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Research Article

Preoperative Optimization of Geriatric Hip Fractures Using a Detailed Multidisciplinary Protocol

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Abstract

Objective: To compare morbidity, mortality and institutional costs for hip fracture patients after implementation of an interdisciplinary protocol to expedite preoperative optimization at our institution.

Design: Single center, prospective cohort study.

Setting: Single tertiary medical center.

Patients: This study included patients with diagnosed hip fractures age 65 and older in both pilot (26 patients) and pre-pilot (43 patients) cohorts requiring surgical intervention who met inclusion and exclusion criteria.

Intervention: An interdisciplinary protocol was implemented for preoperative optimization of patients requiring surgical fixation of hip fractures which included standardized preoperative labs, tests and a pre-determined maximum time allotted for evaluating patients by consulting services.

Outcome Measurements: Primary outcomes assessed included in-hospital mortality, 30-day and 90-day mortality. Secondary outcomes included adverse patient events, 30 and 90-day readmissions, postoperative ICU admissions and institutional costs per admission.

Results: In the pilot group, there were statistically significant decreases in 90-day mortality, 30-day readmission rates and ICU admissions. A 26.1% decrease in average direct cost to the hospital per patient was observed between Pre-pilot ($16,775.65) and Pilot ($12,397.22) groups.

Conclusion: This study outlines the importance of a detailed protocol to expedite surgical intervention. It demonstrates effectiveness of patient outcomes for treatment of hip fractures in a patient population with average comorbidity index scores higher than similar studies. Protocol implementation also resulted in a dramatic decrease in overall costs at our institution, which is important as our current medico-economic environment focuses on minimizing excessive medical expenditures nationwide.

Level of Evidence: II

INTRODUCTION

Hip fractures have become an increasing public health concern worldwide, and represent one of the most common orthopedic diagnoses leading to hospital admission, morbidity, and mortality in the elderly population [1]. Persons 65 years of age and older account for about 90% of all hip fractures each year, [1] and the US Census Bureau predicts that the number of people in this age range will double in the next 25 years [2]. There are an estimated 350,000 hip fractures every year in the United States, and it is predicted that, by 2040, this number will grow to over 500,000 annually [3] Because hip fractures predominantly occur in older adults, [1] patients often have comorbid conditions which put them at a higher risk of developing complications during hospitalization. These patients must be appropriately managed medically and surgically. Less than optimal management can result in complications leading to poor outcomes including functional decline, long term care needs, and death.

Hip fractures have become very costly to hospitals and health care systems around the country. In 2003, the American Academy of Orthopedic Surgeons (AAOS) estimated that the average inpatient cost of hip fractures was $26,912 [4]. In 2004, the estimated inpatient cost of hip fracture care was $10.1 billion in the United States, and it has been projected that by 2040 the overall costs may reach $240 billion annually if current trends in population growth continue as expected [5]. The strongest predictors of total hospital charges for hip fractures have been shown to be length of stay (LOS), in-hospital complications, and patient comorbidities [6]. Several studies published in the last decade have demonstrated that a co-managed, protocol driven hip fracture program for elderly patients reduces LOS and inpatient complications, resulting in significant in-hospital cost savings in nearly all expenditure categories [7-9].

Almost all hip fractures require surgical intervention, predominantly for restoration of function, mobility, and minimization of pain. Several studies have also shown that a delay in surgery increases morbidity and mortality, especially when the delay is greater than 48 hours from the time of admission [10-16]. In 2014, the American Academy of Orthopedic Surgeons published evidence-based clinical practice guidelines for management of hip fractures in the elderly. These guidelines recommend that surgery be done within 48 hours of admission to decrease mortality, pain, complications, and length of stay [17].

Given the evidence, we developed a protocol to decrease variability and increase timeliness in preoperative management of elderly patients with hip fractures at our institution. The purpose of this protocol is to expedite preoperative medical optimization and risk stratification to minimize time to definitive surgical fixation. We aim to avoid unnecessary consults, tests, and subsequent delay in surgery. In doing so, we hypothesized that there would be an increase in the percentage of patients receiving the appropriate surgical management within 48 hours of diagnosis. Subsequently, we postulated that the pilot cohort would experience an improved hospital course (decreased ICU admissions, in-hospital complications, and hospital LOS), decreased readmissions, mortality and costs.

