Hanes H. Brindley, Sr. Orthopaedic Lectureship and Orthopaedic Resident Research Forum

June 13, 2014
Hanes H. Brindley, Sr.

Orthopaedic Lectureship
and
Orthopaedic Resident Research Forum

Co-editors:
Douglas Fornfeist M.D.
Program Director,
Orthopaedic Residency Program

Gina Du Par
Medical Editor,
Publications Department
Hanes H. Brindley, Sr. M.D.

A native of Temple, the late Hanes H. Brindley, Sr., M.D. was a graduate of the University of Texas at Austin. He earned a medical degree from Washington University in St. Louis, Missouri, and completed a surgical internship at Charity Hospital in New Orleans in 1943. Following his internship, he joined the U.S. Army Medical Corps, serving in Europe during World War II. After returning to Texas, he completed a surgical residency at Scott & White and earned a master’s degree in anatomy from the University of Texas Medical Branch at Galveston. In 1950, Dr. Brindley completed a three-year orthopaedic residency at the W.C. Campbell Clinic at the University of Tennessee.

In 1951, he returned to Scott & White to practice orthopaedic surgery. He was Chief of the Division of Orthopaedic Surgery from 1974 until 1980.

As a member of the Board of Trustees of Scott & White Memorial Hospital and Scott, Sherwood & Brindley Foundation from 1968 to 1989, Dr. Brindley served as Secretary (1969 –1972); Second Vice President (1972 – 1979); and First Vice President (1979 – 1982). He was then elected President of the Board and served in that capacity until 1984.

In addition, Dr. Brindley was a member of more than 20 local, state, regional, and national professional organizations. He was Vice President of the American Orthopaedic Association in 1979 and 1980; Past President of the Texas Orthopaedic Association in 1979 and 1980; and Vice President of the Clinical Orthopaedic Society. He also served as Chairman of the Liaison Committee for the American College of Surgeons and President of the Southwestern Chapter of the American College of Surgeons.

While at Scott & White, Dr. Brindley trained about eighty orthopaedic residents. According to his son, Dr. George W. Brindley, Dr. Brindley “instilled a desire for excellence in patient care and encouraged the natural inquisitiveness of young orthopaedic surgeons.”

Dr. Brindley’s contributions went far beyond the world of medicine and surgery. He was also a member of the first elected Temple Independent School District Board and a founding 21-year member of the Temple College Board. He received gubernatorial appointment to the Crippled Children’s Medical Advisory Commission of the State Health Department (1968 – 1984) and to the Texas Commission of Jail Standards (1975 –1987). He also served on the Temple City Commission (now called the Temple City Council) for four terms from 1978 to 1990.

After he retired from Scott & White in June 1989, he continued to practice and teach at the Olin E. Teague Veteran’s Center in Temple until his death in October 1990. He was 72 years old when he died.

Throughout Dr. Brindley’s distinguished career, he was a highly respected member of the medical community. According to Dr. Robert E. Myers, Past President and Chief Executive Officer
of Scott & White Memorial Hospital, “Dr. Brindley was a role model for medical professionals. He was a quiet, unassuming, gentle man who went about getting the job done.”

Dr. Kermit B. Knudsen, Past President of Scott & White Clinic, added that Dr. Brindley, who was the recipient of the Boys Scouts of America’s prestigious Silver Beaver Award for meritorious contributions, “was an individual who epitomized the lofty ideals Boy Scouts memorize and try to live by. He never stopped living by those principles: faithfulness, loyalty, dedication, kindness, and helping people. He always exhibited true humility and he was always content to do his best to help people, never expecting great praise or commendation.”

Dr. Brindley is survived by his three sons, Dr. H.H. Brindley, Jr, Dr. George Brindley, and Dr. Glen Brindley; one daughter, Mrs. Don (Nan) Cuba, of San Antonio, nine grandchildren and nine great-grandchildren. He was preceded in death by his wife, Julia, son Paul, and brothers G.V. Brindley, and more recently deceased Clyde Brindley.

Dr. Brindley was part of a long-standing family tradition at Scott & White. His father, the late G.V. Brindley, Sr., M.D. was a pioneer physician and surgeon at Scott & White in the early 1900s. His brother Dr. G.V. Brindley, Jr. was a Scott & White Thoracic and Cardiovascular Surgeon. The Brindley medical legacy continues with Dr. Brindley’s three sons, Dr. H.H. Brindley, Jr., Orthopaedic Surgeon; Dr. George Brindley, also an Orthopaedic Surgeon; and Dr. Glen Brindley, an Ophthalmologist.

About the Lectureship . . .

In December of 1989, the Hanes H. Brindley Lectureship was established to honor Dr. Brindley’s contributions to Scott & White and the medical profession. The purpose of this lectureship is to keep physicians abreast of current knowledge, therapies, and research efforts made in Orthopaedic Surgery.
Dr. Scott Mubarak is the Emeritus Chief of Rady Children’s Hospital’s Pediatric Orthopedic Division and Clinical Professor Dept. of Orthopedics at UCSD. He is a founding member of this Pediatric Orthopedic Division and helps oversee a group of 10 pediatric orthopedic surgeons, 4 pediatric orthopedic fellows, 4 pediatric orthopedic residents and 11 nurse practitioners/physician assistants.

He graduated from the University Of Wisconsin School Of Medicine, completed his Orthopedics training at the University of California, San Diego and his Pediatric Orthopedic Fellowship at the Hospital for Sick Children in Toronto, Canada. Dr. Mubarak is board certified in orthopedics.

Dr. Mubarak is Past President of the Pediatric Orthopedic Society of North America(POSNA). He is also a member of the American Academy of Orthopaedic Surgeons, Scoliosis Research Society, International Pediatric Orthopedic Think Tank, American Orthopedic Association and the European Pediatric Orthopedic Society.

Dr. Mubarak’s clinical interests are: hip dislocation, foot deformities, fractures, clubfeet, muscular dystrophy, cerebral palsy and compartment syndromes. He has authored 146 journal articles, 39 book chapters and a textbook entitled “Compartment Syndromes and Volkmann’s Contracture”. Some of his noteworthy publications include: (1) “Pitfalls in the Use of the Pavlik Harness for Treatment of Congenital Dysplasia, Subluxation and Dislocation of the Hip,” (2) “The San Diego Pelvic Osteotomy,” and (3) “Calcaneal, Cuboid and Cuneiform Osteomies for Valgus Foot Deformities.”

His honors and award include: The Alpha Omega Alpha (AOA) American Academy of Orthopedic Surgeons’ highest award for research on Compartment Syndromes and muscle pressure measurement; the Achievement Award in Anatomy, UCSD; and the Walter P. Blount Pioneer Award (POSNA) for Outstanding Clinical Scientific Paper for scientific paper on muscular torticollis.
DEPARTMENT OF ORTHOPAEDIC SURGERY
and
H.H. BRINDLEY, SR. ORTHOPAEDIC LECTURESHP

Friday, June 13, 2014
Sid Richardson Auditorium

10:00 - 12:00 Case Presentations by Scott & White Staff to Dr. Mubarak

12:00 - 1:00 HANES H. BRINDLEY, SR. ORTHOPAEDIC LECTURESHP
“Treatment of tarsal coalitions of the foot” – Scott Mubarak, MD

1:00 – 1:30 BREAK

1:30 - 1:45 “Infection rates in arthroscopic versus open rotator cuff repair” – Justin Bartley, MD

1:45 - 2:00 “The use of low-dose Recombinant Human Bone Morphogenic Protein-2 in the elderly: a comparative study assessing safety and fusion success in the posterior lumbar spine” – Jeffrey Knabe, MD

2:00 – 2:15 “The relationship of obesity to increasing healthcare burden in the setting of orthopedic polytrauma” – Heather Licht, MD

2:15 - 2:30 “Mortality after femoral neck fractures in the elderly based on Age-Modified Charlson Comorbidity Index Score and treatment modality” – Adam Shar, MD.

2:30 – 3:30 “Compares legal requirements and ethical considerations in the context of health care for minors” – S&W Risk Management, Dr. Lori Wick

3:30 – 3:45 BREAK

3:45 – 4:00 “The use of routine thoracoabdominal CT scans in the polytrauma patient to estimate obesity” – David Ferguson, MD

4:00 – 4:15 “Evaluation of an inter-professional clinician-patient communication workshop utilizing standardized patient methodology.” – Casey Lagan, MD.

4:15 – 4:30 “Hemoglobin trends after primary total hip and knee arthroplasty: Are daily post-operative hemoglobin phlebotomies necessary?” – Kushal Patel, MD.


5:00 - 6:00 HANES H. BRINDLEY, SR. ORTHOPAEDIC LECTURESHP
“Compartment syndrome study in my career ”– Scott Mubarak, M.D.
Infection Rates in Arthroscopic versus Open Rotator Cuff Repair

Justin Bartley, MD, Kindyle Brennan, PhD, Daniel Jupiter, PhD, Derek Lichota, MD, Robert Reeve, MD, John Welsh, MD, and William Hamilton, MD

Background:
The prevalence of rotator cuff repair operations continues to rise with a noted transition from open to arthroscopic technique in recent years. One advantage of arthroscopic repair has been a reported lower infection rate in the literature. However, to date, the infection rates of these two techniques have not been compared directly at a single institution with fully integrated medical records.

Methods:
We retrospectively compared the postoperative infection rates between arthroscopic and open rotator cuff repair in 2,909 patients at a single institution using a Fisher’s exact test.

Results:
A total of 940 patients were managed with an open repair and 1,969 were managed with an arthroscopic repair. Patients who underwent open repair were significantly more likely to develop a post-operative infection, with 13 (1.38%) confirmed infections in the open group vs. 4 (0.20%) in the arthroscopic group (p < 0.001).

Conclusions:
Patients undergoing open rotator cuff repair had a significantly higher rate of post-operative infection in comparison with those undergoing arthroscopic rotator cuff repair. This is the first study to our knowledge that compares the infections rates of arthroscopic versus open rotator cuff repairs at a single institution with integrated medical records.
The Use of Low-dose Recombinant Human Bone Morphogenic Protein-2 in the Elderly: a Comparative Study Assessing Safety and Fusion Success in the Posterior Lumbar Spine

Knabe, Jeffrey MD, Gabe Hurtado BS, Daniel Jupiter PhD, Mark Rahm MD, Christopher Chaput MD

Background Context: The use of rhBMP-2 (INFUSE, Medtronic, Memphis, TN, USA) has been linked to infrequent but potentially severe complications, many of which appear to be dose and location specific. Elderly patients have increased risks of morbidity and mortality from lumbar fusion in general and might be at particular risk for BMP related complications such as radiculitis, infection, and cancer. No study to date has addressed the use of low dose rhBMP-2 (LDBMP) in this group.

Purpose: Compare 90-day complication rates. Secondary goals were to assess fusion and reoperation rates.

Study Design/Setting: Case control clinical and radiographic outcome study.

Patient Sample: 208 patients

Outcome Measures: Clinic records, Radiographs/computed tomography (CT) scans

Methods: All patients 65 or older undergoing 1-2 level decompression with instrumented posterolateral fusion were identified from a large multispecialty group database. Electronic hospital and clinic records were reviewed. Care was taken to assess both the medical record and imaging for any complication that might be related to the use of BMP. Patients were considered fused if bridging posterolateral bone was visible and there was less than 3 degrees of motion on digital radiographs. LDBMP was defined as no more than 2.1mg of rhBMP-2 per level. All LDBMP patients received one strip of rhBMP-2 in the posterolateral gutter. When a TLIF was performed, no BMP was used in the interbody space or on the side of the facetectomy. Graft material for the control group included local autograft bone and demineralized bone matrix (DBM).

Results: 208 patients met inclusion criteria. 104 females and 104 males average age 73 (range, 65-93) had an average follow up of 2.45 years (range 0.2-9.71, median 1.12). LDBMP was used in 45 surgeries. The groups were comparable in terms of age, diabetes, cancer, respiratory disease, nutritional status, American Society of Anesthesiologists (ASA)score, and number of levels fused. The BMP group had significantly more females, osteoporosis, cardiovascular disease, and prior surgeries. Medical complications occurred in the 20% of the LDBMP and 16% of the controls (p>0.05). Surgical complication rates were 2% and 7%, respectively (p>0.05). Infections were seen only in four of the control patients. Two LDBMP patients required revision, one pseudoarthrosis above a prior L5-S1 ALIF and one adjacent segment stenosis requiring laminectomy. Four patients required revision in the control group (dural leak with loose hardware, pseudoarthrosis, retained drain, and contralateral radiculopathy). One patient in the LDBMP group had transient, new radicular symptoms attributed to a seroma, but did not require treatment. At an average of 3.97 years, fusion rates were 71.4% (20 of 28) in the BMP patients and 89.8% (80 of 89) in the non-BMP patients for those patients with a minimum of one year follow up.

Conclusions: The use of LDBMP in the elderly for posterolateral fusion yielded similar rates of complications compared to local autograft with DBM. Medical complications were common in both groups of elderly patients, but surgical complications were not. Only one complication possibly attributable to BMP was seen (transient radiculitis with seroma), and it resolved without treatment.
Background: With the rise of obesity in the American population, there has been a proportionate increase of obesity in the trauma population. While several studies have suggested an increased rate of complications and costs in the general trauma situation, data specific to obese orthopedic polytrauma patients is limited. The purpose of this study was to use a CT-based measurement of adiposity to determine if obesity is associated with an increased burden to the healthcare system in orthopedic polytrauma patients.

Methods: A prospective comprehensive trauma database at a Level 1 trauma center was utilized to identify 301 polytrauma patients who had orthopedic injuries and ICU admission from 2006 to 2011. Routine thoracoabdominal CT scans allowed for measurement of the Truncal Adiposity Volume (TAV). Truncal Three-Dimensional Reconstruction Body Mass Index (TBMI) was calculated from the CT based volumes based on a previously validated algorithm. Patients with a TBMI < 30 were considered nonobese and those patients with a TBMI of 30 or greater were considered obese.

Results: Of the 301 patients, 21.6% were classified as obese (TBMI ≥ 30). Higher TBMI was associated with longer hospital LOS (p = 0.02), more days spent in the Intensive Care Unit (p = 0.03), more frequent discharge to a long-term care facility (p < 0.0002), higher rate of orthopedic surgical intervention (p < 0.01), and increased total hospital costs (p < 0.001).

Conclusions: CT scans, which are routinely obtained at the time of admission, can be utilized to calculate truncal adiposity and investigate the impact of obesity on the polytrauma patients. Obesity is associated with higher total hospital charges, longer hospital stays, discharge to a continued care facility, and a higher rate of surgical orthopedic intervention.

Level of Evidence: Level II prognostic study; a retrospective review of a prospective trauma database.

Introduction

In the last two decades, there has been a substantial increase in the prevalence of obesity in the United States. In 2010, more than 78 million US adults (35.7% of the adult population) were obese [1]. Obesity is associated with other disease processes such as metabolic syndrome (a constellation of hypertension, dyslipidemia, and diabetes in the setting of obesity), coronary artery disease, congestive heart failure, obstructive sleep apnea, and degenerative joint disease [2,3,4]. These comorbidities can complicate medical care; and, the economic burden of treating obesity and its associated comorbidities is significant and growing. From 1998 to 2008, the annual medical financial burden of obesity rose to 9.1% of all medical spending, or approximately $147 billion a year [5]. It has been estimated that medical spending is $1,429 (or 42%) higher per year for an obese patient compared to a patient of normal body mass [5].

