GERIATRIC HIP FRACTURES: DO THEY NECESSITATE ADMISSION TO A LEVEL 1 TRAUMA CENTER?

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Nov. 01, 2012

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of Masters of Science

DEDICATION

This thesis is dedicated to those who never back down from a challenge no matter how insurmountable the path is to climb.

Stay hungry, stay foolish. – Steve Jobs

ACKNOWLEDGMENTS

I want to begin by expressing my sincere appreciation to Dr. John Sampalis for the opportunity to join his research team. I further would like to thank Dr. Sampalis for taking me on as a Masters student and offering me the ability to work under him. I am extremely grateful to Julie Vaillancourt for all her assistance, guidance and feedback throughout this project.

I would further like to thank my thesis chairperson Dr. Peter Roughley and committee members, Dr. Antoniou and Dr. Liberman for their insight and suggestions. Without them this project would not have been possible.

It is imperative to also thank all my clinical and academic mentors who have provided support, guidance and encouragement throughout all of my academic and scholarly pursuits. I would particularly like to mention Dr. Daniel Ricciardi for all his support throughout my medical career.

Lastly I would like to thank my parents, grandparents and sister for all their loving support and encouragement throughout all my academic endeavors.

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LIST OF ABBREVIATIONS

ADL	Activities of Daily Living
AIS	Abbreviated Injury Score
GCS	Glasgow Coma Scale
ICU	Intensive Care Unit
ISS	Injury Severity Score
LOS	Length of Stay
QTR	Quebec Trauma Registry
SD	Standard Deviation
TC	Trauma Center

ABSTRACT

BACKGROUND: Hip fractures result in significant mortality, morbidity, and costs. Falls are the main mechanism of injury in the geriatric population with hip fractures associated with an annual cost of $9 billion dollars in the United States. Within the next decade, it is estimated that approximately 25% of the Canadian population will be 65 years and older. The cost of trauma center care is high, raising questions about the value of treating isolated hip fractures at Level 1 (tertiary) trauma centers.

OBJECTIVES: To conduct a cost-effectiveness analysis of isolated geriatric hip fractures treated in Level 1 trauma centers compared with Level II and III centers.

METHODS: A retrospective cohort study was comprised of patients over 65 years of age treated for isolated hip fractures in the Province of Quebec, Canada between January 1, 1998 and December 31, 2002. Data for the study was obtained from the Quebec Trauma Registry (QTR) and 3 patient cohorts were created according to treatment at 3 Level I, 29 Level II, and 21 Level III trauma centers. The primary outcome was total treatment cost defined as hospital costs for patient care from time of arrival at the hospital to discharge. All statistical analyses were carried out with SPSS version 19.0 (SPSS Inc., Chicago, Illinois).

RESULTS: We identified 11,009 cases which met our inclusion criteria. The majority of patients were female (77%). Average age was 82 (Range: 65-105; SD: 7.5). The vast majority (96.9%) of admissions were as a result of falls. There were no significant differences with respect to mean age of patients, complication rate, and mortality amongst patient admitted to Level 1, 2 and 3 Trauma Centers. Average length of stay for all patients was 15.4 days (Confidence Interval 95%: 2-55). Our study finds a 20% and 60% savings of approximately $5 and $16 million dollars when patients are admitted to Level 2 and 3 Trauma Centers when compared to Level 1 Centers.

CONCLUSIONS: Level 1 trauma centers do not improve the long term functional and rehabilitation outcomes of geriatric isolated hip fracture patient when compared to Level 2 and 3 centers. Our results suggest that treatment of

Isolated Hip Fractures at Level 1 Trauma Centers is not cost-effective. A separate geriatric triage criteria for isolated hip fractures could lead to improved resource utilization, cost effectiveness and acute care outcomes.

KEY WORDS: Elderly, Isolated hip fractures, Cost of trauma care, Trauma center performance, Level I.

ABRÉGÉ

CONTEXTE: Fractures de la hanche suite à une importante mortalité, la morbidité et les coûts. Les chutes sont le principal mécanisme de blessure chez les personnes âgées avec des fractures de la hanche liées à un coût annuel de 9 milliards de dollars aux États-Unis. Dans la prochaine décennie, on estime qu'environ 25% de la population canadienne sera âgée de 65 ans et plus. Le coût des soins de traumatologie est élevé, ce qui soulève des questions sur la valeur du traitement des fractures de la hanche isolées au niveau 1 (tertiaire) des centres de traumatologie.

