis to identify associations of complications with type of treatment was limited. However, this is a pragmatic study executed at an academic center in which patients were under the care of fellowship-trained orthopedic trauma surgeons with extensive expertise in managing these fractures. Finally, this study used an age of 60 years to define elderly patients. This is an arbitrary value, but represents one often used in the literature. There is no evidence to suggest that this age provides a meaningful dichotomy, as the authors note the importance of physiologic age over chronological age.

In conclusion, this study found that complications during the initial admission hospitalization were common, with 37% of patients developing at least one complication. Advanced age, more comorbid medical conditions, and longer lengths of stay are each independently associated with higher risk of in-hospital complications, whereas operative management of the acetabulum fracture conferred a lower risk.

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