With the increasing prevalence of obese patients, there has been a commensurate increase in the number of obese orthopedic trauma patients [6-7]. However, the impact of obesity on the treatment of the polytraumatized patient is not fully understood. Recent studies have reported conflicting outcomes with regard to associations between obesity and LOS, mortality, complications, discharge disposition, and other variables [6-10]. It has been suggested that these conflicting results may be due to the inherent limitations in defining obesity based solely on Body Mass Index (BMI), as BMI may not be as sensitive and specific as desired [11]. BMI is a height to weight proportion calcula-
Obesity (kg/m²), which in general correlates with excess adiposity. Unfortunately, the BMI does not take into account body-type [11, 12]. For example, patients with high amounts of lean muscle can inaccurately be classified as obese [11, 13]. There are also difficulties with calculating an accurate BMI in the trauma setting. Height and weight are often difficult to accurately obtain in severely injured patients, particularly at initial presentation when severe injuries can preclude mobilization. If the height and weight are obtained later, significant weight fluctuations with early fluid resuscitation can occur and can affect the accuracy of BMI calculations [14].

Given these difficulties associated with BMI, there has been recent interest in defining obesity by measuring adiposity instead of with traditional BMI. Ferguson et al. used CT scans to quantify obesity in polytrauma patients by assembling three-dimensional reconstructions to measure Truncal Adiposity Volume (TAV). This measurement was then used to calculate a Truncal Three-Dimensional Reconstruction BMI estimate (TBMI) [15]. Ferguson’s study showed high intra-observer and inter-observer correlations in measuring TAV: 0.99 and 0.98, respectively. In addition, statistical analysis supported good correlation between TBMI and traditional BMI (correlation coefficient = 0.86, p<0.0001). The results from that study demonstrated the technique to be a simple, reliable, and direct way of calculating adiposity in a trauma patient. The purpose of this study was to use a CT-based measurement of adiposity to determine if obesity is associated with increased total hospital charges, hospital LOS, need for orthopedic surgery, and worse discharge disposition for orthopedic polytrauma patients.

Materials and Methods

After institutional review board approval was obtained, a retrospective radiographic and clinical review was conducted. A total of 1,199 patients in a prospective comprehensive American College of Surgeons (ACS) verified Level 1 trauma database were reviewed from January 2006 through December 2011. Inclusion criteria were 1) 911 trauma registry patients with thoracic/abdominal CT scan, 2) patients 18 years of age or older, and 3) patients with an orthopedic injury. Excluded from this study were patients with penetrating trauma, paralysis resulting from trauma, or no orthopedic injury. In addition, patients not requiring admission to the ICU and those without adequate thoracic/abdominal CT scans were excluded. A total of 301 patients were included in this study.

Routine thoracoabdominal CT scans that were obtained on all 911 trauma patients upon admission were used to quantify adiposity, according to the method of Ferguson, et al. [15]. Utilizing the multidetector CT images and 3 Dimensional Reconstruction software (OsiriX, version 3.1 32-bit, OsiriX Foundation, Geneva, Switzerland), a 3D volume rendering of adipose tissue from the T10 pedicle to the coccyx was created for each patient. From this 3D rendering, TAV was determined and measured in cubic centimeters. The TAV (in cm³) was then divided by the total image length (in mm), yielding the Body Fat Index (BFI) for each patient (Figure 1). BFI was then used to calculate a TBMI for each patient using the equations developed in Ferguson’s study. Next, patients were categorized into two groups based on their TBMI, with classes defined by the World Health Organization [12]: normal patients with TBMI less than 30, and obese patients with TBMI greater than or equal 30.

![Figure 1. Truncal 3D reconstruction of adiposity in a non obese patient obtained from the thoracoabdominal trauma CT scans and 3 Dimensional Reconstruction software which is then used to determine a Three Dimensional Reconstruction BMI estimate (TBMI).](image-url)
Age, gender, race, location of injuries, mechanism of injury, index severity score (ISS), and radiographic measurement for all patients were recorded. In addition, the need for an orthopedic surgery, LOS, LOS in the ICU (ICU LOS), number of days requiring ventilator support, hospital mortality, discharge disposition facility type, and total hospital cost were recorded for each patient.

Demographics, injuries, ISS, and mechanism of injury were tested for association with TBMI class using the appropriate test (chi-squared/Fisher’s exact). Data are summarized utilizing simple means and SD or proportions as appropriate. Similar analyses were done with the need for orthopedic surgery, in-hospital mortality, LOS, cost and discharge disposition. Significance was set at p < 0.05.

Source of Funding

No external funding was received for this study.

Results

Study Population

The study population consisted of 301 patients, 221 (73.42%) males and 80 (26.58%) females. The average age was 34.20 years (SD: 12.22), with a range from 18 to 60 years. Forty (13.29%) patients were African American, 214 (71.10%) Caucasian, 3 (1.00%) Asian, 39 (12.96%) Hispanic, and the remaining 5 (1.66%) were classified as other. Eighty-two (27.24%) patients had documented traumatic brain injury (TBI). The majority of the population (172 patients; 57.14%) was involved in motor vehicle collisions (MVC). The remaining patients were victims of assaults, falls from height, motorcycle collisions (MCC), off-road vehicle accidents, pedestrian accidents, and unclassified (Table 2). Mean ISS was 29.79 (SD: 12.25), with a score range of 4 to 75. Of the recorded injuries, the primary injury location was as follows: 20 (6.64%) were of abdomen or pelvic contents, 1 (0.33%) head, 14 (4.65%) neck, 29 (9.63%) thorax, 166 (55.15%) lower extremity, and 71 (23.59%) upper extremity. All 301 patients sustained an orthopedic injury, as required by the inclusion criteria. Of those patients, 143 (47.51%) had an injury to the upper extremity, 142 (47.18%) sustained an injury to the lower extremity, 110 (36.54%) had a pelvic injury, and 176 (58.47%) were found to have an injury to the spine. One hundred and seventy-six (58.47%) patients required a surgery for their orthopedic injuries.

TBMI Classes

In this study population, the mean TBMI was 27.16 (SD: 4.54) with a range from 21.33 to 50.45. Of the 301 patients, 236 (78.41%) were classified as normal TBMI and 65 (21.59%) were classified as obese (Table 1).

<table>
<thead>
<tr>
<th>Table 1. Characteristics of Patients and Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>No. of patients</td>
</tr>
<tr>
<td>Male sex (no. of patients)</td>
</tr>
<tr>
<td>Age* (yr)</td>
</tr>
<tr>
<td>Cerebral Brain Injury (no. of patients)</td>
</tr>
<tr>
<td>Injury Severity Score *</td>
</tr>
<tr>
<td>Orthopedic Injury Location (no. of patients)</td>
</tr>
<tr>
<td>Upper Extremities</td>
</tr>
<tr>
<td>Lower Extremities</td>
</tr>
<tr>
<td>Pelvis</td>
</tr>
<tr>
<td>Spine</td>
</tr>
<tr>
<td>Mechanism of Injury</td>
</tr>
<tr>
<td>Assault</td>
</tr>
<tr>
<td>Fall</td>
</tr>
<tr>
<td>Motorcycle</td>
</tr>
<tr>
<td>Motor vehicle</td>
</tr>
<tr>
<td>Off Road vehicle</td>
</tr>
<tr>
<td>Miscellaneous (other)</td>
</tr>
<tr>
<td>Pedestrian</td>
</tr>
</tbody>
</table>

Normal = TBMI < 30, Obese = TBMI > 35
*The values are presented as means with standard deviation in parentheses unless otherwise indicated. † Significant.

Study Outcomes

Men comprised a lower percentage of the higher TBMI class (p < 0.00001, Table 1). Of the 236 normal TBMI patients, 188 (79.66%) were men and 33
of the 65 patient in the obese class (50.77%) were men. A statistically significant association was also found between age and TBMI class (p = 0.016): normal TBMI individuals had a mean age of 33.25 (SD 11.83) and obese individuals had mean age 37.65 (SD 13.05). TBMI class was also found to be statistically significantly associated with cerebral brain injury (p = 0.034) with 30% of the normal TBMI class population having a traumatic brain injury compared to 17% of the obese class. No statistically significant associations were found between TBMI class and race, mechanism of injury, or ISS. When isolating orthopedic injuries in our population, obesity was associated with lower extremity injuries (p = 0.004) while no association was seen with upper extremity, pelvic, or spinal injuries (Table 1). Rates of orthopedic surgery also differed significantly between TBMI classes (p = 0.011). In this population, 129 normal patients (54.66%), and 47 (72.31%) obese patients required orthopedic surgical intervention. Dividing the obese TBMI class up further into those with TBMI between 30 and 35 (Class I) and those with TBMI ≥35 (Class II), it was demonstrated that 33 (66.66%) of the Class I obese patients and 14 (93.33%) of the Class II patients required orthopedic surgery for their injuries (p = 0.006) (Figure 2).

The mean LOS was 13.25 days (SD 11.11) with a range from 1 to 83 days. Mean ICU LOS was 7.77 days (SD 7.98) with a range of 1 to 43 days. Analysis revealed an association between TBMI class and LOS (p = 0.023) and days spent in the ICU (p = 0.033). Normal TBMI patients had mean ICU LOS of 7.24 days and total LOS of 12.39 days compared to the obese patients who had a mean ICU LOS of 9.72 days and a total LOS of 16.35 days (Table 2). A statistical association was also seen between the TBMI classes and in-hospital mortalities (p = 0.028) with an increase seen in the normal TBMI class (Table 2). Out of the 301 patients, 38 (12.62%) patients died in the hospital, 29 (9.63%) went to a continuing care hospital (CCH), 33 (10.96%) went to a skilled nursing facility (SNF), 109 (36.21%) went to a rehabilitation center, 91 (30.23%) went home, and 1 (0.33%) was transferred to a military hospital for continued care. A difference was seen between the TBMI classes and discharge disposition (chi-squared p = 0.0002), with more patient from the higher TBMI class requiring discharge to a continuing care facility such as a SNF or CCH (Table 2).

The average cost was $176,629.54 with a range from $3,799 to $819,923.02. A significant association between TBMI class and accrued hospital cost was seen (p < 0.001). Normal TBMI patients had lowest mean cost of $160,606.02 (SD $119,586.18) compared to the obese patients who accrued a mean cost of $234,863.58 (SD $162,863.58).

### Table 2.

<table>
<thead>
<tr>
<th>Comparison of outcomes by TBMI Obesity Class</th>
<th>Normal</th>
<th>Obese</th>
<th>P Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital LOS* (d)</td>
<td>12.39</td>
<td>16.35</td>
<td>0.023 †</td>
</tr>
<tr>
<td>(10.51)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICU LOS* (d)</td>
<td>7.24 ± 7.82</td>
<td>9.72 ± 8.33</td>
<td>0.033 †</td>
</tr>
<tr>
<td>Required Ventilator* (d)</td>
<td>6.57 ± 8.03</td>
<td>8.69 ± 8.96</td>
<td>0.088</td>
</tr>
<tr>
<td>In-hospital mortality (no. of patients)</td>
<td>35</td>
<td>3</td>
<td>0.028 †</td>
</tr>
<tr>
<td>Orthopedic Surgery (no. of patients)</td>
<td>129 (54.66%)</td>
<td>47 (72.31%)</td>
<td>0.011 †</td>
</tr>
<tr>
<td>Mean Cost* ($)</td>
<td>160,606.02 (119,586.18)</td>
<td>234,807.24 (162,863.58)</td>
<td>&lt; 0.001 †</td>
</tr>
<tr>
<td>Disposition Location</td>
<td>0.00016 †</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCH</td>
<td>17 (7.2%)</td>
<td>12 (18.46%)</td>
<td></td>
</tr>
<tr>
<td>SNF</td>
<td>18 (7.63%)</td>
<td>15 (23.08%)</td>
<td></td>
</tr>
<tr>
<td>Rehab</td>
<td>88 (37.29%)</td>
<td>21 (32.31%)</td>
<td></td>
</tr>
<tr>
<td>Home</td>
<td>77 (32.62%)</td>
<td>14 (21.54%)</td>
<td></td>
</tr>
<tr>
<td>Expired</td>
<td>35 (14.83%)</td>
<td>3 (4.62%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>1 (0.42)</td>
<td>0 (0%)</td>
<td></td>
</tr>
</tbody>
</table>

**Abbreviation:** LOS, length of stay; ICU, Intensive Care Unit; CCH, Continued care hospital; SNF, skilled nursing facility; *The values are presented as means with standard deviation in parentheses unless otherwise indicated. † Significant.
Discussion

Obesity has reached epidemic proportions and is increasingly recognized as a major economic burden to the healthcare system [1,5,16,17]. BMI has traditionally been used to assess obesity in studies that attempt to quantify the impact of excess adiposity on the healthcare system, but it can be inaccurate and difficult to obtain in orthopedic polytrauma patients [11,12,14,15]. This is the first study to use a three-dimensional CT reconstruction process to explore an association between obesity and an increase in the overall burden to the trauma system. By utilizing CT based reconstructions of adipose volume to estimate obesity, this study uses data already available in most polytrauma patients to provide more direct assessments of obesity in this population.

The impact of obesity on injury severity in trauma patients has been examined in several recent studies. Arabi et al. hypothesized that BMI would influence injury patterns sustained in trauma, and their results indicated that overweight individuals gain a certain “cushion effect” from an increase in insulating tissue, resulting in lower ISS than normal and obese individuals [18]. Our data supports this association between adiposity and ISS, with those patients with a normal TBMI having more severe ISS than those in the obese class. Even though our patients with higher adiposity had lower ISS, they still required significantly more orthopedic intervention and had higher in-hospital charges. One possible reason for this is that obese patients may have different rates of orthopedic injuries compared to patients with normal adiposity. For example, several studies have reported that the obese polytrauma patient has an increased risk of pelvic and lower extremity injuries [18-20]. A recent report reviewing distal femur fractures showed that obese patients had more severe fractures compared to nonobese patients [21]. Our results show a strong association between obesity and lower extremity injuries (Table 1). This may be the reason higher TBMI patients also required orthopedic surgical intervention more often (Table 2). However, no association was seen between TBMI class and upper extremity, pelvic, or spinal injuries (Table 1).

Significant obesity can make the care of polytrauma patients more challenging for hospital staff and increase the risks of complications for trauma patients [4,22,23]. The technical difficulty in performing surgery can be greater due to the amount of adipose tissue and a commensurate need for an increase in the working length of surgical tools [24]. At the same time, penetration of fluoroscopy and image quality is decreased, which can preclude or complicate the use of newer, less invasive techniques for internal fixation [25]. Other complications that have been reported to be more common in the obese surgical patient include: DVTs, nerve palsies and compartment syndromes secondary to poor positioning, and increased wound complications [24]. Obese and morbidly obese patients have as much as a 4.7-fold and 6-fold higher risk of infections, respectively, when compared to patients with normal BMI [4] and are 4.68 times more likely to require reoperation after fixation of pelvic ring injuries [21]. Since the very obese patients in our study had a significantly higher need (93% vs. 55% for nonobese) for orthopedic surgery in the first place, it is likely that the economic impact of truncal obesity on the American healthcare system is magnified in the trauma population.

Recent studies have also explored the association between obesity and ICU LOS, hospital lengths of stay, and in-hospital mortality. Despite the fact that the majority of these studies support an association between obesity and these outcome variables [4,16,17,20,26,27], there are some studies published showing no difference among BMI groups [28,29]. As mentioned previously, the limitations of using BMI to define obesity in the trauma population may contribute to these contradictory results. Traditional BMI may mistakenly classify very muscular patients as obese [15]. Despite having an obese percent body fat on DXA scans, a direct measure of adipose tissue, one study demonstrated that approximately one-half of women these were misclassified as non-obese [11]. The method we used to extrapolate BMI in this study has been shown to correlate with traditionally calculated BMI. Since it relies on a direct measurement of adiposity, it is not subject to the inaccuracy inherent in a simple height/weight proportion when it is applied to heavily muscled patients or patients with large amounts of interstitial fluid volumes from trauma resuscitation [14,15].