OBJECTIFS: Pour effectuer une analyse coûts-efficacité analyse des fractures de la hanche isolés gériatriques traités dans les centres de traumatologie de niveau 1 par rapport aux niveaux II et III. Centres

Méthodes: Une étude de cohorte rétrospective a été composé de patients de plus de 65 ans traités pour des fractures de la hanche isolées dans la province de Québec, au Canada entre Janvier 1, 1998 et Décembre 31, 2002. Les données de l'étude a été obtenue à partir du Registre des traumatismes du Québec (QTR) et 3 cohortes de patients ont été créés selon le traitement au niveau 3 I, 29 II niveau, et 21 centres de traumatologie de niveau III. Le critère principal était coût total du traitement définis comme les coûts hospitaliers pour les soins aux patients de l'heure d'arrivée à l'hôpital de se décharger. Toutes les analyses statistiques ont été réalisées avec SPSS version 19,0 (SPSS Inc, Chicago, Illinois).

Résultats: Nous avons identifié 11.009 cas qui répondaient à nos critères d'inclusion. La majorité des patients étaient des femmes (77%). L'âge moyen était de 82 (intervalle: 65-105; SD: 7,5). La grande majorité (96,9%) des admissions étaient à la suite de chutes. Il n'y avait pas de différences significatives en ce qui concerne moyenne d'âge des patients, le taux de complications et de la mortalité parmi les patients admis au niveau 1, 2 et 3 centres de traumatologie. Durée moyenne de séjour pour tous les patients était de 15,4 jours (intervalle de confiance à 95%: 2-55). Notre étude a montré une réduction de 20% et 60% des économies de l'ordre de $ 5 et $ 16 millions de dollars lorsque les patients sont

admis au niveau 2 et 3 centres de traumatologie par rapport au niveau 1 centres. **CONCLUSIONS**: Les centres de traumatologie de niveau 1 ne pas améliorer les résultats fonctionnels à long terme et de réadaptation gériatrique du patient de fracture de la hanche isolé par rapport aux niveaux 2 et 3 centres. Nos résultats suggèrent que le traitement des fractures de la hanche isolés dans les Centres de traumatologie de niveau 1 n'est pas rentable. Un des critères de triage séparées pour les fractures de la hanche gériatriques isolés pourrait conduire à une meilleure utilisation des ressources, la rentabilité et les résultats des soins aigus.
MOTS CLÉS: Personnes âgées, isolées fractures de la hanche, coûts des soins de traumatologie, le rendement centre de traumatologie de niveau I.

Introduction

The aging baby boomer cohort will place a significant burden on the sustainability of the status quo of modern health care systems. While the age specific incidence of hip fractures has stabilized, individuals aged 65 years and older are currently the fastest growing segment of the population and coincidentally at highest risk for falls (Sirois, Cote et al. 2009). Falls are the main mechanism of injury in the geriatric population with hip fractures associated with an annual cost exceeding $9 billion dollars in the United States (Alolabi, Bajammal et al. 2009).

In the province of Quebec, Canada, those aged 65 years and older will account for 25 percent of the population eventually expected to triple in size from the present proportion by the year 2031 (Statistics Canada. 2010). Between 30 and 40 percent of community-dwelling individuals over the age of 65 years fall each year; increasing to 50 percent for those aged 80 years and older (Rubenstein and Josephson 2002). Falls in this population subgroup currently account for 79% of injury-related hospital costs and 40% of hospital days representing a tremendous burden when contrasted to a younger age cohort (Clancy, Kitchen et al. 1998; Young, Cephas et al. 1998; Locker 2002; Lewis, Abouelenin et al. 2007).

The scope of the problem will only worsen. These individuals will continue to generate an increasing number of hospital admissions which will amount to a proportionally large increase in the number of hip fractures and use of a disproportionate amount of resources devoted to trauma care (Champion, Copes

et al. 1989; Papadimitropoulos, Coyte et al. 1997; Battistella, Din et al. 1998; Alolabi, Bajammal et al. 2009).