METHODS

In August 2016, our new hip fracture protocol was finalized and implemented with the help of our interdisciplinary team which consisted of clinical faculty from the departments of orthopedics, internal medicine, vascular medicine, cardiology, anesthesiology, and representatives from the Clinical Improvement Administration. Our protocol is intended for management of hip fractures (femoral neck, intertrochanteric, or subtrochanteric) in patients age 65 years or older presenting to our emergency department or via transfer from an outside facility. Patients with diagnosed pathologic fractures, previous orthopedic surgery to the affected hip, or those who refused surgical treatment were excluded from this protocol.

In our model, the protocol was activated at the time initial radiographs demonstrated an acute hip fracture in patients who arrived through the emergency room, or at the time of admission to the floor for patients transferred directly from an outside hospital with a hip fracture. Once the diagnosis of a hip fracture was made, the on-call orthopedic resident was notified and promptly evaluated the patient for further pre-operative optimization. The patient was admitted to the orthopedic service. All patients underwent standardized lab analysis and radiographic evaluation (Table 1). There were set of established indications used to guide the decision making process when determining the necessity of an internal medicine consult. If deemed necessary, the medicine consult staff then conducted a preoperative risk assessment and optimization. The decision to involve specialty consulting services (ie: Cardiology, Pulmonary) was left up to the medicine team. Response time goals were established for each of the main consulting services to help expedite the preoperative optimization process shown in Table 2. Criteria were also established regarding when to order pre-operative chest x-rays and lower extremity ultrasounds for the evaluation of the presence of deep vein thrombi (defined by the Wells DVT Criteria), shown in Tables 3 and 4 respectively. Predetermined indications were also established for an Anesthesia consult, shown in Table 5. A standardized Hip Fracture H&P template note was created to simplify these decision points for the surgeon by creating a visual check list. This H&P template note as well as the order set containing standard labs and imaging were embedded in the electronic medical record (EMR) for ease of use.

After approval of this continuous quality improvement process by the Institutional Review Board, patients who met inclusion/exclusion criteria were consecutively enrolled from August 2016 to March 2017 at Cleveland Clinic Main Campus Medical Center. These patients were placed into our pilot cohort. A pre-pilot cohort was obtained from a 7-month time period leading up to protocol initiation. Outcome measures were collected from our institutions EMR and included: time to surgery, hospital length of stay, patients to surgery <48 hours, in-hospital mortality, 30-day mortality and readmission, 90-day mortality and readmission, ICU admission and length of stay, in hospital complications, and consult times. Information pertaining to total direct cost to the hospital was obtained by our institute's finance director. The data collection was conducted by chart review in a prospective fashion, and the results were recorded and reviewed bi-weekly by the hip fracture team to ensure that the protocol was being implemented correctly. Data was collected and analyzed by our team with the help of the department's statistician.

Table 1: standardized lab analysis and radiographic evaluation.

Standardized Orders		
Laboratory Studies	**Imaging Studies**	**Cardiac Study**
Complete blood count	AP Pelvis radiograph	Electrocardiogram
Complete metabolic panel	Full length femur AP and lateral radiographs	
Prothrombin time/International Normalized Ratio (INR)		
Activated partial thromboplastin time (aPTT)		
Type and screen (T&S)		
Crossmatch if antibodies on T&S		
Urinalysis		

Table 2: Preoperative optimization process.	
Medical Center Consulting Services:	Response Time:
Internal Medicine	< 3 hours
Cardiology	4-6 hours
Vascular Medicine	4-6 hours
Anesthesia	<12 hours

Table 3: Pre-operative chest x-rays and lower extremity ultrasounds.
Chest X-ray Criteria:
1. Acute lung symptoms
2. History of lung disease with no chest x-ray within past 6 months
3. If Cardiology or Pulmonary consult is needed