Using direct measurements of truncal adiposity normalized for truncal height, our study demonstrated a significant association between obesity and an increase in days spent in the ICU, total LOS, and overall hospital costs. Obesity was also associated with increased hospital LOS that alone can cause an increase in hospital cost. The patients in the obese class stayed on average 2 days longer in the ICU and 4 days more in
the hospital than those with a normal TBMI. Obesity is strongly associated with increases in morbidity and complications which also could explain higher accrued hospital cost during a patient’s stay [4, 26,27,29,30]. Obesity was also strongly associated with the need for orthopedic surgical intervention in our population. Over 93% of the patients in class II obesity required surgery for their orthopedic injuries, compared to only 55% of patients with normal TBMI. The additional charges from orthopedic surgical intervention increases the overall hospital cost in these patients, and this in combination with the longer LOS appear to be the main contributors to the significant differences in hospital charges seen in the obese patients.

Obesity has also been demonstrated to predict poorer discharge disposition of patients compared to those with normal weight [27,31,32]. There was an association seen between TBMI class and discharge dispositions (p = 0.0002) with a trend for patients in higher TBMI class requiring discharge to facilities specializing in continued high level of medical care such as a continuing care hospital or a skilled nursing facility. The obese patients were more likely to be discharged to skilled nursing facilities and less likely to be discharged home when compared to individuals in the normal TBMI class. At least one study demonstrated that once at an inpatient rehabilitation center, obese patients do not have as much functional improvement as nonobese patients. Further, they have lower functional independence measurements despite having no difference in therapy participation frequency, therapy duration, or LOS in the rehabilitation setting [33]. While it was beyond the scope of this study to assess costs associated with obesity in the post-acute care setting, any increase in the need for further skilled care will certainly increase the costs associated with the care of the obese trauma patient.

There is strong support in the literature demonstrating an association between obesity and increases in morbidity [6,8,18,20,27,29,30,31]. Despite this, an association between obesity and higher mortality rates has not always been reported [8,27,30]. Our findings coincide with several other studies, revealing an association between obesity and mortality (p = 0.028). It is worth noting that a higher percentage of patients in the normal TBMI class expired in the hospital. Several studies support the concept of a “cushion effect” of increased adiposity possibly leading to a protective physical shield in obese patients, with evidence of fewer head injuries and intra-abdominal injuries [18,19]. However, caution should be used when trying to generalize our results because of the relatively small number of obese patients in our study.

Other limitations of our study include the inability to establish causal relationships, which is inherent to any retrospective analysis. Additionally, at our institution, no standardized protocols were in place for the management for these patients; and, their treatment regimen was carried out per the discretion of the treating surgeon and ICU physician. The absence of underweight patients and the small number of morbidly obese patients may have influenced our results. This study examined the final cost of each patient’s hospital care and did not take into consideration the influences of comorbidities or complications that may affect outcomes. Although we have found associations between obesity and hospital LOS, orthopedic surgery rates, hospital costs, and discharge dispositions, we can only hypothesize about the reason(s) for these findings. This is the first study of its kind to utilize a three-dimensional CT reconstruction process to more directly quantify adiposity in trauma patients, which may help strengthen the validity of our conclusions when compared to indirect methods of quantifying obesity.

In conclusion, the increasing prevalence in obesity has been shown to be a financial burden on the healthcare system in general [5,16,17]. Our study demonstrated an association between obesity and increased rates of orthopedic surgery, higher total hospital charges, longer ICU and total hospital stay, and decreased rate of discharge to home in the orthopedic polytrauma population. Importantly, this increase in resource utilization occurred even though our patients with higher adiposity had a trend towards lower injury severity scores. These factors should be taken into consideration when determining resource allocation and re-imbursement for care. In addition, sophisticated and standardized measurement techniques like direct CT based measurements of adiposity obtained at the time of admission have the potential to help more appropriately define the impact that obesity has on the orthopedic polytrauma patient.

REFERENCES:
The relationship of obesity

24. Jupiter JB, Ring D, Rosen H. The complications and


Mortality after Femoral Neck Fractures in the Elderly Based on Age-Modified Charlson Comorbidity Index Score and Treatment Modality

Adam Shar, Timothy Randell, Michael L Brennan, Kindyle L. Brennan, Daniel C Jupiter, and Zachary T Hubert.

Objectives: (1) Determine if Age-Modified Charlson Comorbidity Index (ACCI) and surgical modality impact mortality after a femoral neck fracture; and (2) determine if there is a cutoff ACCI at which the risk for mortality increases substantially.

Design: Retrospective cohort study.

Setting: Single Level 1 Trauma institution from 1998-2009.

Patients/Participants: 1,440 patients aged ≥60 with 1,525 femoral neck fractures secondary to low energy trauma. Exclusion criteria consisted of extracapsular fractures, history of surgery to proximal femur, pathologic fractures, and need for open reduction.

Intervention: Closed reduction percutaneous pinning (CRPP), hemiarthroplasty (HA), or total hip arthroplasty (THA).

Main Outcome Measurements: We divided ACCIs into severity groups (low=2-4, medium=5-6, high ≥7) and calculated 1-month, 6-month, 1-year, and 2-year mortality, with and without adjusting for treatment modality. Results were compared using Cox regression. We utilized Kaplan-Meier estimates to determine ACCI above which hazard ratio for death increases significantly.

Results: Increase in ACCI of 1 point increased hazard ratio for death by a factor of 1.35. There is a statistically significant increase in mortality rates between low, medium, and high ACCI groups at measured post-operative periods, even after adjusting for surgery type. High ACCI group exhibited highest mortality (60% for CRPP & 58% HA at 2 years). At ACCI ≥11, hazard ratio for death increased 5 fold, but only 6 cases (0.4%) met this criterion.

Conclusions: Increasing ACCI was associated with increased mortality, and this association remained significant even after adjusting for treatment modality. Statistically significant differences in 1-and 2-year mortality existed between ACCI groups.

Introduction

Femoral neck fractures contribute to significant morbidity and mortality in the elderly population throughout the United States and the world, with overall estimated 1-year mortality ranging from 15-30%. Its incidence in the US is reported to be around 350,000 per year, and given the aging population, this is predicted to increase substantially. Furthermore, femoral neck fractures place an increasing financial burden on the healthcare system. According to Braithwaite et al., $20 billion dollars were spent for hip fracture care in 1997 alone, and this may increase to $62 billion by 2040. Brauer et al. also reported a significant increase in comorbidities in patients being treated for femoral neck fractures from 1986-1988 and 2003-2005.

Most femoral neck fractures are treated operatively, with surgical options consisting of closed reduction with percutaneous pinning (CRPP), hemiarthroplasty (HA), or total hip arthroplasty (THA). When deciding upon treatment modality, factors including fracture displacement, age, health and functional status, and bone quality all contribute to a surgeon’s decision making. Generally speaking, CRPP is preferred for patients with a non-displaced or valgus-impacted fracture, in less functional patients, or those with higher risk of intraoperative complications from anesthesia; whereas, HA or THA are reserved for patients who have suffered from displaced fractures and/or have higher functional or better health status. However, the choice of optimal surgical treatment remains controversial.

Based on previous research performed at our institution using retrospective data from a large scale database, overall 1-month, 6-month, 1-year, and 2-year mortality rates after femoral neck fracture are estimated to be 6.4%, 16%, 21.5%, and 31.4%, respectively. Median survival time post-operatively was found to be 4.02 years. Among the treatment methods, patients receiving THA demon-
strated the lowest mortality as compared to those treated with CRPP and HA. Patients who underwent HA had the highest mortality rate with a hazard ratio of 1.22 versus CRPP and 2.19 versus THA, on Cox regression analysis, with both differences reaching statistical significance.

Since a majority of the patients who suffer from femoral neck fractures are elderly, defined by the United Nations as people aged 60 years and older, it is important to consider their comorbidities when deciding upon a treatment modality. To account for this in our analyses, we used the Age-Modified Charlson Comorbidity Index (ACCI), a scoring system that measures patient comorbidity status based on age as well as the number and severity of pre-existing diseases. The original Charlson Comorbidity Index (CCI) is the system most widely used by researchers and clinicians for assessing severity of patients’ comorbidities. In addition to the contents of the original CCI scoring system, ACCI factors age into the scoring system by awarding one point for each decade beyond 40–49 years of age. The ACCI scoring system was validated in a study by Charlson et al., where the goal was to estimate relative risk of death from potentially prognostic clinical covariates. In another study, pre-operative comorbidities were shown to be stronger predictors of post-operative complications and mortality as compared to intraoperative complications. According to Eiskjer et al., medical conditions at the time of surgery were the most important determinants of survival in patients who underwent bipolar hemiarthroplasty for the treatment of a femoral neck fracture. Furthermore, studies have shown that CCI is a reliable marker for predicting mortality in elderly patients with hip fractures.

Although these studies incorporate comorbidity, they do not differentiate between the types of surgical intervention. The purposes of this study were to (1) determine if ACCI and surgical modality independently impact mortality when analyzed in combination using multivariate regression; and (2) determine if there a cutoff ACCI at which the risk for mortality increases substantially.

**PATIENTS AND METHODS**

**Research Design**

This study was approved by our institutional review board. The medical record database at a large level one trauma hospital was queried for diagnosis and treatment codes associated with femoral neck fracture in the years 1998–2009. The codes used were ICD-9 820, and CPT 27235, 27236, and 27132. The exclusion criteria were: age less than 60 years, fracture secondary to high energy trauma, fracture secondary to neoplasia, extracapsular hip fracture, prior unrelated surgery to the proximal femoral region, need for open reduction, or treatment other than CRPP, HA, or THA.

Data collected from the chart review included medical record number (MRN), age at time of surgery/date-of-birth, gender, surgery performed (including date of surgery), classification of femoral neck fracture, laterality of fracture, and dates of the last contact or death note. We identified current comorbidities of each patient at the time of surgery and calculated the ACCI (Table 1). Surgeries performed were further classified as primary/revision. Revision surgery was any reoperation following the index procedure on the affected hip that met inclusion criteria. Only index surgeries were examined in this study. Patients’ death records were obtained from Texas Vital Statistics based on name, date of birth, and sex. All radiographs and reports were reviewed by the same investiga-

| Table 1. | Ivy-St modiﬁed Charlson Comorbidity Index Scoring System
<table>
<thead>
<tr>
<th>Score</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Myocardial infarction (history)</td>
</tr>
<tr>
<td></td>
<td>Congestive heart failure</td>
</tr>
<tr>
<td></td>
<td>Peripheral vascular disease (includes aortic aneurysm &gt;6cm)</td>
</tr>
<tr>
<td></td>
<td>Cerebrovascular disease: CVA with mild or no residua or TIA</td>
</tr>
<tr>
<td></td>
<td>Dementia</td>
</tr>
<tr>
<td></td>
<td>Chronic pulmonary disease</td>
</tr>
<tr>
<td></td>
<td>Connective tissue disease</td>
</tr>
<tr>
<td></td>
<td>Peptic ulcer disease</td>
</tr>
<tr>
<td></td>
<td>Mild liver disease (without portal hypertension; excludes chronic hepatitis)</td>
</tr>
<tr>
<td></td>
<td>Diabetes without end-organ damage (excludes diet-controlled diabetes)</td>
</tr>
<tr>
<td>2</td>
<td>Hemiplegia</td>
</tr>
<tr>
<td></td>
<td>Moderate or severe renal disease</td>
</tr>
<tr>
<td></td>
<td>Diabetes with end-organ damage (retinopathy, neuropathy, nephropathy, brittle diabetes)</td>
</tr>
<tr>
<td></td>
<td>Tumor without metastases (exclude if &gt;5 years from diagnosis)</td>
</tr>
<tr>
<td></td>
<td>Leukemia (acute or chronic)</td>
</tr>
<tr>
<td></td>
<td>Lymphoma</td>
</tr>
<tr>
<td>3</td>
<td>Moderate or severe liver disease</td>
</tr>
<tr>
<td>6</td>
<td>Metastatic solid tumor</td>
</tr>
<tr>
<td></td>
<td>AIDS (not just HIV positive)</td>
</tr>
</tbody>
</table>

For each decade >40 years of age, a score of 1 is added to the above score to obtain the Age-Modified Charlson Comorbidity Index score. Table 1. Ivy-St modiﬁed Charlson Comorbidity Index scoring system. ¹⁴ Reprinted by J Chronic Disease. 40, Charlson ME, Pompei P, Ales KL, et al. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. 373-383., © (1987) with permission from Elsevier.

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Femoral Neck Fractures Based on Age-modified CCI

Surgery was performed or overseen by 1 of 20 senior staff physicians. The patients who were treated with multiple screws had reduction achieved through closed means on a fracture table, and implant placement as described by Probe et al. 20. ASNIS III (Stryker, Kalamazoo, MI, USA) 6.5mm cannulated screws were used on all patients with the decision to place 3 or 4 screws based on surgeon preference. In the vast majority of hemiarthroplasty cases, a modified Hardinge lateral approach combined with a cemented modular stem was utilized. Total hip arthroplasty was also largely performed with a modified Hardinge lateral approach, with a variety of prosthetic components from different manufacturers.

Statistical Analysis

Demographic and injury data as well as data describing surgery types were summarized using means and standard deviations or percentages, as appropriate. To gain an overall understanding of our population’s mortality and the impact of ACCI and surgical method, Kaplan-Meier estimates and Cox proportional hazards regression were used to examine (a) overall mortality after index surgery, (b) mortality rates as impacted by surgery type, (c) mortality rates as affected by ACCI, and (d) mortality as impacted by ACCI and surgery type independently (the last assessed in a multivariate model).

To determine if there is a cutoff ACCI at which mortality increases precipitously, we dichotomized ACCI into high and low. We varied the cutoff point for dichotomization between the first quartile and third quartile of observed scores. For each cutoff, we built a Kaplan-Meier estimator including age, gender, surgery type, displacement and dichotomous ACCI. The hazard ratio of mortality in high versus low was assessed through closed means on a fracture table, and implant placement as described by Probe et al. 20. ASNIS III (Stryker, Kalamazoo, MI, USA) 6.5mm cannulated screws were used on all patients with the decision to place 3 or 4 screws based on surgeon preference. In the vast majority of hemiarthroplasty cases, a modified Hardinge lateral approach combined with a cemented modular stem was utilized. Total hip arthroplasty was also largely performed with a modified Hardinge lateral approach, with a variety of prosthetic components from different manufacturers.

In a post-hoc exploratory analysis, we built models where we looked within a given range of ACCI (low, medium, or high, as defined by our authors using the rationale explained in the discussion portion of this manuscript), and we measured mortality at 1 month, 6 months, 1 year, and 2 years after surgery, with and without taking surgery type into account. Tests were considered significant at α≤0.05 in all cases.

RESULTS

Demographics

Using the inclusion/exclusion criteria and ICD-9 and CPT codes mentioned above, we identified 1,449 patients with 1,534 femoral neck fractures for which we had Garden Type classification. Of the fractures, 383 (24.97%) were in males, and 1,151 (75.03%) were in females. Of the total patients, 365 (25.19%) were male and 1,084 (74.81%) were female. Age of subjects was relatively normally distributed with a mean of 80.84 (8.22) years. ACCI data was missing for 9 patients. For the rest, the mean ACCI was 5.05 (1.66). ACCI differed by gender, as males had a mean ACCI of 5.42 (1.91) and females had a mean ACCI of 4.93 (1.56), (p<0.001). After excluding patients with missing ACCI data, there were 1,440 patients with 1,525 fractures. The surgical methods employed in repair were 741, 744, and 40 for CRPP, HA, and THA groups, respectively.

Overall Mortality

A Kaplan-Meier model of survival after surgery indicated that median survival time post-operatively was 1,468 days (95% CI 1,334-1,612 days). One month, 6-month, 1-year and 2-year mortality rates were estimated to be 6.2% (95% CI 5.0-7.4%), 16.0% (14.2-17.9%), 21.5% (19.4-23.6%), and 31.4% (28.9-33.8%), respectively.