An increasingly large portion of health care spending is currently being consumed providing care to the elderly. The total healthcare spending is expected to rise from nearly 12 percent to 18 ¾ percent of the GDP over the next two decades and resources must be allocated to improve the productivity and efficacy of the system while financing the costs of providing services (Dodge and Dion 2011). Hospital costs associated with hip fractures exceeds those for all other fractures and other commons hospitalizations (Cox, Bowie et al. 1993; Bergstrom, Jonsson et al. 2009; Holvik, Ranhoff et al. 2010). The advancements in modern medicine coupled with increased life expectancy has created public health obstacles requiring evidence-based, fiscally conservative changes in health care delivery.

Our research group has previously described the added demand geriatric patients sustaining falls of low severity place on Level 1 trauma centers in Quebec (Liberman, Mulder et al. 2003; Sampalis, Nathanson et al. 2009). The pre-hospital over triage of patients of advanced age according to American College of Surgeons ATLS guidelines errs on the side of caution while not necessarily providing the best long term outcome for these patients (Jacobs 2003; Lehmann, Beekley et al. 2009).

Trauma systems represent a public health initiative designed to standardize the process in which care is delivered to seriously injured patients through novel triage protocols and critical guidelines implementing designated levels of care (Phillips, Rond et al. 1996; Sampalis, Denis et al. 1997; Sampalis, Denis et al. 1999; Mann, Cahn et al. 2001; Tien, Chu et al. 2004; Liberman, Mulder et al. 2005; Shafi, Ahn et al. 2010). A thorough comparison of the outcomes of patients treated at various institution types such as Level 1 and Level II (secondary) trauma centers has been recommended in the literature but very few studies have been undertaken.

Patients with isolated hip fractures have been shown to have higher resource use in addition to poor outcomes compared to other trauma patients (Finelli, Jonsson et al. 1989; Jacobs 2003; Bhandari, Sprague et al. 2009; Sirois, Cote et al. 2009; Stewart, Chantrey et al. 2011; Keller, Sciadini et al. 2012). The total costs associated directly and in-directly with hip fractures is significant. The added pressure this growing cohort will place on public healthcare requires recognition, planning and the reorganization of acute care resources to maintain the present standard of care and increase efficiency at our hospitals. MacKenzie et al. (MacKenzie, Weir et al. 2010) described the costs occurred during initial hospitalization at Level 1 Trauma Centers as 71% higher than non-trauma centers.

While the value of trauma care for patients with high baseline risk of morbidity and mortality whom sustain severe injury has been widely documented, there

remains little data in the literature pertaining to geriatric individuals sustaining low injury severity isolated hip fractures.

Literature Review

The fragile aging geriatric population is expected to continue to consume an extortionate amount of healthcare resources. The elderly are predisposed to an increased risk for hip fractures and have been shown to have weaker bones. This increased risk for falls is secondary to poor balance, medication side effects in addition to confounding medical comorbidities such as cardiovascular and endocrine (diabetes and hyperthyroidism). A thorough review of the literature was conducted pertaining to the morbidity, mortality and risk factors of geriatric patient sustaining isolated hip fractures.

Morbidity and Mortality

In the United States there is an annual incidence of 250,000 hip fractures at an annual cost of 9 billion dollars (Stone, Barbaro et al. 2007). The incidence of hip fractures is roughly 30,000 in Canada and its age appropriate risk is associated with increasing age as 3.9% occur prior to age 50, 21.0% occurring in individuals aged 50-75, and the majority occurring aged 75 years and older (75%) (Leslie, O'Donnell et al. 2010).

The length of stay at Canadian hospitals for hip fractures was estimated to be 465,000 patient-days between 1993 and 1994 with a projected increase to 1.8 million patient-days per year by 2041 (Lefaivre, Macadam et al. 2009).

It has been reported that in-hospital mortality varies between 6% and 16.5% based on isolated hip fracture admissions with a one year mortality as high as 30% (Stone, Barbaro et al. 2007; Brauer, Coca-Perraillon et al. 2009). Alzahrani (2010) showed that there was no difference in overall mortality in patients treated in academic versus community hospitals in Ontario.

The significant functional loss and long-term consequences of hip fractures are tremendous. Leslie (2009) found that approximately 11% of the proximal femurs had a second hospital admission within the same calendar year due to a second fracture.