Table 4: Pre-operative chest x-rays and lower extremity ultrasounds.
Wells DVT Criteria:
1. Active cancer – Treatment or palliation within 6 months
2. Bedridden recently ≥ 3 days or major surgery within 12 weeks
3. Calf swelling >3 cm compared to the other leg
4. Collateral (non-varicose) superficial veins present - Measured 10cm below tibial tuberosity
5. Entire leg swollen
1. Localized tenderness along the deep venous system
2. Pitting edema, confined to symptomatic leg
3. Paralysis, paresis, or recent plaster immobilization of the lower extremity
4. Previously documented DVT
5. Alternative diagnosis to DVT at least as likely

Table 5: Predetermined indications were also established for an Anesthesia consult.
Anesthesia Consult Criteria:
1. History of difficult airway
2. History of anesthesia complication to the patient or life threatening complication to one of his relatives
3. History of severe cardiopulmonary disease (severe AS, severe pulmonary hypertension, HOCM, Low EF, uncontrolled hypertension)
4. Patient in ICU
5. Patient with altered mental status or dementia
6. Jehovah's witness patients

Statistical methods including Welch's two-sample t-test, Wilcoxon rank sum test, Pearson's chi-square (χ2) test, and Fischer's exact test were used to determine that the pre-pilot and pilot cohorts were similar to each other by looking at average patient age, ASA score and Charlson Comorbidity Index. The Wilcoxon rank sum test was also used to compare the length of stay, hours to surgery, ICU length of stay, and consult times. In-hospital mortality, 30-day readmission and mortality, 90-day readmission and mortality, in-hospital complications, time to surgery, and post-surgical ICU admission were compared using Fischer's Exact test, as the number of events recorded in the pilot cohort were 5 or less in all of these outcomes measured. The 90-day readmission combined with 90-day mortality were compared between cohorts using the Pearson chi-square (χ^2) test.

RESULTS

A total of 26 patients comprised the pilot cohort and a total of 43 patients comprised the pre-pilot cohort. Comparison of patient age, Charlson Comorbidity Index and ASA classification were assessed and found to be similar in both groups (Table 5). The median Charlson Comorbidity Index for both the pilot and pre-pilot cohorts was 3.0 [2.0, 5.0] (p=0.99). The average age of the pre-pilot group was 81.4±6.7 and the average age for the pilot cohort was 81.4±6.1 (p=0.99). Each patient was assigned an ASA score by the treating anesthesiologist and there was no statistical difference between the groups (p=0.58). Thirteen orthopedic surgeons were involved in providing surgical treatment. Fisher's Exact Test was used to assess for significant differences between the two cohorts and none was found (p=0.22).

For those patients requiring an internal medicine consult, there was a significant decrease in time to evaluation in the pilot group. Consult time was decreased from 8.8 hours to 3.5 hours in the pre-pilot *vs* pilot groups respectively (p<0.001) (Table 7). Cardiology consult time was also decreased by 8.4 hours, from 9.1 to 0.68 hours in the pre-pilot versus pilot groups respectively in those patients requiring cardiology evaluation of pre-operative optimization (p=0.011) (Table 7).

Secondarily, median hours to surgery decreased from 34.0 in the pre-pilot group to 23.0 in the pilot group (p=0.077). The percent of patients who went to surgery in less than 48 hours increased from 67.4 in the pre-pilot group to 88.5 in the pilot group (p=0.082).

Length of stay decreased by 1.2 days after implementation of the protocol from a median of 7.6 days in the pre-pilot cohort to a median of 6.4 days in the pilot cohort. Although this was not a statistically significant difference (p<0.23), there was an observed downward trend.

Of the 43 pre-pilot patients, 16 (37.2%) required post-surgical ICU admission. Pilot cohort post-surgical ICU admission rates were significantly lower with admission of only 11% of patients to the ICU (p<0.05) (Table 6, Figure 3). In-hospital mortality also decreased from 9.3% in the pre-pilot cohort to 0% in pilot group (p=0.29). At 30 days, mortality decreased by 7.8% in the pilot group (p=0.40) from 11.6% to 3.8%. 90 day mortality rates were significantly lower in the pilot cohort compared to the pre-pilot cohort (3.9% and 27.9% respectively, p<0.05).