Mortality Based on ACCI

Cox proportional hazards model revealed that mortality did differ significantly by ACCI (p<0.001), as each increase of one in ACCI increased the hazard ratio for death by a factor of 1.35 (95% CI 1.30-1.40). There were also statistically significant differences (p<0.012, ANOVA) in the ACCI of patients who underwent different surgical intervention. The mean ACCI of patients who underwent CRPP was 4.98 (SD 1.75), which is slightly less than those who underwent HA (5.16, SD 1.56), but greater than those who underwent THA (4.25, SD 1.82) (see Figure 1).

Figure 1.
Results: mortality among low, medium and high CCI Groups

<table>
<thead>
<tr>
<th>Mortality</th>
<th>Low CCI</th>
<th>Medium CCI</th>
<th>High CCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month</td>
<td>7%</td>
<td>16%</td>
<td>19%</td>
</tr>
<tr>
<td>6 months</td>
<td>12%</td>
<td>24%</td>
<td>25%</td>
</tr>
<tr>
<td>1 year</td>
<td>21%</td>
<td>34%</td>
<td>35%</td>
</tr>
<tr>
<td>2 years</td>
<td>35%</td>
<td>58%</td>
<td>52%</td>
</tr>
</tbody>
</table>

p < 0.001 based on pairwise comparisons among CCI groups at each time interval.
In a post-hoc exploratory analysis, we categorized the study population into 3 groups based on severity of Age-Modified CCI scores (low = 2-4, medium = 5-6, high = 7 or greater). Table 2 shows the breakdown of treatment modality based on the 3 ACCI groups.

<table>
<thead>
<tr>
<th>Severity of ACCI</th>
<th>Number of Cases Based on Surgery Type (% of total cases)</th>
<th>CRPP</th>
<th>HA</th>
<th>THA</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>322 (21.1%)</td>
<td>261 (17.1%)</td>
<td>25 (1.6%)</td>
<td>608 (39.9%)</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>298 (19.5%)</td>
<td>366 (24.0%)</td>
<td>12 (0.8%)</td>
<td>676 (44.3%)</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>121 (7.9%)</td>
<td>117 (7.7%)</td>
<td>3 (0.2%)</td>
<td>241 (15.8%)</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>741 (48.6%)</td>
<td>744 (48.4%)</td>
<td>40 (2.6%)</td>
<td>1525 (100%)</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Breakdown of cases by ACCI group and surgery type.

There is a statistically significant increase in observed mortality as ACCI increases from low to medium to high. This difference is observed at 1 month, 6 months, 1 year, and 2 years (Table 1A; see appendix for corresponding table). Using the aforementioned ACCI ranges, the 1-month mortality was 2%, 7%, and 16%, in low, medium and high ACCI groups, respectively (p<0.001). At 6 months, mortality was 7%, 19%, and 34%, respectively (p<0.001). At 1 year, it was 10%, 24%, and 46%, respectively (p<0.001). At 2 years, mortality was 17%, 35%, and 58%, respectively (p<0.001).

Mortality Based on Treatment Modality

The median survival time post-operatively based on Cox proportional hazards model was 1,537 days for CRPP (95% CI 1406-1829), 1,298 days for HA (95% CI 1110-1494), and 2,293 days for THA (95% CI 1888-NA), and the differences were statistically significant (p<0.001). Table 3 shows observed mortality at various post-operative periods based on treatment modality. Pairwise comparisons show statistically significant differences (p<0.05) in mortality between the 3 treatment modalities at both 1- and 2-year post-operative periods. The HA group had the highest mortality, followed by CRPP and THA.

Mortality Based on ACCI and Treatment Modality

Based on multivariate Kaplan-Meier analysis/Cox regression, the overall mortality of those who underwent THA differed from the overall mortality of those who underwent CRPP, with hazard ratio for death in THA vs. CRPP of 0.56 (95% CI 0.33-0.96, p = 0.035). The mortality of those who underwent HA differed from the mortality of those who underwent CRPP (p = 0.017), and the hazard ratio for death of HA vs. CRPP was 1.18 (95% CI 1.03-1.35). The mortality of those who underwent HA differed from the mortality of those who underwent THA (p = 0.007). The hazard ratio for HA vs. THA was 2.09 (95% CI 1.23-3.56).

Cutoffs for ACCI:

Kaplan-Meier estimates were used to identify an ACCI at which hazard ratio for death changed significantly. The hazard ratio for death in those with ACCI ≥ 11 vs. those with ACCI<11 was roughly 5, whereas the hazard ratio for death in those with ACCI ≥10 vs. those with ACCI<10 was approximately 2.5 (Figure 2). However, only 6 patients (0.4%) in the study had ACCI ≥11. None of the models differ greatly in terms of AIC or concordance.

Exploratory Analysis of Mortality Based on ACCI Groups and Treatment Modality

Tables 3 and 4 contain mortality data at 1 month, 6 months, 1 year, and 2 years, based on ACCI group and type of surgical intervention pursued. After separating surgery types, there is an overall trend of increasing mortality rate as the ACCI increases from low to medium to high. The 2 groups with the highest mortality rate at each measured post-operative period are patients in the high ACCI group who underwent CRPP and patients in the high ACCI group who underwent HA. At 1 month after surgery, the mortality rates were 14% for CRPP and 19% for HA. At 6 months after surgery, the mortality rates were 33% and 35%, respectively. One year after surgery, the mortality rates were 45% and 47%, respectively. The mortality rates were highest at the 2-year post-operative period in patients with high ACCI who underwent CRPP (60%) or HA (58%).
Table 3. Breakdown of observed mortality at 1 and 6 months based on ACCI group and surgery type.

<table>
<thead>
<tr>
<th>ACCI</th>
<th>CRPP</th>
<th>HA</th>
<th>THA</th>
<th>1 month P</th>
<th>CRPP</th>
<th>HA</th>
<th>THA</th>
<th>6 months P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>2%</td>
<td>2%</td>
<td>0%</td>
<td>0.53</td>
<td>4%</td>
<td>10%</td>
<td>0%</td>
<td>0.02</td>
</tr>
<tr>
<td>Medium</td>
<td>5%</td>
<td>8%</td>
<td>9%</td>
<td>0.65</td>
<td>19%</td>
<td>19%</td>
<td>9%</td>
<td>0.65</td>
</tr>
<tr>
<td>High</td>
<td>14%</td>
<td>19%</td>
<td>0%</td>
<td>0.15</td>
<td>33%</td>
<td>35%</td>
<td>33%</td>
<td>0.76</td>
</tr>
</tbody>
</table>

Low: 2-4, medium: 5-6, high: 7 and up

**DISCUSSION:**

Our study suggests that mortality rates after a femoral neck fracture are strongly associated with patient comorbidities, as a Cox proportional hazards model revealed that an increase in ACCI of 1 point increased the hazard ratio for death by a factor of 1.35. In addition, there is a statistically significant increase in mortality rates between the low, medium, and high ACCI groups at 1 month, 6 months, 1 year, and 2 years after surgery. This concept holds true even after accounting for surgery type, as patients in the CRPP and HA groups exhibited a similar pattern of increasing mortality rate between low, medium, and high ACCI groups.

Limited data exists in the orthopaedic literature regarding the relationship between CCI or ACCI and mortality after a femoral neck fracture. Our literature search revealed only one study regarding the subject. It was a study by Radley et al., which concluded that the original CCI is a promising tool for predicting post-operative complications and mortality, and has modest ability to predict 1-year mortality in hip fracture patients. However, the study did not further evaluate the relationship between varying severity of CCI and mortality rate. In our study, we found statistically significant increases in mortality rates between low, medium, and high ACCI groups at all measured post-operative periods.

Our ability to evaluate the THA group was limited by the low number of cases in this group (40 cases total, which made up only 2.6% of the study). This limitation was amplified after we subdivided the THA subjects into low, medium, and high ACCI groups. Ultimately, due to the low number of THA cases, we were unable to make reliable conclusions regarding patients who underwent THA while accounting for their comorbidities. However, past studies suggest that despite THA being a more extensive surgery, patients who undergo THA do not have worse mortality rate than those who undergo CRPP or HA. This is likely because patients who undergo THA are healthier and more physically active at baseline, which makes them appropriate candidates for a more extensive surgery. A review article by Rogmark et al. suggested that elderly patients with displaced femoral neck fractures should undergo arthroplasty instead of internal fixation. It further suggested that THA is favored over HA for those who are otherwise healthy, active, and mentally competent, due to fewer failures and a lower re-operation rate with THA compared to HA. However, a meta-analysis by Hopley et al. compared HA to THA for displaced intracapsular hip fractures and found no statistically sig-
A study by Eisler et al. of patients with non-displaced femoral neck fractures who underwent CRPP found a 5.7% 6-month mortality rate. In our patient population, those with CRPP and low ACCI had a lower mortality rate than this, while those in the medium and high ACCI groups had a higher mortality rate. Those who underwent CRPP had a better survival rate than those who underwent HA. Sikand et al. found similar trends, particularly in 1-month and 1-year mortality, in patients with non-displaced subcapital femoral neck fractures who underwent CRPP vs. HA.

We aimed to elucidate the role of ACCI in conjunction with surgical modality impacting the risk of mortality in patients with femoral neck fractures. In our study, we used the ACCI because it also takes patient’s age into account. Since our patient population consisted of patients aged ≥60, the lowest possible Age-Modified CCI (ACCI) score for our patient population is 2 (see Figure 1), although the vast majority of patients’ ACCIs range from 3-6. Of note, ACCI does not increase on a linear scale, as most diseases weigh 1-2 points on the scoring system, but can potentially weigh up to 6 points (e.g., AIDS or metastatic disease). We tried to determine if there was an ACCI level above which mortality increases precipitously and found that at a cutoff ACCI ≥ 11, hazard ratio for death increased to 5 (whereas at any cutoff ACCI less than 11, the hazard ratio hovered around 2.5). However, since only 6 patients, or 0.4% of the study population, had ACCI ≥11, this finding was of limited clinical application.

In order to utilize ACCI in a more clinically applicable manner, we performed a post-hoc, exploratory analysis. We divided the study population into 3 categories of ACCI based on severity: low (2-4), medium (5-6), and high (7 and greater). We determined the low-medium cutoff under the following rationale: since ACCI increased by one with each increase in decade of age, physically healthy older patients will have higher ACCI scores despite a low number of comorbidities. For instance, a patient in his 70s with no past medical history will have ACCI of 3 based on age alone, as will a patient in his 60s whose only comorbidity is diabetes without end organ damage. We deemed that these patients are relatively healthy for their age and thus should belong in the low ACCI group. We calculated 1-month, 6-month, 1-year, and 2-year mortality strictly based on ACCI, and as expected, found significant differences between the 3 groups. That difference in mortality was greater between medium and high ACCI populations (22% at 1 year, 23% at 2 years) than between low and medium ACCI populations (14% at 1 year, 18% at 2 years). Remarkably, nearly half (46%) and more than half (58%) of the patients in the

<table>
<thead>
<tr>
<th>ACCI</th>
<th>Observed Mortality (95% CI) Based on ACCI and Surgery Type</th>
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<tbody>
<tr>
<td></td>
<td>1 year</td>
</tr>
<tr>
<td></td>
<td>CRPP</td>
</tr>
<tr>
<td>Low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8% (5-10%)</td>
</tr>
<tr>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22% (17-26%)</td>
</tr>
<tr>
<td>High</td>
<td></td>
</tr>
<tr>
<td></td>
<td>47% (37-55%)</td>
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<tr>
<th>p-value</th>
<th>Low vs. med: &lt;0.001</th>
<th>Low vs. med: &lt;0.001</th>
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<td>Low vs. high: &lt;0.001</td>
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<td>Med vs. high: &lt;0.001</td>
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</table>

ACC: low = 2-4, medium = 5-6, high = 7 and up
high ACCI group were dead at 1 and 2 years post-injury, respectively. These mortality rates are higher than reported in previous studies for femoral neck fractures, which did not take ACCI into account and had shorter follow-up.\textsuperscript{5,25-28} However, there is a potential confounder in these analyses. Co-morbidities are taken into account when assessing surgical options, and since mortality likely varies among surgery types, we anticipate that surgery type is not identically distributed among the 3 ACCI groups, and this could possibly affect our mortality data. We addressed this issue by analyzing mortality in the 3 ACCI groups separately, after separating patients by surgery type, and found similar effects of ACCI on survival in the CRPP and HA groups. Of note, in the low ACCI group, there was a statistical difference in both 1- and 2-year mortalities between CRPP and HA groups; this was not the case in the medium and high ACCI groups.

\textit{Limitations}

Due to the retrospective nature of the study, potential biases existed during the data collection process, as the accuracy of calculating the ACCI depended on the completeness of the available medical records. There were also limitations to the ACCI scoring system itself. For example, the scores did not take into account acute exacerbation of a co-existing disease. Furthermore, scoring some of the diseases required subjective interpretation of the severity of the disease. It also did not account for functional status at the time of injury, which may be linked to mortality.\textsuperscript{29}

Finally, the low number of subjects in the THA group limited our ability to make statistically valid comparisons with CRPP and HA groups. This was particularly true when ACCI groups were taken into account, as in this setting we had more subcategories, leading to fewer patients within each category.

\textbf{CONCLUSIONS}

This study suggests that, in elderly patients who suffered from femoral neck fractures, there is an association between an increase in ACCI and increased mortality at 1 month, 6 months, 1 year, and 2 years after surgical intervention. This association persists even after adjusting for surgery type. Although previous studies have evaluated the effect of co-morbidities on mortality, this study is unique in that (1) we represented various severities of co-morbidities using specific ACCI ranges and evaluated mortality at 4 different time points post-operatively; (2) we also accounted for type of surgical intervention in a subset analysis to eliminate the potentially confounding effect of surgery type on mortality; and (3) we have a large patient database comprising mostly of patients who underwent the most commonly utilized treatment groups (CRPP and HA). The greatest mortality is seen in patients in the high ACCI range, surpassing 50% by 2 years (60% for CRPP and 58% for HA).

\textbf{REFERENCES}

Femoral Neck Fractures Based on Age-modified CCI

APPENDIX A.

Table 1A. Observed 1 month, 6 month, 1 year, and 2 year mortality based on ACCI group.

<table>
<thead>
<tr>
<th>ACCI Group</th>
<th>Observed % Mortality (95% CI) Based on Age-Modified CCI</th>
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<tbody>
<tr>
<td></td>
<td>1 month*</td>
</tr>
<tr>
<td>Low (608)</td>
<td>2% (1-3%)</td>
</tr>
<tr>
<td>Medium (676)</td>
<td>7% (5-8%)</td>
</tr>
<tr>
<td>High (241)</td>
<td>16% (11-21%)</td>
</tr>
</tbody>
</table>

* Pairwise comparisons reveal p <0.001 between low, medium, and high ACCI groups at respective time intervals

Age-Modified CCI: low = 2-4, medium = 5-6, high = 7 and up

The Use of Routine Thoracoabdominal CT Scans in the Polytrauma Patient to Estimate Obesity

David F. Ferguson1, Bryce J. Busenlehner2, Mark D. Rahm1,2, Sachin M. Mehta2, Juhee Song3,4, Matthew L. Davis2,5, H. Wayne Sampson1,6 and Christopher D. Chaput1,2

Objective: To utilize data from routine CT scans to quantify obesity in polytrauma patients without the need to obtain a height and weight.

Design and Methods: We utilized a comprehensive database including multidetector CT thoracoabdominal images of all polytrauma patients admitted to a Level 1 trauma center. One thousand one hundred seventy-four patients were reviewed from 2006 to 2008 and of these, 162 had previous documentation of Body Mass Index (BMI) or height and weight measurements as an outpatient within 6 months of trauma activation and with a truncal girth smaller than the scanning area of the CT machine. Truncal Adiposity Volume (TAV) was calculated from three dimensional reconstructions (3DRs) of the CT scans of the thorax and abdomen obtained in the emergency department.