Patients admitted with hip fractures also have a significant higher risk of death, prolonged hospital stay and are more frequently transferred to a rehabilitation center or to a long term nursing homes when compared to other age and injury severity matched trauma patients (Bergeron, Lavoie et al. 2005).

Hip fractures are a potentially devastating condition for older adults and have been shown to increase the risk of death and major morbidity (Hung, Egol et al. 2012). One year mortality has been shown to range from 15 to 25 percent but has been declining in recent years (Bentler, Liu et al. 2009). It has further been shown that approximately one half of patient are able to regain mobility following sustaining a hip fracture and regain functional independence while 80% fail to

regain their pre-fracture level of function (Morrison, Chassin et al. 1998; Gianoudis, Bailey et al. 2012).

Aging Population

The aging baby boomer population will continue to have tremendous economical and planning significance. As a consequence of increased longevity, every hospital and trauma center is expected to see a rise in their proportion of elderly patients treated. It has been shown that elderly patients admitted with minor injury severity scores have a threefold increase in morbidity and a fivefold increase in mortality compared their younger respected cohorts (Shifflette, Lorenzo et al. 2010).

It is well documented by Bergeron (2009) that all geriatric isolated hip fractures should be surgically managed regardless of co-morbidity burden. Modern advancements and innovations in medical care has resulted in reduced surgical mortality especially for super-geriatric patients. The mortality rate of patients aged 90 years and above is 50% less than it was observed 10 years ago with a current survival of 74% (Bergeron, Moore et al. 2009).

Osteoporosis

Osteoporosis is a multifactorial condition predisposing individuals to skeletal fragility and increased risk for fractures. Osteoporosis is a major threat to the health of the aging population. It have been shown to affect up to 16% of women and 7% of men over 50 years of age (Leslie, O'Donnell et al. 2010). It represents a major threat to the well-being of the aging population.

The National Osteoporosis Foundation postulates that nearly 50% of women and 25% of men over the age of 50 will experience an osteoporosis-related fracture. Osteoporosis was responsible for 2 million fractures in the United States (2005) and this is expected to rise to more than 3 million annually by the year 2025 (Hepguler, Cetin et al. 2011). It is well documented that hip fractures are the most devastating complication of osteoporosis (Nikitovic, Wodchis et al. 2012).

A female aged 50 has a 40% lifetime risk of suffering a fracture with 95% of the fractures occurring in those aged 75 years and older and 80-90% in those 60-74 years. These figures are directly attributable to osteoporosis (Byszewski, Lemay et al. 2011; Gutierrez, Roskell et al. 2012).

The incidence of osteoporotic fractures has been shown to correlate with reduced quality of life, decreased functional capacity, higher costs and increased mortality. The use of bisphosphonates has been shown to reduce the incidence of hip

fractures in addition to lifestyle changes, calcium and vitamin supplementation, avoidance of smoking, weight bearing exercise, awareness of falls and limiting alcohol intake (Papadimitropoulos, Coyte et al. 1997; Chen, Lee et al. 2007; Brauer, Coca-Perraillon et al. 2009).

Overweight and obesity are epidemic in modern society. These diseases contribute to a reduction in fracture rate as they are associated with higher bone density and non-ovarian aromatization of estrogen on top of providing padding over the trochanter (Leslie, O'Donnell et al. 2009).

Medical Co-morbidities

Hip fractures are primarily a disease of the elderly which when complicated by co-morbidities can lead to postoperative complications including death. The concurrent comorbidities are multifactorial often complicated by cardiac and renal deficiencies (Leung, Lam et al. 2011). The physiological response to trauma is complicated by degenerated organ system changes; decreased physiological reserve; and the inability to mount an adequate response to stress (Shifflette, Lorenzo et al. 2010). Differences in patterns of heath and illness include low body weight, body mass or bone density (Tracey, Forte et al. 2007).

The risk of falls has been shown to occur in increased rates in patients suffering from co-morbid conditions including myocardial infarctions, congestive heart

failure, peripheral vascular diseases, dementia such as Alzheimer diseases, chronic obstructive pulmonary diseases, and diabetes. Dementia presents unique obstacles as patients are more likely to be admitted to long term care facilities post discharge (Bergeron, Moore et al. 2009). It is important to consider the possibility that patients treated in Level 1 Trauma centers may not receive ideal care for the prevention of complications due to the combined effect of the injury and their coexisting medical conditions.

