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Manuscript Title:

Hip Fracture Treatment at Orthopaedic Teaching Hospitals: Better Care at a Lower Cost

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Abstract

Objective: To compare the cost and outcomes of patients treated at orthopaedic teaching hospitals (OTH) compared to those treated at non-teaching hospitals (NTH)

Design: Retrospective study

Setting: The Statewide Planning and Research Cooperative Systems (SPARCS) database, which includes all admissions to New York State hospitals from 2000-2011.

Patients/Participants: 165,679 isolated closed hip fracture patients aged 65 and older met inclusion criteria. Of these, 57,279 were treated at OTH and 108,400 were treated at NTH.

Intervention: Admission for the management of a hip fracture.

Main Outcome Measure: Cost, length of stay, and inpatient mortality.

Results: Univariate analysis shows that mean total hospital costs were higher at OTH ($16,576 ± $17,514) versus NTH ($13,358 ± $11,366) ($p < 0.001$), LOS was equivalent at OTH (8.0 ± 9.0 days) versus NTH (8.0±7.6 days) ($p=0.904$) and mortality was lower in OTH (3.4%) versus NTH (4.0%) ($p<0.001$). In the multivariate total cost analysis, in addition to demographic differences, we identified total hospital beds and total ICU beds as significant confounding variables. Interestingly, when controlling for these patient and hospital factors, OTH designation was not a significantly predictor of cost. Additionally, multivariate analysis found that OTH status decreased LOS by 0.743 days (95% CI: 0.632-0.854, $p<0.001$) and mortality by 21% (OR 0.794, 95% CI: 0.733-0.859, $p < 0.001$), confirming the univariate trends.

Conclusions: While OTH may appear to have higher hospital costs for operative hip fractures on cursory analysis, controlling for patient and hospital factors including hospital bed number negates this effect such that OTH has no additional cost compared to NTH. In addition, OTH status is associated with shorter LOS and lower in-hospital mortality. With the results of this

study, health care systems and patients should feel confident that the quality of care at teaching hospitals is no less and potentially better than that at a non-teaching hospital with no added cost.

Key Words: hip;fracture;Teaching;hospital;quality;cost;mortality;surgery

Level of Evidence: Prognostic Level III. See Instructions for Authors for a complete description of levels of evidence.

INTRODUCTION:

Hip fractures are a well-reported source of significant morbidity, mortality, and cost in the elderly.[1,2] The worldwide annual incidence of hip fractures is approximately 1.6 million and this number is expected to increase to approximately 6.3 million by 2050.[3,4] In the United States alone, the absolute number of hip fractures in adults is projected to increase 12% from 258,000 in 2010 to 289,000 in 2030.[5] This increasingly prevalent fracture has been reported to reduce life expectancy by 1.8 years, have a 1-year mortality that is reported to be as high as 30%, and have an estimated lifetime cost of $81,300.[2,6,7]

The high cost and mortality of operative hip fractures has been attributed to a number of different sources. Factors associated with increased in-hospital mortality include long surgical delay, increased in-hospital complications, and increased number of comorbidities.[8,9] Increased hospital cost has been linked with large hospital size.[8,9] Recently, attention has been drawn to the seemingly high cost of healthcare at academic medical centers compared to community hospitals. In a retrospective cohort study, the cost of treating a hip fracture at a major teaching hospital with a Level I trauma center and more than 200 beds was found to be approximately $24,000, while the cost at a non-teaching hospital was around $6,000 less at $18,000.[10]

No study, to our knowledge, has examined outcomes of patients with operative hip fractures at hospitals affiliated with orthopaedic surgery residency programs, specifically. The purpose of this study is to examine the effect of orthopaedic teaching hospital (OTH) status on hospital quality measures and mortality. We hypothesize that when controlling for potential confounding factors, OTH will have lower mortality rates, length of stay, and hospital cost than non-OTH for hip fracture management.

METHODS:

From 2000 to 2011, all patients admitted to the hospital with the principal diagnosis of a hip fracture were queried from the New York Statewide Planning and Research Cooperative System (SPARCS) inpatient database. This database is a publicly available, de-identified source of discharge records for all New York State hospitals. It includes admission, diagnosis and procedure data, as well as demographic and hospital charge information.

Initially, all patients 65 years of age and older admitted with an ICD-9-CM diagnosis code indicating a fracture of the hip (820.00 – 820.9) were queried from the SPARCS database. Patients were excluded from the analysis if they were transferred from an outside hospital or had sustained an open fracture.