Hospital readmission was also assessed at 30 and 90 days post-operatively. At the 30-day endpoint, there was a statistically significant difference in readmission rates between the two groups with 11 readmissions in the pre-pilot cohort (25.6%) and zero readmissions (0%) in the pilot cohort (p=0.005) (Table 7). At 90 days post-op, an insignificant downward trend was shown with 15 readmissions in the pre-pilot cohort (34.9%) and 5 readmissions (19.2%) in the pilot cohort at 90 days, indicating a decrease in the pilot cohort by 15.7% (p=0.185) (Table 7). Ninety-day readmission combined with 90-day mortality was also compared in the two cohorts, demonstrating a significant 30.4% decrease with the pilot cohort (p=0.013) (Table 7).

Table 6: Statistics presented as Mean ± SD, Median [P25, P75], Median (min, max) or N (column %).

Factor	Total (N=69)	Pre-Pilot (N=43)	Pilot (N=26)	p-value
Charlson Comorbidity Index	3.0[2.0,5.0]	3.0[2.0,5.0]	3.0[2.0,5.0]	0.99[b]
Age (years)	81.4±6.4	81.4±6.7	81.4±6.1	0.99[a]
ASA				0.58[d]
. **2**	2(2.9)	1(2.3)	1(3.8)	
. **3**	26(37.7)	16(37.2)	10(38.5)	
. **3E**	5(7.2)	2(4.7)	3(11.5)	
. **4**	29(42.0)	18(41.9)	11(42.3)	
. **4E**	7(10.1)	6(14.0)	1(3.8)	
Surgeon				0.22[d]
. **A**	1(2.1)	1(4.2)	0(0.0)	
. **B**	15(31.3)	7(29.2)	8(33.3)	
. **C**	3(6.3)	2(8.3)	1(4.2)	
. **D**	6(12.5)	3(12.5)	3(12.5)	
. **E**	3(6.3)	1(4.2)	2(8.3)	
. **F**	1(2.1)	1(4.2)	0(0.0)	
. **G**	4(8.3)	4(16.7)	0(0.0)	
. **H**	7(14.6)	3(12.5)	4(16.7)	
. **I**	1(2.1)	0(0.0)	1(4.2)	
. **J**	3(6.3)	0(0.0)	3(12.5)	
. **K**	1(2.1)	1(4.2)	0(0.0)	
. **L**	1(2.1)	1(4.2)	0(0.0)	
. **M**	2(4.2)	0(0.0)	2(8.3)	

p-values: a= Welch's two-sample *t*-test, b=Wilcoxon rank sum test, c=Pearson's chi-square test, d=Fisher's Exact test.

Table 7: Statistics presented as Mean ± SD, Median [P25, P75], Median (min, max) or N (column %).

Factor	Total (N=69)	Pre-Pilot (N=43)	Pilot (N=26)	p-value
Length of Stay (days)	6.8[5.7,9.7]	7.6[5.8,10.5]	6.4[5.0,9.2]	0.23[b]
Hours to Surgery	23.9[18.7,43.7]	34.0[21.3,54.4]	23.0[17.4,26.9]	0.077[b]
ICU Length of Stay (hours)	51.6[22.9,89.4]	51.9[30.7,82.4]	23.6[21.7,210.5]	0.91[b]
Internal Medicine Consult Time (hours)	5.8[3.3,14.2]	8.8[4.4,16.6]	3.5[2.5,5.3]	***<0.001[b]***
Cardiology Consult Time (hours)	3.5[0.90,11.4]	9.1[3.2,12.1]	0.68[0.36,2.7]	***0.011[b]***
Anesthesia Consult Time (hours)	6.2[2.7,9.8]	8.6[4.8,13.4]	4.1[1.3,7.5]	0.25[b]
Vascular Medicine Consult Time (hours)	5.8[2.3,14.2]	5.3[3.6,10.7]	7.9[2.0,14.2]	0.99[b]
Patients in Surgery < 48 hours				0.082[d]
. **No**	17(24.6)	14(32.6)	3(11.5)	
. **Yes**	52(75.4)	29(67.4)	23(88.5)	
In-Hospital Mortality				0.29[d]
. **No**	65(94.2)	39(90.7)	26(100.0)	
. **Yes**	4(5.8)	4(9.3)	0(0.0)	
30-Day Mortality				0.40[d]
. **No**	63(91.3)	38(88.4)	25(96.2)	
. **Yes**	6(8.7)	5(11.6)	1(3.8)	
90-Day Mortality				
. **No**	56 (81.2)	31 (72.1)	25 (96.2)	***0.023[d]***
. **Yes**	13 (18.8)	12 (27.9)	1 (3.9)	