Geography of Quebec

Quebec is Canada's largest province by surface area occupying a territory nearly three times the size of France or Texas (Quebec 2004). The geography is very different from one region to another due to varying topography, climate, and proximity to water. The majority of citizens live in urban areas near the Saint Lawrence River between Montreal and Quebec City.

The increased risk of fractures in inclement weather and during winter months has been widely demonstrated. However, certain studies dispute this argument and find no differences in rate of fractures during the winter months (Papadimitropoulos, Coyte et al. 1997). It is possible that increased fracture rates in the Northern Hemisphere may be attributed to poor vitamin D status and environmental hazards such as ice and snow.

The ability to provide comprehensive medical care in both the urban and rural setting presents unique obstacles in public health. The majority of Quebec's Level 1 Trauma Centers are located in large urban settings. The clinical and socio-economic significance of this study pertains to whether patients need to be transported to large tertiary centers or whether these injuries can be efficiently and cost-effectively treated at the local, community setting.

Pre-hospital Triage

The American College of Surgeons Committee on Trauma has evolved protocols for the triaging of injured patients in the field. These guidelines provide a structured framework for the on-scene management of trauma patients and are critically important in determining which patients' sustaining serious injuries requiring comprehensive treatment at major trauma centers (Figure 1). Pre-hospital triage is responsible for initiating pre-hospital and hospital events that directly affect patient care and resource utilization while conserving limited trauma resources. It has been shown that the decision scheme lacks high sensitive for elderly patient.

There is a bias towards the over triage of patients. This argument has been further complicated by its applicability to the geriatric population. These criteria were designed to identify major trauma patients requiring definitive care at Level 1 trauma centers. The ACS guidelines may be ineffective at treating this unique

patient subset. Triage is operator dependant and the ambulances personal are instructed to over-triage in order to minimize false-negative rates.

The logistical and financial concern of optimizing the individual patients need to degree of care required is the primary issue defining which patients require timeliness transfer to a trauma center. Overtriage occurs with a false assumption that the patient is seriously injured. While undertriage is a patient quality of life issue; overtriage is politically, financially and administratively motivated (Keller, Sciadini et al. 2012).

It has been shown that undertriage is significantly higher in patients aged 65 years or older than younger patients by 49.9% vs. 17.8 (Hung, Egol et al. 2012). If it cannot be documented that an outcome benefit exists from the management of these patients at trauma centers the combined efforts of primary (field) and secondary (hospital) triage criteria must be modified (Peden, McGee et al. 2002).

Elderly patients present a clinical challenge in trauma triage. This is largely secondary to the lack of reliable parameters of injury and resuscitation. The undertriaged elderly patient has 4 times the mortality and discharge disability then the age matched younger patient and are less likely to have trauma team activation (Keller, Sciadini et al. 2012).

Our research group has published extensively on the patient demographics, injury type and severity and mechanisms of injury in patients presenting to Level 1 Trauma Centers in Quebec. It was discovered that roughly 24 percent of visits were secondary to falls and these patients were elderly with significantly longer hospital length of stays when compared to a younger cohort (Liberman, Mulder et al. 2003). It was further shown that falls most commonly involve a single injury to the extremity and low ISS. Mortality has been shown to increase with age for all injuries with the exception of falls (Finelli, Jonsson et al. 1989). In a hemodynamically stable patient with isolated orthopedic injury of low ISS, adequate care may be possible at Level 2 and 3 trauma centers.

Hospital Admission and Management

Despite the potential for adverse outcomes, many hospitals routinely admit hip fractures from the Emergency Department directly to the Orthopedic Service. These patients are traditionally admitted to a general hospital floor or orthopedic ward. Stone (Stone, Barbaro et al. 2007) demonstrated geriatric hip patients managed by the trauma service have a lower mortality (2.1%) representing a significant improvement over the national norms.

These patients are admitted to a Stepdown Unit with higher levels of nursing care and patient monitoring. The trauma surgeon routinely uses a multidisciplinary approach to manage the severely injured or ill patient with many physiological

systems compromised. These services allow the ability to manage and communicate between the various consulted services while providing optimal care to the multi-system injured patient.