All orthopaedic residency programs in the state of New York (17 total) were contacted by telephone to determine the specific hospitals that hosted orthopaedic surgery residents during the study period. These hospitals were designated as orthopaedic teaching hospitals (OTH). Teaching hospitals that did not have orthopaedic surgery residents were not considered teaching

hospitals for the purpose of this analysis. Additionally, information about hospital bed numbers and any trauma center designations were obtained from the New York State Department of Health and linked to the SPARCS data. All residency programs included in the analysis were allopathic. While New York State has one osteopathic orthopaedic surgery residency program, this program was approved in 2011 and thus was not be included.

In an effort to account for differences in patient comorbidity burden, Charlson Comorbidity Index (CCI) scores were calculated for each patient based upon ICD-9-CM comorbid conditions reported for each admission record.[11] This comorbidity scoring index assigns a numerical weight to various comorbid conditions, such as heart disease, peripheral vascular disease and diabetes mellitus, in order to quantify a patient's illness burden. The cost for each admission was calculated by applying the cost-to-charge ratios obtained from Centers for Medicare & Medicaid Services Healthcare Cost Report Information System (HCRIS).[12]

Hierarchical multiple linear and logistic regression models were performed to determine how orthopaedic teaching hospital designation impacts in-hospital mortality, length of stay (LOS) and total hospital costs. Analyses controlled for patient age, gender, race, CCI, insurance status, fracture type, trauma level and hospital bed size by inserting these variables into the regression model prior to OTH status designation. Statistical assumptions were independently tested. $P < 0.05$ was considered significant. Means for primary outcomes are reported with ± 1 standard deviation. All calculations were performed using SPSS version 22 (SPSS Inc., Chicago, Illinois).

RESULTS:

Univariate Analysis

A total of 165,679 closed hip fractures patients met inclusion criteria and were included in the analysis. Of these fractures, 57,279 were treated at OTH and 108,400 were treated at non-teaching hospitals (NTH). Overall, gender distribution was similar for both groups (OTH 75.3% F vs. NTH 75.7% F, p = 0.091). Average age of the patients was 83.2 years at OTH and 83.3 years at NTH (p=0.418). Patients at NTH had a mimimally higher mean CCI (0.94) than patients at OTH (0.89) (p<0.001). Lastly, time to surgery was minimally longer at OTH compared to NTH (1.87 days vs. 1.80 days, p < 0.001).

Overall, mean total cost was higher at OTH ($16,576 ± $17,514) than NTH ($13,358 ± $11,366) (p < 0.001). Overall length of stay (LOS) was equivalent at OTH (8.0 ± 9.0 days) compared to NTH (8.0±7.6 days) (p=0.904) and mortality was lower in OTH (3.4%) compared to NTH (4.0%) (p<0.001).

Multivariate Analysis

In the multivariate model for total hospital cost (Table 1A), OTH designation was not an independent predictor of cost when controlling for differences between OTH and NTH (B=-1.9, 95% CI: -192.9-189.1, p=0.985). Hospital size as measured by Total Bed Count was noted to be a significant contributor to total hospital cost such that each additional 100 hospital beds contributed a predicted cost of $762.50 to the total hospital cost. Since we hypothesized that overall hospital size was playing a significant role in the increased cost seen in patients treated at OTH, the regression model was performed again without controlling for total bed size

and ICU bed size to quantify the impact of these two hospital factors. The resulting model identified OTH as a significant variable in determining total cost with OTH having predicted costs of $2,088 dollars more than NTH (95% CI: $1,922-$2,255, p<0.001) (Table 1B).

The multivariate analysis found that when controlling for all patient and hospital factors, OTH status decreased predicted LOS by 0.743 days (95% CI: 0.632-0.854, p<0.001) confirming the univariate trends (Table 2). Longer lengths of stay were associated with admission to regional trauma centers, increasing number of comorbidities (CCI), increasing age, male gender, and Medicaid insurance status. The decrease in LOS seen with OTH status was maintained when hospital size was dropped from the model.

Orthopaedic teaching hospital designation was also found to be associated with decreased in-hospital mortality (OR 0.794, 95% CI: 0.733-0.859, p < 0.001), confirming the univariate trends (Table 3). Other significant predictors of in-hospital mortality include male gender, increasing age, admission to a regional trauma center and an increasing number of medical comorbidities (CCI). Type of hip fracture was not a significant predictor of in-hospital mortality. This significant decrease in in-hospital mortality seen in the OTH cohort was also maintained when hospital size was dropped from the model.

DISCUSSION:

In an era of healthcare reform, there has been a large emphasis on the value, quality and safety of patient care. As such, academic hospital centers have been scrutinized for their seemingly higher costs relative to nonteaching hospitals and their overall value has been questioned. In this study, we sought to examine near-term hip fracture outcomes in orthopaedic teaching hospitals while controlling for patient- and system-level differences that may confound the raw data. When the raw data is examined, OTH appear to have lower mortality rates and similar lengths of stay albeit at a significantly higher cost. However, when controlling for confounding factors, we found that OTH deliver shorter lengths of stay and lower mortality rates than originally anticipated and are, in fact, not a factor in driving total hospital cost.