Results: Statistical analysis yielded a fairly good correlation between TAV and BMI (correlation coefficient \( r = 0.77 \); \( p \)-value < 0.0001). The intra-observer and inter-observer correlations in measuring TAV were high; 0.99 and 0.98 respectively. A linear regression equation of BMI on TAV was estimated and it had a form: 3DR BMI = 20.81 + 0.00064 \( \times \) TAV. In conclusion, TAV provides a reproducible means of evaluating obesity in trauma patients from routinely obtained CT scans.

Conclusions: The TAV eliminates the often problematic task of obtaining a height and weight in a trauma patient and it correlates fairly well with the most commonly used clinical method of quantifying patient adiposity, BMI. This method may provide a more direct measurement of adiposity than does BMI, and holds promise for improving trauma care and research in the obese patient.

Disclosure: The authors declared no conflict of interest.

See the online ICMJE Conflict of Interest Forms for this article.

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25% of men may be classified as obese by BMI standards but non-obese based on dual-energy X-ray absorptiometry (DXA) scans. The inverse is also true in that approximately one-half of women are classified as nonobese by BMI, but having an obese percent body fat by DXA (11). There are also issues specific to the polytrauma patient that might limit the accuracy and utility of the BMI. Calculating an accurate height is difficult in the polytrauma patient, who is generally supine, intubated, and immobilized. The weight might be difficult to measure and document soon after arrival to the emergency department when the focus is on resuscitation. Early weight measurement is important, as significant weight fluctuations can be seen with fluid resuscitation (12). A reproducible method to calculate obesity from routine thoracoabdominal computed tomography (CT) scans that correlates with BMI might obviate the need for these measurements, and the study of patient obesity in the trauma setting would be facilitated.

In addition, the calculation of adiposity by itself has potential value, regardless of whether the degree of adiposity qualifies the patient as obese. The adipocyte is an active cell and it is known to produce many pro-inflammatory cytokines and chemical mediators, and excess adiposity has potential for causing excess systemic pro-inflammatory cytokines (13-16). Recently, interest in the potential role of these adipokines in relationship to bone quality, heterotopic bone, and metabolic syndrome has increased (17). A method of easily quantifying adiposity from already available studies would, thus, facilitate further research in this area.

The purpose of this study was to use data from routine CT scans to quantify obesity in polytrauma patients without the need to obtain a height and weight. We hypothesized that three dimensional reconstructions (3DRs) of standard trauma CT scans can quantify obesity in a reproducible manner and have an acceptable correlation with BMI.

Methods and Procedures
Selection criteria and search strategy
This was a retrospective analysis with radiographic and clinical review. A total of 1,174 patients in the comprehensive American College of Surgeons verified level 1 database were reviewed from 2006 to 2008. Predefined inclusion criteria were (i) 911 trauma registry patients with a CT scan and BMI available in the electronic medical record less than 6 months prior to the trauma and (ii) patients 17 years of age or older. Exclusion criteria for the primary group included (i) penetrating abdominal injuries, (ii) lack of a documented BMI within 6 months of CT scan, (iii) pregnancy, (iv) obvious signs of abdominal trauma, and (v) truncal girth larger than the scanning area of the CT machine. There were 261 patients identified to meet inclusion criteria. The primary group was comprised of 162 patients, and a subclass group was also identified of 99 patients who were excluded based on criteria (v). They fell out of the scanning range of the CT scanner due to positioning, body habitus, or overcropping with resultant gantry cutoff. Age, gender, height, weight, and radiographic measurements were recorded for all patients.

Two methods were used to quantify adiposity: (i) direct measurements of the subcutaneous adipose tissue were obtained from unreconstructed axial CT scans and (ii) The original Dicom data was used to optimize penetration with a slice/detector rows setting of 3 mm 64 x 0.6 mm at a pitch of 0.9 and rotation time of 1 s. Measurements were made on the unreconstructed CT images (Centricity Enterprise Web, version 3.0; GE Healthcare, UK) and were compared with the 3DR images for quality control. 3DRs of truncal body fat were made using the volume of interest cutter tool within the 3DR software. This tool allows one to define a cubic area of interest and exclude certain tissues of disinterest (in this case, nonfat tissue). Images were cropped by focusing between an axial view of the T10 vertebral body at the pedicles inferiorly to the inferior-most portion of the coccyx. If transitional levels were encountered, the films were reviewed and S1 was identified, and eight vertebrae were counted numerically superiorly until T10 was visualized. The total number of images and thickness were then recorded from the cropped image and their product determined the total image length. An image was then brought into the plane where the superior most portion of the superior iliac crest could be seen. A

FIGURE 1 Axial view of superior iliac crest, adipose tissue highlighted 1 cm perpendicularly from the superior iliac crest. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]
1-cm measurement was made perpendicularly and the adipose tissue at this measurement was highlighted, as seen in Figure 1. Using the “Segmentation Parameters” function, truncal adiposity was constructed within ±110 Hounsfield units of the highlighted tissue. This resulted in a 3DR model of adiposity as seen in Figure 2, thus yielding truncal adiposity volume (TAV), which was measured in cubic centimeters and rounded to the nearest whole number. This volume (in cm$^3$) was then divided by the total image length (in mm) representing what we termed BFI.

Data analysis

A power analysis suggested that a total sample size of 162 patients would have a 83% power to detect a correlation difference of 0.1, which was considered as a small effect (18), assuming 0.7 as the null hypothesis correlation using a two-sided hypothesis test with a significance level of 0.05. The same sample size achieved 99% power to detect an R-squared of 0.1 attributed to one independent variable (BFI) using an $F$-test with a significance level of 0.05. Intra-observer and inter-observer agreement regarding the measurements on CT scans were assessed by three evaluators by calculating intraclass correlation coefficient. An intraclass correlation coefficient of 1.0 represents perfect agreement, and 0 suggests that measurements are random.

All variables including demographic characteristics were summarized for the primary group and subclass group using descriptive statistics; mean (s.d.) for continuous variables and frequency (%) for categorical variables. A univariate linear regression model of traditional BMI on BFI was applied to the scatter plot in Figure 3 and a linear regression equation (truncal 3DR BMI (T3DR BMI) estimate equation) was obtained.

In the subgroup of patients with cutoff of the anterior and lateral portions of the abdomen a conversion factor was needed to prevent underestimating BMI. In this group, a measurement was taken from the midline at the level of the superior iliac crest to the lateral border of the skin (topograph lateral IC length) and a conversion factor was developed to modify the T3DR BMI estimate. A multiple linear regression model of traditional BMI on T3DR BMI estimate and topograph lateral iliac crest length was used. Bland-Altman 95% limits of agreement for residuals were obtained for linear regression models. A $P$ value less than 0.05 indicated a statistical significance. SAS version 9.2 (SAS Institute, Cary, NC) was used for data analysis.
Results

There were 162 patients in the primary group. The average age was 42 years (s.d.: 18), and 121 patients (74.7%) were males. The average BMI was 26 (s.d.: 4) with the minimum of 18 and the maximum of 40. The subclass group was comprised of 99 subjects with the average age of 41 years (s.d.: 17), and 54 patients (54.5%) were males. The average BMI was 30 (s.d.: 7) with the minimum of 19 and the maximum of 49. There were 10 subjects (10.1%) of which BMI exceeded the maximum BMI of the primary group.

Statistical analysis confirmed the hypothesis that T3DR of standard trauma CT scans can estimate obesity with a high degree of reproducibility. The intra-observer and inter-observer correlations in measuring BFI were higher than 0.99 and 0.98, respectively, demonstrating excellent agreement among three raters and within each rater.

A scatter plot of traditional BMI vs. BFI demonstrated a positive linear association between BFI and traditional BMI (correlation coefficient = 0.86; \( P < 0.0001 \); Figure 3). A linear regression equation called T3DR BMI estimate has a form: 

\[
\text{T3DR BMI estimate} = 20.590 + 0.241 \times \text{BFI}
\]

R-square of the model was 73.44% and root mean square error was ±2.40. This subclass of patients with gantry cutoff demonstrated a considerably good agreement between observed BMI (traditional BMI) and predicted BMI (T3DR BMI estimate conversion) (Figure 5). Bland-Altman 95% limits of agreement for residuals were (-4.65, 4.65), which indicated that differences between traditional BMIs and T3DR BMI estimates with conversion were within ±4.65 kg/m² most of the time.

Discussion

Over the past 15 years, there has been a sharp increase in the use of CT scans made possible by increasing speed of modern scanners and advances in the quality of the images obtained (19). Previous studies have shown that CT-based adipose tissue measurements are reproducible and can accurately determine volumetric adiposity and distribution (20,21,22,23). Mourtzakis et al. (23) showed that fat mass on a single CT axial image at the level 3 had a strong correlation to whole body fat mass based on whole body DXA measurements (\( r = 0.88 \)). However, previous use of CT scans for this purpose required multiple measurements that were time consuming and therefore had limited adoption outside the research setting (21). In the polytrauma patient, thoracoabdominal multidetector computerized tomographies are now routinely obtained at many trauma centers. Our 3DR method of estimating obesity allows for a reproducible and easily performed method of evaluating truncal adiposity in this patient population.

A T3DR BMI estimate equation based on a linear regression model (Figure 3; solid line T3DR BMI estimate = 20.590 + 0.2407 × BFI) can be used to help a clinician relate a particular BFI to BMI.

\[
\text{T3DR BMI estimate conversion} = -4.860 + 0.961 \times \text{T3DR BMI estimate} + 0.799 \times \text{topograph lateral IC length}
\]

R-square of the model was 88.01% and root mean square error was ±2.40. This subclass of patients with gantry cutoff demonstrated a considerably good agreement between observed BMI (traditional BMI) and predicted BMI (T3DR BMI estimate conversion) (Figure 5). Bland-Altman 95% limits of agreement for residuals were (-4.65, 4.65), which indicated that differences between traditional BMIs and T3DR BMI estimates with conversion were within ±4.65 kg/m² most of the time.
The bold lines in Figure 3 demarcate the WHO obesity classification: underweight, <18.50; normal, 18.5-24.99; overweight, ≥25.00; and obese, ≥30.00, (class I, 30.00-34.99; class II, 35.00-39.99; and class III, ≥40.00) (6). Figure 3 also demonstrates a good agreement between traditional BMI and the predicted BMI estimated using BFI (T3DR BMI estimate) with R-square of 73.44% and root mean square error of ±2.25.

Excess body fat has been associated with metabolic dysregulation regardless of body weight, and BMI should not be considered as the only measure of obesity in patient care settings, particularly in patients with a BMI <30kg/m² (9). The inability of BMI to distinguish adiposity from lean mass is a significant potential source of error. In fact, in a recent study by Shah and Braverman, BMI classified 26% of subjects as obese, however 64% of subjects were classified as obese by DXA. 39% of patients who were classified as having BMI < 30 were found to be obese by DXA. 48% of women were misclassified as nonobese by BMI, but were found to be obese by DXA. 25% of men, however, were misclassified as obese by BMI whereas having a nonobese percent body fat by DXA (11).
This discrepancy can also be seen in our data at lower BMIs (Figure 4). Figures 6 and 7 show scout views and axial views at the level of the L4 vertebral body in a young male with substantial lean body mass and a female with much less lean body mass. The areas highlighted in green illustrate the amount of fat content in two apparently thin patients. Since the accuracy of traditional BMI varies according to multiple factors, the BFI may prove to be a more accurate approach to quantifying adiposity since all lean muscle and fluid weight is easily removed and only truncal adiposity is considered.

This study has several limitations. BMI, height and weight were not calculated at the time of the trauma, but recorded within 6 months of the trauma. Due to Hounsfield units corresponding to certain densities, in a few patients the thin pad overlying the table of the CT scanner highlighted when Hounsfield units were selected for TAV. These cases could inadvertently inflate the new method of calculating obesity. In cases where this occurred, 1,000 cm$^3$ were subtracted from the fat volume to correct for the volume of the table pad that was inadvertently included. In addition, when highlighting Hounsfield units, certain densities within the intestinal lumen would also be highlighted; it is uncertain if this occurred due to artifact or to digested lipids. This occurred rarely, and the volume of the highlighted region in the lumen was small and not thought to have bearing upon the result.

As mentioned, a subclass of patients were also analyzed where accurate T3DR BFI could not be made due to truncal girth exceeding the scanning area of the CT (usually) or positioning/over cropping errors by the CT technician. The T3DR BMI estimate with conversion calculation using the topograph lateral IC length appears to account for this effect allowing for BMI calculation in these individuals as well.

There are several advantages in estimating obesity with BFI. Height and weight can be difficult to obtain, and many polytrauma patients have CT scans taken immediately on arrival before large weight shifts due to fluid resuscitation occur. This method also allows for a calculation of adiposity that excludes lean muscle and other nonadipose tissue that, with further research, may prove to be more clinically relevant than the traditional BMI. In particular, this technique could be applied to large existing CT databases to determine associations with excess adiposity and multiple other disease states, some of which may not have been reported previously (17).

In summary, this study supports quantifying adiposity based on T3DRs of CT scans of the chest/abdomen/pelvis. This method is reproducible and may more accurately reflect true adiposity. This rapid, simple, and reproducible method can be calculated for all patients with a CT scan using either the T3DR BMI estimate or conversion factor equations and may more accurately reflect a patient’s true adiposity. This method could also aid in identifying hospitalized trauma patients with risk factors for poor outcomes that are associated with obesity, allow analysis of large trauma databases with regard to obesity and clinical outcomes even when height and weight measurements are not available.

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References

Evaluation of an Interprofessional Clinician–Patient Communication Workshop Utilizing Standardized Patient Methodology

Casey Lagan, MD,*† Hania Wehbe-Janek, PhD,*† Kim Waldo, RN,* Amy Fox, AA,* Chanhee Jo, PhD,*† and Mark Rahm, MD*†

*Department of Orthopaedic Surgery, Scott and White Healthcare, Temple, Texas; and †College of Medicine, Texas A&M Health Science Center, Temple, Texas

OBJECTIVE: Communication and interpersonal skills (CIS) are one of the 6 general competencies required by the Accreditation Council for Graduate Medical Education (ACGME). The clinician–patient communication (CPC) workshop, developed by the Institute for Healthcare Communication, provides an interactive opportunity to practice and develop CIS. The objectives of this study were to (1) determine the impact of a CPC workshop on orthopedic surgery residents’ CIS (2) determine the impact of physician alone or incorporation of nursing participation in the workshop, and (3) incorporate standardized patients (SPs) in resident training and assessment of CIS.

METHODS: Stratified by training year, 18 residents of an Orthopaedic Surgery Residency Program were randomized to a CPC workshop with only residents (group A, n = 9) or a CPC workshop with nurse participants (group B, n = 9). Data included residents’ (1) CIS scores as evaluated by SPs and (2) self-reports from a 25-question survey on perception of CIS. Data were collected at baseline and 3 weeks following the workshop.

RESULTS: Following the workshop, the combined group (group A and B) felt more strongly that the ACGME should require a communication training and evaluation curriculum (post mean = 52.7, post–pre difference = 15.94, p = 0.026). Group A residents felt more strongly that communication is a learned behavior (post mean = 82.7, post–pre difference = 17.67, p = 0.028), and the addition of SPs was a valuable experience (post mean = 59.3, post–pre difference = 16.44, p = 0.038). Group B residents reported less willingness to improve on their communication skills (post-mean = 79.7, post–pre difference = −7.44, p = 0.049) and less improvement in professional satisfaction in effective communication than group A (post mean group A = 81.9, group B = 83.6, post–pre difference group A = 7.11, group B = 1.89, p = 0.047). Few differences between groups regarding CIS scores were detected.