Time to Surgical Management

There have been reports that associate delays in surgical fixation are associated with increased mortality and morbidity in geriatric patients. The concept of early fixation within 24 hours allows for early mobilization of fractures and can be linked to decreased pulmonary associated complications such as atelectasis, pneumonia, acute respiratory distress syndrome and thromboembolic events (Stone, Barbaro et al. 2007; Simunovic, Devereaux et al. 2010). In a medically optimized patient with less than 3 co-mborbidities, surgery performed within 24 and 48 hours is ideal in the attempt to return the patient to their preinjury level of function (Moroni, Hoque et al. 2011; Simunovic, Devereaux et al. 2011).

Femoral neck fractures in the elderly population are commonly secondary to a direct fall on the lateral hip and can be detected through plain film radiography of the hip. Surgical management of hip fractures traditional involves open reduction or internal fixation or both hemiarthroplasty, or total hip arthoroplasty. There remains debate on which operative technique is ideal; however, a thorough discussion of surgical management is beyond the scope of this study. It is

important to emphasize that non-operative management is generally reserved only for debilitated patients.

The effect of delay of surgical fixation from emergency to scheduled management is a documented consequence of delayed treatment at a non-trauma center. This would likely result secondary to increased cancellations due to lack of adequate night staffing and possibly result in an associated increase in preoperative and total length of hospital stay (Adie, Harris et al. 2009). Operative delays are commonly due to competition for limit operating suite time and there remains no clear consensus as to whether early operative time improves patient outcome. Lefaivre (Lefaivre, Macadam et al. 2009) previously noted that a delay to surgery of 24 hours was associated with an increased risk of minor medical complications while a further delay of 48 hours was associated with an increased risk of a major medical complication, a minor medical complication and the development of pressure sores.

Unlike admission for elective surgery, most hospital admissions for hip fractures are not planned (Tracey, Forte et al. 2007). The wait time to surgery is affected by the change in the severity of disease, indications for surgery and the availability of specialists and other hospital resources (Tracey, Forte et al. 2007). Due to the low severity of their injury, potentially introducing life-threatening delays to definitive care may occur in trauma centers with high major trauma volume and progressively reduced resources (Sampalis, Nathanson et al. 2009). All in all,

conservative or delay in management of hip fractures may greatly increase mortality and morbidity.

Postoperative Complications

The prevention and management of perioperative complications remains one of the greatest challenges in modern surgery. In addition to most non-elective procedures, the common complications are expected to be infection and thrombo-embolitic events; both of which can potentially be life threatening. Prophylactic measures are commonly employed for prevention. In addition careful consideration must also be given to the risks for chronic pain, dislocation, non-union and avascular necrosis (Eiff and Hatch 2012).

Discharge Planning and Destination

Delay in patient discharge is common in every hospital system and possess significant operational consequences. These delays can be due to difficulties in patient placement such as lack of a rehabilitation or sub-acute hospital bed (Thomas, McGwin et al. 2005). It is possible that these delays could significantly increase hospital length of stay and contribute to increased treatment costs.

Trauma Center Classification

Level 1 Trauma Centers were designed to treat younger patients injured in motor vehicle collisions and through acts of violence (Sampalis, Nathanson et al. 2009). The treatment provided at Level 1 centers may not be ideally suited for the older patient with an isolated hip fracture. These tertiary care centers have evolved over the last 4 decades to provide undisputed critical care for trauma patients sustaining life threatening injuries effectively reducing mortality in the urban setting (Sampalis, Nathanson et al. 2009; Glance, Osler et al. 2012).

In the Province of Quebec, Canada, regional trauma care was implemented in 1992 and has evolved to address population based needs. The trauma center organization and pre-hospital triage protocols are based on the American College of Surgeons Triage Decision Scheme (Figure 1). The regionalization of trauma care has resulted in a steady increase in patient volume treated at tertiary care centers. Currently there are 3 functional Quebec Level 1 trauma and 29 Level II trauma centers serving a population of approximately 9 million.

Since the establishment of trauma care in Quebec, a decline in mortality from major trauma from 52% in 1992 to 13% in 2005 was documented (Sampalis, Lavoie et al. 1995).