Pressure Ulcers				0.99^{d}
. **No**	68(98.6)	42(97.7)	26(100.0)	
. **Yes**	1(1.4)	1(2.3)	0(0.0)	
DVT				0.99^{d}
. **No**	63(91.3)	39(90.7)	24(92.3)	
. **Yes**	6(8.7)	4(9.3)	2(7.7)	
PE				
. **No**	69(100.0)	43(100.0)	26(100.0)	
Pneumonia				0.99^{d}
. **No**	65(94.2)	40(93.0)	25(96.2)	
. **Yes**	4(5.8)	3(7.0)	1(3.8)	
Patients Requiring ICU Admission				***0.027^{d}***
. **No**	50(72.5)	27(62.8)	23(88.5)	
. **Yes**	19(27.5)	16(37.2)	3(11.5)	
30-Day Readmission				***0.005^{d}***
. **No**	58(84.1)	32(74.4)	26(100.0)	
. **Yes**	11(15.9)	11(25.6)	0(0.0)	
90-Day Readmission				
. **No**	49 (71.0)	28 (65.1)	21 (80.8)	0.185^{d}
. **Yes**	20 (29.0)	15 (34.9)	5 (19.2)	
90-Day Readmission + 90-Day Mortality				
. **No**	40 (58.0)	20 (46.5)	20 (76.9)	***0.013^{c}***
. **Yes**	29 (42.0)	23 (53.5)	6 (23.1)	

p-values: a=Welch's two-sample *t*-test, b= Wilcoxon rank sum test, c=Pearson's chi-square test, d=Fisher's Exact test.

Post-operative complications were quantified in each cohort. Pressure ulcers, pneumonia, pulmonary emboli and deep vein thrombi were taken into account and although there was a decrease among all, there was no significant difference in either group (Table 7).

In evaluating average direct cost to the hospital per hip fracture patient, there was a 26.1% decrease in cost per patient after implementation of the protocol between the Pre-pilot ($16,775.65) and Pilot ($12,397.22) groups.

DISCUSSION

The development and implementation of this protocol confirmed what was hypothesized regarding the time from hip fracture diagnosis to definitive orthopedic surgical intervention. Patients were evaluated earlier by internal medicine and cardiology consultant services and subsequently were able to be treated surgically earlier than the pre-pilot group.

There were several measurable improvements with the implementation of the interdisciplinary hip fracture protocol. There was a direct correlation between decreased consult times and 30-day readmission, 90-day mortality, 90-day readmission + 90-day mortality, and patients requiring ICU admission after implementation of the protocol. We also observed a trend toward decreased hospital length of stay, hours to surgery, ICU length of stay, in-hospital mortality, 90-day readmission, and percent of patients to the OR within 48 hours.

There are very few studies comparing the results between two groups before and after implementation of a true multidisciplinary protocol model in the United States. In regards to patient outcomes, the most noteworthy results were observed when comparing patient mortality. In one study conducted in the United States using a co-managed hip fracture model, the 90-day mortality rate was shown to be 11.8% [18]. After implementation of our protocol we observed a 24% decrease in 90-day mortality. In-hospital mortality between the two cohorts also showed a nonsignificant downward trend from 9.3% to 0%. Previous studies have demonstrated in-hospital mortality rates ranging from 3%-17.6% [19-21] in some models and 30-day mortality rates ranging from 12-13% [22,23] in two other models. Even though the in-hospital mortality and 30-day mortality of 0% and 3.8% respectively did not reach statistical significance, when compared to rates of other published hip fracture protocols our results demonstrated similar rates.