CONCLUSIONS: While there was no demonstrable difference regarding CIS, our study indicates that participants valued the importance of communication training and found SPs to be a valuable addition. The addition of interprofessional participation appeared to detract from the experience. Further study is warranted to elucidate the variables associated with interprofessional education within the context of CIS training and assessment using SPs in residency. (J Surg 70:95-103. © 2012 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: ACGME competencies, interpersonal communication, IPC course, interprofessional, residency program

COMPETENCIES: Professionalism, Interpersonal and Communication Skills, Systems-Based Practice

INTRODUCTION

Communication and interpersonal skills (CIS) are one of the 6 general competencies the ACGME endorses to define requirements for medical education during residency.1 CIS encompasses multiple activities, including building quality doctor–patient relationship quality, articulate data-gathering, and patient education.2,3 Ineffective CIS with poor physician–patient communication may lead to patient mistrust, dissatisfaction, and litigation.1,3

The ACGME endorsed the 6 general competencies in 1999, and further required programs to implement both training and assessment tools addressing the competencies in 2002.5,6 In general, the core competencies lend themselves readily to traditional methods of training and assessment, however, CIS also pose interesting and unique challenges. Many alternative approaches to teaching CIS are being explored in response to the definition of the core competencies in lieu of traditional didac-
tic methods. These include simulated situations, Objective Structured Clinical Exams (OSCE), role play, the use of standardized patients (SPs), creation of portfolios, direct observation, journaling, and a host of other methods. Simulation methodologies using SPs may be effective tools for teaching and assessing CIS. SPs are individuals trained to accurately and consistently simulate a patient and to assess the physician behavior based on fixed criteria. This educational tool has become more accepted, and assessment strategies using SPs have been shown to reliably measure physician–patient CI.

SPs have been utilized by medical schools in OSCEs to objectively measure numerous areas of clinical competence and the United States Medical Licensure Examination requires passing a similar Clinical Skills examination before licensure. The ACGME also endorses the use of SPs in training and as an outcome assessment tool to measure residents’ competency in various areas, including CIS.23 The CPC workshop was developed by the Institute for Healthcare Communication to provide participants with an interactive opportunity to practice and develop CIS,24 and has been endorsed by the American Academy of Orthopaedic Surgeons as a means to improve CIS. Participants work individually and in teams to analyze videotaped reenactments of actual cases, reach agreement on effective communication, and create effective responses where appropriate. Participants also role play in simulated cases during the workshop to practice CIS. While interprofessional communication is considered an important facet of effective healthcare communication and patient care, it is uncertain if educational activities would be more beneficial with multidisciplinary participants (i.e., including nurses, rather than physicians alone). Scott and White Memorial Hospital (SWMH), a level 1 academic trauma center, is affiliated with the Texas A&M Health Science Center (HSC), College of Medicine in Temple, Texas. Simulation including SPs has been a fundamental educational tool for teaching and assessing CIS for various components in our HSC. Since 2009, the CPC workshop has been delivered as a Continuing Medical Education activity to multiple departments. The following study was designed to incorporate the CPC workshop, SPs, and interprofessional education into an orthopedic residency program for CIS teaching and assessment. We sought to (1) determine the impact of an interprofessional CPC workshop on orthopedic surgery residents’ CIS, (2) determine the impact of physician alone or incorporation of nursing participation in the workshop, and (3) incorporate SPs in resident training and assessment of CIS.

**Methods**

**Study Design**

This study was a pre–post two-group randomized study evaluating the impact of a CPC workshop on orthopedic surgery residents’ CIS.

**Human Subjects**

The study was granted an exempt status by the Scott and White Institutional Review Board. Before the workshop, study participants received information describing the study details and voluntary involvement. Participant information was de-identified, and results were saved in a secure locked environment, only accessible to the research team.

**Participants**

Eighteen residents of the Orthopaedic Surgery Residency Program were stratified based on training year to one of two CPC workshop groups. Group A (n = 9) attended a CPC workshop with only fellow residents, while group B (n = 9) attended a CPC workshop with nurses included as participants. Nine nurses were recruited from SWMH electronic news distribution. Registered nurses who had not previously participated in a healthcare communication workshop were eligible to participate.

**Clinician–Patient Communication Workshop**

The CPC workshop was 4 hours in duration and included didactic discussion, small group and simulated scenarios with SPs. Due to time constraints, both workshops were conducted in 1 day with group A as a morning session and group B an afternoon session. The workshops were led by trained CPC faculty (A.F. and K.W.) who conduct the workshop on a regular basis. The activities took place at a simulation center, modeled as a state-of-the-art “mini hospital,” including a Standardized Patient Clinic.

**Standardized Patient Scenarios**

Six orthopedic-focus simulation scenarios were developed for resident assessment. The scenarios were developed by an orthopedic surgeon (M.R.) and a medical educator experienced in SP methodology (H.W.J.) using an SP case scenario template provided by the Scott and White Standardized Patient Program. Case content included case objectives, summary, setting, SP recruitment specifications, SP presentation during the encounter, chief complaint/opening statement, current and past medical history, family history, social-personal profile, and statements/questions/responses to be stated verbatim. The scenarios were 10 minutes in duration. The 3 scenarios used at baseline were pelvic metastases, knee pain, and intoeing. The 3 scenarios used at follow-up were end of life, back pain, and ulna fracture. The cases were similar in difficulty and type. The cases were randomized for utilization during pre- and post-assessment. Additionally, the order of the SP encounters was randomized and the residents participated in the encounters in the standardized order. CPC workshop scenarios with SPs were utilized for the workshop simulations. The scenarios were preplotted with the research team and with SPs before utilization in the study. SPs were trained to accurately and reliably portray the cases by an SP educator of the Scott and White Standardized Patient
TABLE 1. Group Comparisons of Demographics and Summarized Scores

<table>
<thead>
<tr>
<th></th>
<th>CPC Workshop: Residents (Group A, n = 9)</th>
<th>CPC Workshop: Residents and Nurses (Group B, n = 9)</th>
<th>p Value**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race [B/W/A/H] (%)</td>
<td>0/89/11/0</td>
<td>11/78/0/11</td>
<td>0.381</td>
</tr>
<tr>
<td>Age</td>
<td>29.33 ± 2.45</td>
<td>29.33 ± 2.24</td>
<td>&gt;0.999</td>
</tr>
<tr>
<td>No. of years</td>
<td>3 ± 1.41</td>
<td>2.67 ± 1.5</td>
<td>0.666</td>
</tr>
<tr>
<td>Diff of total self reports</td>
<td><strong>139.11 ± 115.89</strong></td>
<td><strong>-7.67 ± 169.37</strong></td>
<td><strong>0.015</strong></td>
</tr>
<tr>
<td>Diff of communication scores (CIS)</td>
<td>0.93 ± 3.71</td>
<td>-2.22 ± 4.97</td>
<td>0.235</td>
</tr>
<tr>
<td>Diff of interpersonal skills scores (CIS)</td>
<td>1.22 ± 2.81</td>
<td>-1.07 ± 3.62</td>
<td>0.285</td>
</tr>
<tr>
<td>Diff of global (CIS)</td>
<td>0.43 ± 0.8</td>
<td>0 ± 1.14</td>
<td>0.721</td>
</tr>
</tbody>
</table>

*Within comparison (pre vs. post)
**Between comparisons (Group A vs. Group B). Statistically significant outcomes (p value < 0.05) are shown in bold.

Program. Training consisted of trial role playing, discussion and review of role expectations, and assessment utilizing the required form. Case portrayal was repeated several times to ensure consistent role play during encounters. Selected and trained SPs had previous experience as SPs and in assessment of CIS.

Data Collection

Resident assessment data were collected at baseline before the CPC workshop and 2 weeks following delivery of the workshop. Three types of data were collected for resident assessment (1) basic demographics (Table 1); (2) a resident self-assessment tool, which the research team developed through an iterative process and evaluated for content validity; the final tool included 25 questions on perceptions of CIS measured on a continuous visual analogue scale (VAS) ranging from 0 to 100 mm, anchored strongly disagree to strongly agree, respectively (Table 2); and (3) SP evaluation of the residents’ CIS during 3 controlled SP encounters using the University of Illinois, Chicago-CIS scale, a validated and established resident assessment tool (16 questions, 5-point Likert) (Table 3). Residents also completed a CPC workshop evaluation following the activity. Two weeks after the initial workshop, residents completed follow-up self-reports and participated in the 3 post-workshop scenarios with SPs.

Data Analysis

Participants’ characteristics were tabulated by frequencies and percentages or described by mean and standard deviation (SD). Demographics and baseline characteristics were summarized using mean ± SD. Wilcoxon signed rank test was used for changes within groups, and for 2 groups comparison, Mann–Whitney test was used. We assessed the difference between the 2 groups (groups A and B) and compared the mean change of the total scores of CIS and self reports. p Values less than 0.05 were considered statistically significant. R 2.12.1 (R Development, 2010) was used for the statistical analysis.

RESULTS

Group demographics are summarized in Table 1. There was no difference with regards to age of the participants or year in residency training. As a combined group (group A and B), there was no significant change in self reports (p = 0.145), SP reported communication scores (p = 0.687), interpersonal skills (p = 0.906), or global scores (p = 0.207) after the CPC workshop. Table 2 demonstrates the results of the individual items of the self-perception reports. As an overall group, the participants felt more strongly that their communication skills were effective after the workshop (post-mean 83.3, post–pre difference 5.83, SD 11.5. p = 0.038). Participants also felt more strongly that communication is a learned behavior (mean 11.28, SD 20.60, p = 0.022), and that the ACGME should require a communication training and evaluation curriculum in an orthopedic surgical residency (post-mean 52.7, post–pre difference 15.94, SD 24.91, p = 0.026). The overall group, however, felt less strongly that effective communication increases patient satisfaction (post-mean 87.9, post–pre difference −4.00, SD 6.54, p = 0.015) and that patients value effective physician communication (post-mean 84.1, post–pre difference −4.61, SD 7.48, p = 0.032). There were no differences in individual SP reported CIS items for the combined group (Table 3).

When the groups were examined individually, group A demonstrated an increase in post-pre self reports (p = 0.015, Table 1). Furthermore, group A felt more strongly that their communication skills are effective (post–pre difference 10.33, SD 6.76, p = 0.008) after the workshop, while group B demonstrated no significant change (p = 0.866, Table 2). In group A, there was also a significant increase in the perception that communication is a learned behavior (post–pre difference 17.67, SD 18.81, p = 0.028) and that there was value in practicing communication with SPs (post–pre difference 16.44, SD 21.09, p = 0.038), but
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Effective communication skills
I find professional satisfaction in
Clinician–patient communication
My nurse-physician communications are effective.
My communication skills with patients are effective.
There is value in practicing communications skills with standardized patients.
My communication skills with patients are more difficult in high-stress situations.
Communication skills are a learned behavior.
I am willing to communicate effectively with patients.
There is value in practicing communications skills with nurses.
Effective communication skills increase patient satisfaction.
I am confident applying effective communication skills with patients.
I enjoy communicating with patients.
The ACGME should require a communication training and evaluation curriculum in orthopedics surgical residency.

TABLE 2. Group Comparisons on Difference of Individual Scales of Self-Perception Reports

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre Mean</td>
<td>Post Mean</td>
<td>Diff</td>
</tr>
<tr>
<td>I have a strong awareness of the importance of effective clinician–patient communication.</td>
<td>83.6</td>
<td>85.1</td>
<td>1.5</td>
</tr>
<tr>
<td>I have experienced high-stress situations requiring effective communication skills.</td>
<td>84.3</td>
<td>84.2</td>
<td>-0.11</td>
</tr>
<tr>
<td>Effective communication to patients is vital to being a good surgeon.</td>
<td>88</td>
<td>86.4</td>
<td>-1.61</td>
</tr>
<tr>
<td>My communication skills with patients are effective.</td>
<td>77.4</td>
<td>83.3</td>
<td>5.83</td>
</tr>
<tr>
<td>Effective communication skills positively impact patient safety.</td>
<td>84.4</td>
<td>84.3</td>
<td>-0.17</td>
</tr>
<tr>
<td>There is value in practicing communications skills with standardized patients.</td>
<td>43.7</td>
<td>51.3</td>
<td>7.61</td>
</tr>
<tr>
<td>I am willing to enhance my communication skills with patients.</td>
<td>77.5</td>
<td>83.7</td>
<td>6.17</td>
</tr>
<tr>
<td>My communication skills with patients are more difficult in high-stress situations.</td>
<td>77.8</td>
<td>83.7</td>
<td>5.94</td>
</tr>
<tr>
<td>Communication skills are a learned behavior.</td>
<td>61.8</td>
<td>73.1</td>
<td>11.28</td>
</tr>
<tr>
<td>I am confident applying effective communication skills with patients.</td>
<td>88.4</td>
<td>88.3</td>
<td>-0.17</td>
</tr>
<tr>
<td>There is value in practicing communications skills with nurses.</td>
<td>70.3</td>
<td>70.9</td>
<td>0.56</td>
</tr>
<tr>
<td>Effective communication skills increase patient satisfaction.</td>
<td>91.9</td>
<td>87.9</td>
<td>-4</td>
</tr>
<tr>
<td>I am confident applying effective communication skills with patients.</td>
<td>81.9</td>
<td>81.7</td>
<td>-0.22</td>
</tr>
<tr>
<td>I enjoy communicating with patients.</td>
<td>76.9</td>
<td>81.6</td>
<td>4.67</td>
</tr>
<tr>
<td>The ACGME should require a communication training and evaluation curriculum in orthopedics surgical residency.</td>
<td>36.7</td>
<td>52.7</td>
<td>15.94</td>
</tr>
</tbody>
</table>

TABLE 2. Continued

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre Mean</td>
<td>Post Mean</td>
<td>Diff</td>
</tr>
<tr>
<td>Effective communication skills reduce the likelihood of exposure to malpractice litigation.</td>
<td>89.8</td>
<td>87.3</td>
<td>-2.5</td>
</tr>
<tr>
<td>My nurse-physician communication during high-stress situations is effective.</td>
<td>78.3</td>
<td>82.1</td>
<td>3.72</td>
</tr>
<tr>
<td>I find professional satisfaction in communicating effectively with patients.</td>
<td>78.2</td>
<td>82.7</td>
<td>4.5</td>
</tr>
<tr>
<td>Clinician–patient communication workshops are an effective method for communication skills training.</td>
<td>48.9</td>
<td>59.7</td>
<td>10.72</td>
</tr>
<tr>
<td>Effective communication skills positively impact patient care.</td>
<td>84.3</td>
<td>82.6</td>
<td>-1.72</td>
</tr>
<tr>
<td>Patients’ family members value effective physician communication.</td>
<td>85.2</td>
<td>85.8</td>
<td>0.56</td>
</tr>
<tr>
<td>I am willing to enhance my communication skills with patients.</td>
<td>86.4</td>
<td>83.7</td>
<td>-2.67</td>
</tr>
<tr>
<td>Effective communication skills increase clinician satisfaction.</td>
<td>82.4</td>
<td>84</td>
<td>1.61</td>
</tr>
<tr>
<td>My communication skills with patients’ family members are effective.</td>
<td>80.7</td>
<td>83.6</td>
<td>2.89</td>
</tr>
<tr>
<td>Patients’ value effective physician communication.</td>
<td>88.7</td>
<td>84.1</td>
<td>-4.61</td>
</tr>
</tbody>
</table>

Statistically significant outcomes (p-value < 0.05) are shown in bold
*Post-pre difference within comparison.
**Between comparisons (group A vs. group B)
<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>Group A</th>
<th></th>
<th>Group B</th>
<th>Post–Pre Diff</th>
<th>p Value*</th>
<th></th>
<th>Group B</th>
<th>Post–Pre Diff</th>
<th>p Value*</th>
<th></th>
<th>Group B</th>
<th>Post–Pre Diff</th>
<th>p Value*</th>
<th></th>
<th>Group B</th>
<th>Post–Pre Diff</th>
<th>p Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>I felt you were telling me everything; being truthful, up front, and frank; not keeping things from me.</td>
<td>4.6</td>
<td>4.5</td>
<td>-0.06</td>
<td>0.614</td>
<td>4.7</td>
<td>4.6</td>
<td>-0.04</td>
<td>0.705</td>
<td>4.5</td>
<td>4.4</td>
<td></td>
<td>4.3</td>
<td>4.1</td>
<td>-0.19</td>
<td>0.289</td>
<td>4.4</td>
<td>4.4</td>
<td>0.07</td>
</tr>
</tbody>
</table>
this difference was not seen in group B (post–pre difference 4.89, \( p = 0.343 \) and post–pre difference \(-1.22, \ p = 0.953 \) respectively). Group B residents felt more negatively that effective communication improved patient satisfaction (post–pre difference \(-6.22, \ SD 7.33, \ p = 0.020 \), and were less willing to enhance their communication skills (post–pre difference \(-7.44, \ SD 9.93, \ p = 0.049 \) after the CPC workshop. When rated by the SPs, group A residents showed improvement with using plain language rather than medical jargon (post–pre difference 0.37, SD 0.45, \( p = 0.047 \), Table 3). Neither group demonstrated any other significant changes in CIS evaluation by the SPs. Comparing the change in overall self reports between groups, group A demonstrated a significantly higher post-intervention improvement than group B (\( p = 0.031 \), Table 1). Group A participants found higher satisfaction in communication with their patients than did group B (\( p = 0.047 \), Table 2). When rated by the SPs, group A participants were more likely than group B participants to approach sensitive or difficult subject matters with sensitivity and without being judgmental (\( p = 0.044 \) and were more likely to use plain language rather than medical jargon (\( p = 0.046 \), Table 3).