Prior to this study, the most exhaustive examination into the effect of hospital setting and teaching status on the outcomes of patients sustaining hip fractures was performed by Koval et al.[8] This study, which used the National Inpatient Sample to identify 226,239 patients sustaining hip fractures from 1998-2003, found mostly statistically, but not clinically significant differences between teaching and nonteaching hospitals. The only clinically significant difference found was that rural nonteaching hospitals had a significantly higher risk of a prolonged hospital stay (more than five days above the median). While this study did control for hospital size, it was forced to use a less specific definition for teaching hospitals due to limitations inherent in the NIS database recording.

Many studies have examined the cost of hip fracture care at teaching hospitals versus nonteaching hospitals. Most recently, McGuire et al. showed that teaching hospitals are more

expensive than nonteaching hospitals even after taking into account patient severity.[10] However, this study did not take into account hospital size as a potential confounder. Even in studies that do take hospital size into account, we are aware of no study which has used orthopaedic teaching hospitals specifically over the more general definition of teaching hospital, which may include hospitals without orthopaedic surgery resident coverage. Our study suggests that when you control for hospital size and use our strict definition of teaching hospital, teaching hospitals are associated with modestly decreased costs. This finding holds practical significance in an era of healthcare reform. The Patient Protection and Affordable Care Act (PPACA) provides funding for comparative- and cost-effectiveness research, which will likely explore the most effective and cost-efficient venues for patient treatment.[13] It is important that, as these investigations proceed, the scientific community provide evidence to policymakers and identify possible confounding factors that may influence perceived disparities between teaching and nonteaching hospitals. If one was to only observe this study's raw analysis, without an examination of the adjusted multivariate models, different conclusions would likely be drawn.

Investigations into factors affecting mortality after hip fracture have been numerous. While studies examining the effect of teaching hospital status on mortality rates have demonstrated a positive effect,[14,15] they have also shown that teaching hospitals tend to have a longer time to surgery than nonteaching hospitals and that this is an independent risk factor for mortality. Over the past decade, the relationship between hip fracture mortality in time to surgery have been extensively studied.[16-18] This finding has been corroborated most recently by Ryan et al., who examined a cohort of over two million patients and found that increasing hospital size and teaching hospital status are associated with surgical delays, which are independent risk factors

for mortality.[9] Our study did not analyze or control for time to surgery. However, despite this, we believe that our study puts into context the recent interest in time to surgery after hip fracture. Even if teaching hospitals have a longer time to surgery, our study suggests that the benefits of receiving care in an orthopaedic teaching hospital significantly outweigh any potential negative effects of surgical delays.

As suggested in other studies, it is not likely that teaching hospital status or resident involvement, per se, which provides the large clinical benefit observed in our study. While one study showed that resident involvement in orthopaedic surgery cases decreases complication and mortality rates,[19] other studies have shown no effect.[20,21] It is likely that patients benefit indirectly from other organizational factors. Weller et al. demonstrated that the training of medical personnel, such as a higher proportion of registered nurses and board-certified specialists, was the most strongly associated factor with lower mortality after hip fracture,[15] a finding which has been demonstrated in other studies in the literature.[22,23] However, there may be other factors at play that cannot be easily controlled for. Perhaps risk-adjusted outcomes appear better at teaching hospitals because the presence of residents and more clinical support staff leads to more accurate documentation of comorbidities than nonteaching hospitals.[15] However this is less likely an issue in our study since accurate reporting to the SPARCS database is mandatory for all hospitals in the State of New York.

This study has a number of limitations. For one, since SPARCS is a hospital-based database, we were only able to examine near-term outcomes. There are no records on long-term mortality, readmission rates or reoperations. There are also limitations to this study that are inherent to any

study that examines large, administrative databases. These limitations, which have been well described in the literature include potential input error and miscoding.[24-26] However, the New York State Department of Health has a robust audit and data monitoring system. Facilities noncompliant with data reporting and quality standards are subject to reimbursement rate penalties.

Despite the limitations, we believe that the study has several strengths that are worth recognizing. Most studies examining the effect of teaching hospital designation on fracture outcomes have defined teaching hospitals according to the Centers for Medicare and Medicaid Services (CMS) definition, which is any hospital that has received a Graduate Medical Education (GME) payment. However, not all hospitals that receive GME payments necessarily have orthopaedic surgery residents. Our study made contact with each residency program in the State of New York, individually, to determine the exact sites their programs covered throughout the entire study period. We believe that this addresses concerns about previous studies examining this issue and it allows a more accurate assessment of the impact of a teaching environment on patient care. Additionally, we performed a multivariate analysis that attempts to control for potentially confounding factors, such as patient age, gender, race and hospital size. While our study is only limited to the State of New York, the use of a statewide-database gives us the advantage of tight control over the definition of teaching hospital while still achieving a large sample size with adequate power to detect subtle differences.