Regionalization of Trauma Care in Quebec

The trauma system in Quebec is inclusive and regionalized involving 59 designated trauma hospital ranging from urban Level I Centers to rural community hospitals (Moore, Lavoie et al. 2009). The regionalization and implementation of trauma care may not be ideally suited for the increasing large proportion of geriatric patients. Over the last decade the proportion of patients over the age of 65 treated in Quebec trauma centers has increased by 25% (Sampalis, Nathanson et al. 2009). While a higher proportion of patients in motor vehicle collision sustain hip fractures versus isolated falls (21.3% versus 5.7%), our group previously has shown that a significant number of patients in falls sustain isolated hip fractures and no other injuries (Sampalis, Nathanson et al. 2009).

Total Treatment Costs

The cost of treating hospital fractures continues to steadily increase. It was estimated to be $7.2 billion in 1984; $20 billion in 1997 and projected to upsurge to $62 billion by 2040 (Kates, Mendelson et al. 2011). Of the majority of costs, approximately 57% are incurred during the initial acute hospitalization.

Management of hip fractures is costly and the traumatic event continues to generate costs throughout the first year post discharge. The total hospitalization cost for each patient is based on the cost from triage to impatient care to

discharge. These costs will include the cost of surgery, surgical implants, radiological and laboratory investigations, medications prescribed, rehabilitation services utilized and inpatient ward charges (Chen, Lee et al. 2007). It has been shown in the United States that geriatric impatient care for hip fractures is associated with roughly 58% of hospitalization costs followed by outpatient services (39%) and pharmacy (3%) (Kondo, Zierler et al. 2009; Shi, Foley et al. 2009).

It is important to note that Medicare reimbursement rates in the United States are lower than commercial payers. Readmission within 60 days is covered by the initial Medicare payment while commercial payers pay in full. The majority of patients are solely covered by Medicare reimbursements in the United States.

Post Discharge Rehabilitation

Following discharge from the acute care hospital setting, regaining and maintaining functional ability presents a great challenge. Geriatric patients are discharged directly to long or short term care facilities, to a nursing home or to their primary resistance. A considerable decline in functional mobility occurs one year following discharge from a rehabilitation setting with this decline most noticeable in patients who achieve high performance during rehab (Hershkovitz, Pulatov et al. 2012). It has been shown that providing continuous physical training to elderly hip fracture patients following discharge from rehabilitation centers can

improve long term functional outcome. The primary goal of rehabilitation aims to recover ambulatory status and the ability to independently perform activities of daily living.

The majority of patients fail to regain their pre-fracture functional status. After one year, it has been shown that only 9% of patients can function independently in their activities of daily living; 8.2% are able to walk unassisted; and 5.6% regain their original pre-injury functional level (Hershkovitz, Pulatov et al. 2012). The use of a walking aid prior to fracture is the most important prognostic factor associated with poor functional outcome (Sylliaas, Thingstad et al. 2012).

The ability to dress, transfer and ambulate are the key goals for rehabilitation in the geriatric population. The majority of studies show that 73% of patients return to their basic ADL level pre-fracture; with only 40% of patients completely regaining their ability to perform daily ADL' s one year post-fracture often experiencing reduced mobility with need of walking aids, decreased ability to move outside their own home and a deterioration of health status (Neuman, Speck et al. 2010; Hershkovitz, Pulatov et al. 2012; Tseng, Shyu et al. 2012).

The major determinants in recovery include: advanced age, impaired level of cognitive function, and pre-fracture ambulatory status. It has been shown that within one year status post injury, mortality ranges from 8.4% to as high as 36% (Tseng, Shyu et al. 2012). Improved clinical outcomes are greater in individuals

with higher pre-fracture mobility as these individuals require home rehabilitation and day hospitals when compared to post-acute rehabilitation centers which provide care for the more disabled patients (Hershkovitz, Beloosesky et al. 2012).

Length of Stay

Longer length of stay is directly correlated to a higher cost of hospitalization. The greatest factor influencing length of stay and concurrent treatment costs has been speculated to be burden of co-morbid illness. Studies have demonstrated that longer length of stay at urban trauma centers is not profitable for the hospital and health care system (Aldrian, Nau et al. 2005).