**DISCUSSION**

While it is recognized as a core competency by the ACGME, the teaching of communication and interpersonal skills has no formalized or required curriculum among residency programs. As a group, the participants of this study felt more strongly that the ACGME should require a communication training and evaluation curriculum in orthopedic surgical residencies. While this study was not designed to compare different models of communication training, it did demonstrate an improved attitude toward communication among the participants after implementation of this model. It did not, however, demonstrate many improvements in CIS. Other models have also failed to show differences in SP rated outcomes after intervention.\(^{10}\) Perhaps with longer periods to implement and practice changes in patient interactions, more significant changes would have been realized.

Our study groups were divided based on the presence or absence of interprofessional healthcare associates. While it has been reported in the literature that interprofessional educational activities may be of some benefit,\(^ {25,26} \) that was not the result of our study. Participants in the group with nurses had less positive attitudes toward communication following the activity, and interprofessional education appeared to detract from the experience of the CPC workshop. This could be due to a number of reasons. Perhaps they were less likely to feel comfortable in participating in the workshop or sharing their experiences with the small groups. Anecdotally, the faculty leaders of the CPC workshop noted that group A tended to sit closer together, were more informal, appeared more comfortable, and were more interactive. This may have been due to the particular mix of residents, or may be due to the mixed group with unfamiliar participants in group B. The faculty leaders also noted
they felt impacted the quality of the workshop. Faculty observed that group B residents were much less interactive and appeared uncomfortable. Results in the literature to this point have been somewhat mixed on the effectiveness of interprofessional education,25,26 and this study points out that further research into this subject is warranted to elucidate some of the variables associated with interprofessional education. One objective of this study was to incorporate SPs into the training and assessment of CIS. Group A residents found the addition of SPs valuable, and the SPs were able to provide some valuable feedback on participant performance. It is unclear as to why group B residents found less value in the addition of SPs, although this may also be related to interprofessional aspect of their CPC. While there was no detectable documented change in overall performance, the SPs were able to document some specific improvements in the interpersonal skills area. The SPs also simulated high stress and sensitive situations that are sometimes encountered, which allowed for teaching and evaluation in these settings without involving a vulnerable patient or family member. The addition of SPs to a communication workshop was seen as a beneficial and valuable addition to the CPC workshop, which traditionally involves workshop participants role-playing.

There are several limitations to this study, one being small sample size. Small group dynamics could certainly play a role in the overall attitude towards the workshop. Another potential confounder is the timing of the CPC workshop. Group A was performed in the morning, while group B attended the workshop in the afternoon. The workshop faculty noted that group B was more frequently interrupted by pagers and other clinical responsibilities. Fatigue and general attitudes toward the workshop may have been influenced by the time of day as well. Additionally, ceiling effects may have contributed to the lack of post–pre changes noted by the positive baseline responses measured by both assessment tools. CIS is considered an important facet of resident education, and there have been considerably more resources and thought given to teaching and evaluation in this area. Although interprofessional communication is an important area of clinical communication, we found that interprofessional involvement in this CPC workshop detracted from the overall attitude toward communication and the willingness to continue to improve in CIS. This type of educational experience, which is heavily founded on interaction and designed to improve awareness and communication skills essential for clinical practice,24 may be best accomplished with participants who are already comfortable with one another and are comfortable sharing their thoughts and experiences. Other models may lend themselves better to interprofessional involvement. The addition of SPs to this curriculum is seen as beneficial for a number of reasons, as discussed above. The obvious deterrence to implementing a communication workshop complete with SPs includes cost, time, and planning that must be invested in such a program. With effective communication being linked to improved outcomes in these areas.

ACKNOWLEDGMENTS

This work was generously supported by an OMeGa Medical Grants Association Core Competency Innovation grant no. 716. The authors thank the Scott and White Standardized Patient Program for training the SPs, and the Temple College Clinical Simulation Center for providing the facilities. They also thank Mr. Glen Cyer for publication editorial assistance.

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Hemoglobin Trends after Primary Total Hip and Knee Arthroplasty: Are Daily Post-Operative Hemoglobin Phlebotomies Necessary?

Kushal Patel, M.D.

INTRODUCTION:
Common practice is daily post-operative hemoglobin level evaluation in patients undergoing primary total arthroplasty of the hip (THA) and knee (TKA). Frequently, no specific action is taken secondary to these lab results. Our study examined post-operative hemoglobin trends in primary joint arthroplasty patients. We hypothesize that post-operative hemoglobin values do not drop significantly enough to warrant daily phlebotomy in many patients and thereby, improve patient satisfaction and reduce costs.

METHODS:
Retrospective review of patients who underwent primary THA and TKA from 2009 to 2011. Data collected included laterality, age, gender, intra-operative estimated blood loss, body mass index, pre-operative hemoglobin level, and post-operative hemoglobin level 0-8, 8-24, 24-48, and 48–72 hours post-operative. Patients who underwent conversion to total joint arthroplasty were excluded.

RESULTS:
A total of 1929 [One thousand nine hundred and twenty-nine] patients (497 (25.7%) THA and 1433 (74.3%) TKA) were included. Bilateral TKA accounted for 227 of 1433 TKA patients. Mean absolute drop in hemoglobin from pre-operative levels at 0-8, 8-24, 24-48 and 48-72 hours post-operative were, for unilateral TKA patients, -1.8±0.9, -2.4±1.0, -3.2±1.1, and -3.5±1.2; for bilateral TKA patients, -2.4±0.8, -2.8±1.2, -3.9±1.2, and -4.4±1.5; and for THA patients, -2.4±1.0, -2.81±1.0, -3.5±1.1, and -4.1±1.8. In THA patients at 24 hours post-operative 173 (34.8%), 72 (14.5%), and 29 (5.8%) patients had hemoglobin values below 10.0, 9.0, and 8.0, respectively. Corresponding numbers in TKA patients were 320 (22.3%), 92 (6.4%), and 17(1.2%) patients.

DISCUSSION AND CONCLUSION:
With projected rises in elective primary THA and TKA and greater focus on cost and patient satisfaction, daily phlebotomy for hemoglobin values is a potential area of improvement. Our study provides trends in hemoglobin after THA and TKA and questions whether examination of daily hemoglobin values is necessary. In the appropriately selected patient, phlebotomy draws to examine hemoglobin can be forgone especially in the early post-operative period.
Influence of Displacement and Treatment Methods on Patient Mortality after Femoral Neck Fracture

Donavan K. Murphy, Timmothy Randell, Kindyle L. Brennan, Juhee Song, John M. Hamilton, Michael L. Brennan, and Robert A. Proe.

OBJECTIVES: To determine if femoral neck fractures (FNF) displacement and treatment selection influence patient mortality.

DESIGN/SETTING: Retrospective review at Level I trauma center

PARTICIPANTS: 1788 individuals with FNFs treated at a single institution over 11 years

MEASUREMENTS: A review of patient records with low-energy fractures treated with Closed Reduction Multiple Cannulated Screws (CRMCS), Hemiarthroplasty (HA), or Total Hip Arthroplasty (THA) were included. FNFs were classified as nondisplaced or displaced. Associations with treatment method, revision, age, comorbidities, and gender were examined.

RESULTS: There were 1474 patients, 371 (25.17%) male and 1103 (74.83%) female. Ages ranged from 60-106 (80.82) years. CRMCS, HA, and THA were performed on 766, 758, and 41 fractures, respectively. There were 1139 displaced fractures treated by CRMCS (363), HA (745), and THA (41) and 396 nondisplaced fractures treated by CRMCS (383), HA (13), and THA (0). Comparing displaced and nondisplaced fractures, no significant difference in survival rate was found in any time interval except at 1 month; nondisplaced fractures demonstrated a statistically significant lower mortality rate (4.1%) comparing to displaced fractures (6.9%). When comparing mortality between treatment groups, mortality of those undergoing HA was higher than those undergoing CRMCS at all intervals; THA survival was longest. The hazard ratio for HA vs. CRMCS was 1.24, for age >80 versus 2.16 for ages 60-70, men compared with women was 1.55.

CONCLUSION: HA was associated with a higher mortality rate when compared to CRMCS and THA. Treatment selection and comorbid factors must be accounted for when contemplating treatment for FNFs. There is a need to further stratify this patient population and expand on the significance of all comorbid conditions.

INTRODUCTION

Femoral neck fracture is a devastating injury to the elderly, with overall mortality reported between 15-30% within the first year after fracture.1-14 This healthcare burden is carried not only by the patients and their families, but by our healthcare system as well. Ray et al. reported that in 1995 the United States devoted $13.8 billion in health care spending to treatment of osteoporotic fractures, with $8.7 billion going toward the treatment of hip fractures alone.15 While geriatric hip fracture incidence is decreasing,16 world-wide annual prevalence of femoral neck fractures is expected to increase from 1.26 million cases per year in 1990 to 4.5 million cases per year by 2050.17 Understanding factors associated with poor outcomes following surgical management of these fractures is increasingly important, given the expected rise in prevalence.

The majority of femoral neck fractures are treated surgically with internal fixation (IF), hemiarthroplasty (HA), or total hip arthroplasty (THA). The choice of optimal surgical treatment is currently controversial, with several investigators reporting superior clinical outcomes and fewer complications following HA and THA, as compared to IF.18-24 Others, however, have suggested higher rates of mortality following arthroplasty as compared to internal fixation.7,25

Although several prior studies have evaluated the impact of the mode of surgical treatment on outcomes and mortality rates, few have considered the impact of fracture displacement.24 The purpose of this study was to retrospectively compare overall mortality of displaced and nondisplaced femoral neck fractures after the primary surgical intervention among the three surgical treatments. Secondarily, we analyzed a) overall mortality after reoperation surgery for each index procedure, b) mortality rates by age (decade) at time of surgery, c) mortality rates by gender, and d) we described the death associated comorbidities.

METHODS

This study was approved by our institutional review board. The medical record database at a level one trauma hospital was queried for diagnosis and treatment codes.
associated with femoral neck fracture between the years 1998 and 2009. The codes used were ICD9 - 820, CPT 27235, 27236, and 27132. The exclusion criteria were age less than 60 years, fracture secondary to high energy trauma, fracture secondary to neoplasia, extracapsular hip fracture, prior unrelated surgery to proximal femoral region, need for open reduction, or treatment other than closed reduction with IF, HA, or THA. The record search revealed 1788 patients meeting our criteria for chart review.

Data collected from the chart review included medical record number (MRN), age/DOB, sex, surgery(s) performed with date of surgery, classification of femoral neck fracture as displaced or nondisplaced, and dates of the last contact or death note. Surgeries performed were further classified as right/left and primary/reoperation. Reoperation surgery was any surgery following the index procedure on the affected hip that met inclusion criteria. Patients’ death records were obtained from Texas Vital Statistics based on name, date of birth, and sex.

All radiographs and reports were reviewed by the same investigator (TR). Radiographs from 1998 to August 2002 were not stored digitally or readily available for review, thus the classification of these femoral neck fractures was established by review of fracture description by the operating orthopedic surgeon or radiological record. Picture archiving and communication system (PACS) was used for review of all patient films from August 2002 to 2011. Femoral neck fractures were classified as nondisplaced or displaced. Fractures were considered nondisplaced if they were identified as OTA 31B1.1-3. Fractures were considered displaced if they were 31B3.1-3 or 31B2.3. Based on the Garden classification, fractures were nondisplaced (types I-II) and displaced (types III-IV). The intergrader agreement for Garden Stages 1, 2, 3, and 4 fractures is reportedly low (kappa, 0.03-0.56) but high (kappa, 0.67-0.77) for nondisplaced (Garden Stages 1 and 2) and displaced (Garden Stages 3 and 4) fractures.26 A subset of radiographs was used to assess and ensure interobserver reliability with two board-certified trauma surgeons and four chief residents. Consistent with previous reports, intergrader reliability was greater than 90% for nondisplaced and displaced fracture groups.

Those patients treated with multiple screws had reduction achieved through closed means on a fracture table and implant placement as described by Probe et al.27 AS-NIS III (Stryker) 6.5mm cannulated screws were used on all patients with the decision to place three or four screws based on posterior comminution. In the vast majority of hemiarthroplasty cases, a modified Hardinge lateral approach combined with a cemented modular stem was utilized. Total hip arthroplasty was also performed with a modified Hardinge lateral approach using a variety of prosthetic components from different manufactures.

**STATISTICAL ANALYSIS**

Demographic data, injury and surgery types, and occurrence of reoperation were summarized using means and percentages, as appropriate.

Chi-squared tests/Fisher’s exact tests were used to compare surgery types between displaced and nondisplaced fractures. The ages at surgery were compared between fracture and surgery types using t-tests and ANOVA.

Kaplan-Meier estimates and Cox proportional hazards regression was used to examine a) mortality rates by fracture type (displaced vs. nondisplaced), b) mortality rates by surgery type, c) overall mortality after index procedure and reoperation surgery, d) mortality rates by age (decade) at time of surgery, e) mortality rates by operative year, and f) mortality rates by gender. In all cases where fracture type is a covariate, patients missing fracture class data were excluded from the analysis. In certain models we compared rates at 1 and 6 months and 1 and 2 years post operatively. We view this as exploratory analysis and do not apply a multiple test correction. We also carried out pairwise comparisons between groups in some cases where there are more than two strata (e.g., operative year). Tests were run at 5% significance (p≤0.05) in all cases. Additionally, we examined co-morbidity by recording the ICD-9 codes of those who died and calculating the number of patients per code.

**RESULTS**

ICD-9 and CPT code searches resulted in 1788 identified patients. Following chart review and application of exclusions, there were a total of 1474 patients, with 1565 fractures: 371 (25.17%) were male and 1103 (74.83%) female (Figure 1). Ages ranged from 60-106 years; they were roughly normally distributed with a mean of 80.82
Influence of Displacement and Treatment Methods on Patient Mortality after Femoral Neck Fracture

There were a total of 1139 displaced fractures treated by IF (363), HA (745), and THA (41), and a total of 396 nondisplaced fractures treated by IF (383), HA (13), and THA (0). Thirty fractures, unclassified secondary to lack of appropriate information, were treated with IF (20), HA (9), and THA (1). Internal fixation, HA, and THA were performed on 766, 758, and 41 fractures, respectively. A total of 890 (56.87%) patients died, and 235 (15.02%) had reoperation surgeries. One hundred twenty-two (51.91%) patients with reoperations died.