CONCLUSION:

The presence of orthopaedic trainees as part of the care team for elderly hip fracture patients clearly has a positive impact on patient quality measures. While OTH may appear to have higher hospital costs for operative hip fractures when examining the raw data, controlling for patient and hospital factors including hospital bed number demonstrates no difference in total hospital costs between OTH and NTH. Furthermore, OTH status is associated with shorter LOS and lower in-hospital mortality. With the results of this study, health care systems and patients should feel confident that the quality of care at teaching hospitals is no less and potentially better than that at a non-teaching hospital with no added cost.

FIGURE LEGEND

Table 1A – Predictors of Increased Cost (in dollars) when controlling for Hospital Size

Table 1B – Predictors of Increased Cost (in dollars) without controlling for Hospital Size

Table 2 - Predictors of Length of Stay (days)

Table 3 – Predictors of In-Hospital Mortality

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Table 1A: Predictors of Increased Cost (in dollars) when controlling for Hospital Size*

		95% CI		
	B	**Lower**	**Upper**	**Sig**
Male Gender	1574.166	1418.219	1730.114	< 0.001
Age	12.242	3.366	21.118	0.007
CCI	1809.765	1754.201	1865.328	< 0.001
Medicaid	1484.276	964.828	2003.724	< 0.001
Other Federal	-1942.132	-3848.439	-35.826	0.046
Uninsured	1869.982	1179.072	2560.892	<0.001
Regional Trauma Center Designation	1302.156	1092.165	1512.148	< 0.001
Total Bed Count	7.625	7.026	8.223	< 0.001
Total ICU Beds	16.879	9.507	24.252	< 0.001

*** Variables found to be significant are included in this table. Note, when controlling for hospital size (total bed count, total ICU beds) Orthopaedic Teaching Hospital status is not a significant predictor of cost.**

Table 1B: Predictors of Increased Cost (in dollars) without controlling for Hospital Size*

		95% CI		
	B	**Lower**	**Upper**	**Sig**
Male Gender	1626.701	1469.851	1783.551	< 0.001
Age	12.065	3.152	20.979	0.008
CCI	1826.077	1769.968	1882.186	< 0.001
Medicaid	1618.998	1094.042	2143.954	< 0.001
Other Federal	-2688.429	-4652.353	-724.505	0.007
Uninsured	1197.187	512.327	1882.046	0.001
Regional Trauma Center Designation	2073.750	1863.954	2283.547	< 0.001
Orthopaedic Teaching Hospital Designation	2088.437	1921.738	2255.136	< 0.001

Variables found to be significant are included in this table. Note when hospital size (Total Bed Count, Total ICU Beds) is dropped from the multivariate model, Orthopaedic Teaching Hospital Designation becomes a significant predictor of cost, contributing $2088 more to the total cost than Non-Teaching Hospital Designation.

Table 2: Predictors of Length of Stay (days)*

		95% CI		
	B	**Lower**	**Upper**	**Sig**
Male Gender	0.845	.752	.938	< 0.001
Age	0.015	.010	.021	< 0.001
CCI	1.025	.992	1.058	< 0.001
Medicaid	1.806	1.493	2.116	< 0.001
Regional Trauma Center Designation	1.206	1.080	1.332	< 0.001
Total Hospital Beds	0.003	.002	.003	< 0.001
Total ICU Beds	-0.022	-.027	-.018	< 0.001
Orthopaedic Teaching Hospital Designation	-0.743	-.854	-.632	< 0.001

*** Variables found to be significant are included in this table**

Table 3: Predictors of In-Hospital Mortality*

		95% CI		
	Odds Ratio	**Lower**	**Upper**	**Sig.**
Male Gender	1.770	1.672	1.873	< 0.001
Age	1.060	1.056	1.064	< 0.001
CCI	1.581	1.554	1.608	< 0.001
Medicaid Insurance	5.624	1.371	23.075	.017
Medicare Insurance	5.330	1.323	21.476	.019
Private Insurance	5.133	1.272	20.718	.022
Other Federal	9.596	2.112	43.398	.003
Other Nonfederal	18.467	2.424	140.695	.005
Uninsured	4.835	1.168	20.024	.030
Regional Trauma Center Designation	1.422	1.302	1.553	< 0.001
Total ICU Beds	.996	.993	.999	.007
Orthopaedic Teaching Hospital Status	.794	.733	.859	< 0.001

*** Variables found to be significant are included in this table**