The average amount of time for the patient to be seen by the internal medicine and cardiology teams was significantly reduced under the guidance of the hip fracture protocol. We believe this to be a critical element in expediting patient care and ultimately, reducing time to definitive fracture management. This stemmed from a multidisciplinary discussion held to outline the protocol. It was agreed upon by each specialty as to what was appropriate and reasonable. In establishing a standard time to consult it allowed for medical pre-optimization to begin in a timely manner. The infrastructure, consulting services, and policies obviously vary from one medical center to the next and this exact protocol will not be a perfect fit for every institution. However, we believe this study demonstrates the importance of early surgical optimization and risk stratification when treating hip fractures in this population. It also demonstrates the effectiveness a standardized order set and H&P templated note can have on expediting patient care.

In addition, there was a 26.1% decrease in average direct cost to the hospital per hip fracture patient after implementation of the protocol between the Pre-pilot ($16,775.65) and Pilot ($12,397.22) groups. This is similar to the results of other successful interdisciplinary hip fracture protocols that have been published across the country, such as the University of Missouri and University of Rochester models. Both of which demonstrate a decrease in average hospital charges of 26.4% and 33.3% respectively after implementation of their own co-managed hip fracture protocols [24,25].

An important factor that should not be overlooked in our study was that we were able to show the effectiveness of our protocol in patients that had several health issues and comorbidities prior to surgery. The Charlson Comorbidity Index (CCI) is the most widely used comorbidity index and is used as a predictor of patient mortality [26,27]. Medical comorbidity is a strong risk factor for short term mortality [28,29] and the use of the CCI can be a vital tool in evaluating and comparing the effectiveness of different co-managed hip fracture protocols currently in use across the country. Higher CCI scores have been shown to correlate with increased 30-day mortality, 90-day mortality, in-hospital mortality as well as readmission rates after orthopedic procedures in patients with hip fractures [30-33] In a study published at Vanderbilt University, each unit increase in the CCI score corresponded to an increase in length of hospital stay and hospital costs. Patients with a CCI score of 2, on average, stayed 1.92 extra days in the hospital compared to those with a baseline CCI score of 0 and incurred $8,697.60 in additional hospital charges [34].

In the Rochester model described by Kates et al, patients enrolled in the hip fracture protocol had an average CCI score of 2.9 with a standard deviation of 2.1 [35]. In this study, the average CCI score was 3.6 with a standard deviation of 2.0. At the time this study was conducted, a literature search was performed and no other multidisciplinary fracture models had equivalent or higher documented average CCI scores among hip fracture patients. This is important to note because these patients are at a higher risk of short term mortality than previously published models. We believe that because our study was carried out on patients with higher comorbidities the results from this study may underestimate the effect that this model has on overall outcomes when extrapolated to the general.

Another benefit of this study comes from the fact that it is a single center, prospective cohort study which at the time of publishing is the first of its kind. This allowed for a standardized protocol to be implemented and tested without confounding bias stemming from differing hospital staff and infrastructure. However, we plan to implement the hip fracture protocol in affiliated regional medical centers since conducting this study.

Although this study was successful in demonstrating effectiveness of our interdisciplinary hip fracture protocol, there were some limitations. One weakness of the study was the population size. Our pilot cohort consisted of 26 patients. A power analysis showed that an additional 350 to 3600 patients were necessary in both patient groups to show a minimum clinically important difference of a 20% decrease, depending on the outcome of interest. We felt this would be difficult to achieve in a timely manner at a single medical center, and likely would require a larger multicenter study with similar protocols to observe these differences. Our study excluded patients younger than 65 so that we could compare our results to data from other studies and the Medicare database. In order to eliminate variables, we also excluded patients who underwent prior surgery to the affected hip and those fractures deemed to be pathologic. It would be interesting to evaluate the subset of periprosthetic hip fractures given increase in hip replacements in the United States as this is becoming more prevalent. Our study is also limited to 90-day outcomes. However, we intend to expand this protocol to other regional hospitals within the institution's health system, allowing for a much larger sample size and data set for a more robust statistical analysis. It is also our intent to conduct long term follow-up studies which evaluate one-year mortality rates and return to original residence at one year.

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