A Kaplan-Meier model of survival was used to examine mortality after the initial surgery, which indicated a median survival time post-operatively of 4 years. Of the 235 patients who had a revision surgery, a Kaplan-Meier model of survival after revision surgery indicated median survival time post-re-operation to be 5.36 years. Mortality rates at 1 and 6 months, and 1 and 2 years are reported, noting improved mortality in patients undergoing reoperation. (Table 1)

<p>| Table 1. Kaplan Meier Analysis of Median Survival and Mortality Rates across Time Intervals |
|---------------------------------|----------------|----------------|----------------|----------------|----------------|</p>
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<th>Median Survival (yr)</th>
<th>1 month Mortality</th>
<th>6 month Mortality</th>
<th>1 Year Mortality</th>
<th>2 Year Mortality</th>
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<tr>
<td>Index</td>
<td>4.00 (3.65-4.42)</td>
<td>6.0% (7.2-4.8%)</td>
<td>16.3% (18.1-14.4%)</td>
<td>21.8% (23.8-19.6%)</td>
<td>31.8% (34.2-29.3%)</td>
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<td>Reoperation</td>
<td>5.36 (3.94-5.99)</td>
<td>2.6% (4.6-0.5%)</td>
<td>12.2% (16.3-7.9%)</td>
<td>16.3% (21-11.3%)</td>
<td>24.6% (30.1-18.6%)</td>
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<td>IF</td>
<td>4.37 (3.93-5.09)</td>
<td>4.8% (6.3-3.2%)</td>
<td>14.83% (17.36-12.24%)</td>
<td>19.59% (22.41-16.66%)</td>
<td>29.55% (32.83-26.11%)</td>
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<td>HA</td>
<td>3.40 (3.01-3.96)</td>
<td>7.5% (9.4-5.6%)</td>
<td>18.18% (20.94-15.32%)</td>
<td>24.43% (27.84-21.49%)</td>
<td>35.21% (38.71-31.52%)</td>
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<td>THA</td>
<td>6.28 (5.16-NA)</td>
<td>2.66% (7.8-0%)</td>
<td>7.69% (15.69-0%)</td>
<td>7.69% (15.69-0%)</td>
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<td>Age 60-69</td>
<td>6.96 (4.68-NA)</td>
<td>3.26% (6.03-0.41%)</td>
<td>14.68% (20.16-8.81%)</td>
<td>16.82% (22.63-10.57%)</td>
<td>24.2% (30.9-16.85%)</td>
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<td>Age 70-79</td>
<td>5.34 (4.75-6.15)</td>
<td>3.0% (4.6-1.4%)</td>
<td>12.29% (15.26-9.22%)</td>
<td>16.6% (19.98-13.1%)</td>
<td>23.8% (27.76-19.75%)</td>
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<td>Age 80+</td>
<td>3.17 (2.95-3.59)</td>
<td>8.0% (9.8-6.3%)</td>
<td>18.53% (21.03-15.95%)</td>
<td>25.18% (27.99-22.27%)</td>
<td>37.08% (40.25-33.74%)</td>
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<td>Female</td>
<td>4.57 (4.12-5.08)</td>
<td>4.6% (5.8-3.4%)</td>
<td>12.8% (14.7-10.8%)</td>
<td>17.81% (20.03-15.53%)</td>
<td>27.39% (59.98-24.66%)</td>
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<tr>
<td>Male</td>
<td>2.31 (2.03-2.93)</td>
<td>10.36% (13.35-7.27%)</td>
<td>26.5% (30.81-21.93%)</td>
<td>33.4% (38.01-28.45%)</td>
<td>44.81% (49.71-39.44%)</td>
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</table>

When comparing displaced and nondisplaced fractures, there was no significant difference in overall survival or survival at 6 month, 1 year, or 2 year survival. However, the mortality rate at 1 month for nondisplaced fractures was significantly lower when compared to displaced fractures, 4.09% and 6.9% respectively (p=0.026). On subset analyses comparing death rates between displaced and nondisplaced fractures, within each surgery type separately, there was no significant difference in survival between displaced and nondisplaced fractures at any time frame.

Mortalities for patient age groups 60-69, 70-79 and greater than 80 were calculated using Kaplan-Meier estimates and compared using a Cox proportional hazards model. When comparing patients in age groups 60’s to 70’s, no significant differences were found. Survival of those in their 80’s was significantly worse than survival...
of those in their 60’s and 70’s at 1 and 6 months, and at 1 and 2 years. The hazard ratio for 80’s vs. 60’s was 2.16 (95% CI 1.65-2.81, p-value<0.001). The hazard ratio for 80’s vs. 70’s was 1.64 (95% CI 1.41-1.91, p-value<0.001). Mortality data for each age group is represented in Table 1 and Figure 3.

Mortality was significantly greater (p<0.001) for men compared to women, with a hazard ratio of 1.55 (1.34-1.79). The mortality rates at 1 and 6 months, and 1 and 2 years, all differed significantly between genders (p<0.001). Table 1 and Figure 4 illustrate each gender’s mortality data.

ICD-9 codes for cause of death were recorded, and grouped into the following categories (n): cardiologic (343), neurologic (178), respiratory (100), neoplasia (99), endocrine (42), renal (28), infection (27), gastrointestinal (22), congenital (12), miscellaneous (27), and musculo-skeletal (8). We could not identify an ICD-9 code for four deceased patients. Table 2 summarizes data for each death-associated comorbidity.

DISCUSSION

The purpose of this study was to assess the effects of fracture displacement and treatment modality on the mortality rate following femoral neck fracture. Furthermore, we intended to examine these variables in relation to reoperation, age, and gender; while describing the comorbidities associated with mortality. A large femoral neck fracture database, compiled from the records of a level one trauma hospital, was used for the evaluation of these relationships. This patient cohort is unique as it is the largest in the American population, to our knowledge.

This study demonstrated that treatment modality, but not fracture displacement, following femoral neck fracture, was associated with a significant difference in patient mortality. Our results corroborate the results of other studies on patient mortality. Like Lu-Yao et al., our data revealed that treatment of femoral neck fractures with HA results in a slightly higher rate of mortality at 30 days when compared to IF.\textsuperscript{7} Eisler et al. published a 6 month mortality rate of 5.7% in a prospective study including 70 patients with nondisplaced fractures treated with cannulated screw fixation, and Eiskjaer et al. published 6 month mortality rates of 20% following HA.\textsuperscript{4,5} Without accounting for displacement, we reported 14.83% and 18.18% mortality at 6 months for IF and HA respectively. Eiskjaer et al. also reported 12 month mortality rates of 28% after HA.\textsuperscript{4} These one year rates

Table 2 Numbers of Death-Associated Comorbidities

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<tr>
<th>Condition</th>
<th>Overall</th>
<th>1 month</th>
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<th>1 year</th>
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<td>Cardio</td>
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<td>Neurologic</td>
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are higher than those in other studies28-32, but consistent with our results (24.43% mortality at one year after HA). In our study, at each time interval of interest, HA showed a significantly increased mortality as compared to IF and THA. Mortality rate of THA was significantly better than other treatment options, possibly secondary to selection bias. A commonly recognized practice pattern is for the more active and healthier patients to more likely be considered for the more invasive THA. Other factors which could explain why HA patients have an increased mortality include: increased blood loss, anesthesia time, rehabilitation, and functional deficits. These factors were not examined in this study; leaving a number of questions for future investigations.

Overall mortality following reoperation was slightly better than that following the index procedure. This too may be explained by a selection bias: healthier patients are likelier to be considered by surgeons to be capable of performing well following reoperation. Additionally, it is the healthier patients who are likely to survive to a point where reoperation is needed. When examining patients based on age by decade (60-69, 70-79, and greater than 80), we found that our patient population has an increased mortality rate as compared to data form the US Census, and that older patients have a statistically significantly increased mortality compared to younger patients. Using 2009 US Census data, mortality rates of people in their 60s, 70s, and 80s were 1.2%, 3.0%, and 9.5%, respectively.33 Using a Kaplan Meier estimate, death rates of our patient population were estimated at 16.1% for patients in their 60s, 15.9% for patients in their 70s, and 23.8% for patients in their 80s. While comparing the older patients in our study to younger patients, we found that there is an almost 10% difference at 1 year and 13% difference at 2 years between those greater than 80 and those younger. It appears that age greater than 80 provides some prognostic value when considering mortality. Our data also reiterates that men have increased mortality when compared to women; this has been previously shown in the literature.4,33,34

Aside from surgical intervention, other variables have been indicated for their role in mortality of patients with femoral neck fractures. Conditions such as renal disease, heart failure, cardiac ischemia, and neurologic impairment have been shown to increase mortality.4,34,36 The data reported here based on ICD-9 codes associated with patients’ death continues to reaffirm that mortality is dependent on patient comorbidity at the time of the injury and surgery. This data could only be used in a descriptive nature secondary to the method of collection, so rigorous statistical comparisons could not be performed. Future studies designed to analyze the role of comorbidities in the mortality rate of these cohorts are warranted.

This study does present limitations. The retrospective nature of this study, without randomization and blinding, does impart a possibility for a selection bias. The patients’ treatments were selected based on the evaluation of the x-rays by each primary surgeon. Although indications for surgery were largely the same for each surgeon, variability is unavoidable. Despite their choice of treatment, each fracture after 2002 was reviewed by a single grader and analyzed in its treatment group. Radiographs prior to 2002 were not available for review, so radiological reports and orthopedic surgeon descriptions were used to classify fractures. Although inter-grader reliability is reported high, this does break uniformity among data collected. CONCLUSION

Our data illustrate the importance of treatment selection on patient mortality and also shed light on the fact that many of these patients have confounding conditions that may be increasing their mortality risk. Many factors must be accounted for when contemplating treatment for femoral neck fractures. Although noting a higher mortality rate at each time interval with hemiarthroplasty, other studies on this patient population show the risk of complication and reoperation is greater with IF. All of this information should be taken into account. More research has to be done to further risk stratify this patient population and detail the significance of all comorbid conditions of a patient.

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DAVID FERGUSON

CASEY LAGAN


KUSHAL PATEL


Kushal V Patel, Dan C Jupiter, Bryce C Allen. Hemoglobin trends after primary total hip and knee arthroplasty: are daily post-operative hemoglobin phlebotomies necessary? Podium Presentation, SOA Resident Travel Grand Award Winner 2013, Southern Orthopaedic Association Annual Meeting, Palm Beach, FL, July 2013

Kushal V Patel, Adam Shar, Zachary T Hubert, Timothy R Randell, Daniel C Jupiter, Kindyle L Brennan, Michael L Brennan, Robert A Probe, Matthew L Davis. A modified frailty index: correlation to one and two-year mortality in geriatric femoral neck fractures.


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*High-energy femur fractures increase morbidity but not mortality in elderly patients.*


Kusha V Patel, Kwon Park, Daniel C Jupiter, Kindyle L. Brennan, Matthew L Davis, Michael L Brennan. *Mortality and morbidity in high energy trauma patients, aged 60 and greater, with femoral shaft fractures.*


**TIMOTHY RANDELL**


Donavan K. Murphy, Timmothy Randell, Kindyle L. Brennan, Robert A. Probe, and Michael L. Brennan. *Treatment and displacement affect the reoperation rate for femoral neck fracture.*


Adam Shar, Timothy Randell, Michael L Brennan, Kindyle L Brennan, Daniel C Jupiter, and Zachary T Hubert. *Mortality of femoral neck fractures in the elderly based on age-modified charlson comorbidity index score.*

Podium presentation, 29th Annual Southern Orthopaedic Association on July 19, 2012, in Sulphur Springs, WV

**MATTHEW ELLINGTON**


Poster Presentation, Western Orthopaedic Association’s Annual Meeting, Portland, OR, June
CURRENT RESIDENT PUBLICATIONS / PRESENTATIONS

2012.
Southern Orthopaedic Association Annual Meeting, West Virginia, July 2012.

Podium presentation, Hanes H. Brindley, Sr. Orthopaedic Lectureship and Orthopaedic Resident Research Forum, Temple, TX, June 10, 2011.
Podium presentation, Western Orthopaedic Association Annual Meeting 2012, Portland OR, Poster presentation, Southern Orthopaedic Association Meeting 2012


JOSHUA GRIFFIN

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MATTHEW JORDON
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Matthew Jordan, Travis Wilson, Daniel Jupiter, Bryce Allen, Christopher Chaput. Local soft-tissue thickness as a significant risk factor for complications after total hip arthroplasty.
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Matthew Jordan, Kip Murphy, Judith Linton, Allison Scott - Shriners Hospital for Children, Houston, TX
Revision Hamstring Lengthening in Children with Cerebral Palsy. Currently preparing manuscript

DONAVAN K. MURPHY
Paper Presentation #76. Orthopaedic Trauma
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JUSTIN BARTLEY
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Justin Bartley, Scott M. Munroe, and Russell A. Ward. Fibrous dysplasia in the calcaneus
Scott and White Research Days Poster Presentation: May 2013

JEFFREY KNABE

HEATHER LICHT
Heather Licht, John Vassaur, Mark Murray, Daniel Jupiter, Justin Regner, and Christopher Chaput.

Podium presentation, Baylor Scott & White Research Days May 2014. Temple, TX

ADAM SHAR
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Podium presentation - 29th Annual Southern Orthopaedic Association on July 19, 2012, in Sulphur Springs, WV


NATHAN B. HAILE
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Orthopaedic Resident Alumni Continued

1990
Thomas M. Carrell
Scott D. Cochran
Richard D. Nixon

1991
Kirby D. Hitt
David Howie
Robert E. Reeve

1992
Sherwood Duhon
Derek K. Lichota
Mark D. Rahm

1993
David A. Benavides
C. Kent Boese
Mark D. Young

1994
Steven T. Carawan
Stephen P. Courtney
Andrew A. Stoebner

1995
Marshall G. Baca
Eugene E. Curry
Steve A. Shapiro

1996
Robert K. Lieurance
Todd M. Raabe
Richard B. Schultz

1997
Thoma J. Ellis
Kalin D. Kelso
Edwin M. Roeder

1998
Douglas S. Fornfeist
Darey A. Philbrick
Jeffrey N. Spaw

1999
Michael L. Ramsey
Jordan G. Stanley
Harold G. Weems, Jr.

2000
Jonathan W. Fontenot
J. Kevin Rudder
Steven H. Weeden

2001
James W. Burnett
Michael D. Dersam
Plinio Antonio Caldera

2002
Christopher D. Chaput
Matthew P. Cubbage
Scott M. Munroe

2003
Reagan L. Crossnoe
Kyle C. Girod
Bradley D. Harman

2004
Brett E. Casey
Timothy B. Dixon
Michael J. Leahy

2005
Craig C. Greene
Charles F. Kallina, IV
Marcus Roux

2006
Eric Hooley
Robert Reddix
J. Kevin Smith

2007
Michael L. Brennan
Russell J. Clark
Donald S. Stewart

2008
Derek T. Padon
Russell A. Ward

2009
Clint D. Barnett
Jason D. Carter
Ryan M. Tibbetts

2010
John P. Akins
Richard B. Barber
Nicholas P. Souder
Henry (Hank) Wallace

2011
Jason L. Brannen
David E. Dominguez
Daniel L. Stahl

2012
Garrison Benton
Cyrus Caroom
Christopher Souder
Coy Wright

2013
Jared Allred
Matthew Driscoll
David Kummerfeld
Brett Robin
2012 Orthopaedic Residents

PGY-5

David Ferguson  Casey Lagan  Kushal Patel  Timmothy Randell

PGY-4

Matthew Ellington  Joshua Griffin  Matthew Jordan  Donavan Murphy
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