Dementia has been shown to have the highest additional cost (Chen, Lee et al. 2007). Browne (2009) recently showed a significant difference in patient outcomes in patients treated at hospitals with high-volume surgeons on staff demonstrating a lower rate of blood transfusions, pneumonia and decubitus ulcers. Conversely, hospital volume was not associated with significant differences in mortality although low volume centers had higher rates of postoperative infection, transfusion, pneumonia and non-routine discharge (Browne, Pietrobon et al. 2009).

The combination of impatient and ambulatory care costs gives the total cost of medical treatment. The daily cost attributable to the site of care is based on the

total budget of that site divided by the total number of days patients were present in the unit during the fiscal year (Letarte, Longo et al. 2002). The united cost for the operating room includes the salaries of all personnel excluding physicians and the total cost of supplies. The procedure cost, physician fees and costs of medications are standardized by the Provincial government.

It is recently been argued that more severely injured elderly patients are more likely to benefit from treatment at a designated trauma center while less severely injured may be at a disadvantage.

Rationale

The rationale for the current study was based on the following. First, the geriatric population constitutes a large proportion of the Quebec population and will increase exponentially over the coming decades. Second, falls are the most treated type of injury at Level 1 trauma centers. Third, conventional trauma care was designed to treat primary younger patients injured in violent acts and are associated with significant healthcare costs. Conversely, the type of care provided at tertiary trauma centers and the increased demand for care tailored to geriatric patients suffering isolated hip fractures may be more cost effective at non trauma centers.

We attempted to study the quality of care provided at regional and tertiary hospitals to determine patient outcome. These patients suffering less severe injuries but may be at higher risk due to co-morbidities and increased age. This information will be useful in providing guidance for the facilitation of improvements in the management of older trauma patients and providing an accurate determination of their clinical and economic burden. It is imperative to take into account the evolving epidemiology of injury and the availability of appropriate facilities and expertise in regional trauma centers.

The current retrospective cohort study will address these needs by describing the characteristics and outcomes associated with elderly patients treated for isolated

hip fractures at Quebec Level I trauma and non-trauma centers. The final recommendations are based on an economic evaluation utilizing a cost-benefit analysis.

Geriatric patients have increased length of stays and hence utilize increased health care resources. The majority of these patients involved sustain trauma in isolated longs bone or pelvic fractures and may not require the multidisciplinary specialized trauma center care involving general surgeons, neurosurgeons, nursing and intensive care resources.

Our principle objective of this study is to document the economic impact of treating isolated hip fractures at Level 1 Trauma Centers in Quebec. We investigated the total treatment costs and measured the cost-effectiveness of treatment of geriatric isolated hip fracture at Level 1 trauma centers compared with Level II and III centers. This study attempts to further understand the epidemiological and demographic characteristics of the geriatric trauma population and postulate on what level of care they require to ensure optimal health outcomes in addition to fairness and equal resource allocation of increasingly sparse health care assets.

The Canadian population is aging with roughly 15 percent of citizens 65 years and over in the province of Quebec (Statistics Canada 2010). Within the next decade, it is estimated that approximately 25% of the Canadian population will be 65 years and older. Recent advances in healthcare has resulted in an increased life

expectancy with 1.9 percent of the current population 85 years and older (Statistics Canada 2010). As the average life expectancy of the population increases, the number of hip fractures is suggested to double by the year 2050 (Alolabi, Bajammal et al. 2009).

Elderly patients are more prone to trip, slip or falls with some injuries requiring hospitalization (Tracey, Forte et al. 2007). Hip fractures among geriatric patients will place an enormous burden on hospital resources and the sustainability of the Canadian health care system and have been projected to exponentially rise over the coming decades. In Canada their direct healthcare cost is estimated to be $650 million annually and is expected to rise to $2.4 billion by 2040 (Alzahrani, Gandhi et al. 2010). Hip fractures also result in undesirable outcomes for the patient including loss of mobility and independence and mortality. A significant number of hip fractures occur in the community in nursing homes and long-term care facilities.

The changing social demographics will continue to contribute to the rising cost of health care in the industrialized world. It had previously been shown that while the geriatric population represented only 11% of the population, they accounted for 41% of public health care expenses in Quebec (Tousignant, Hebert et al. 2003). The aging population will continue to present harsh challenges in order to maintain the current health care status quo. Hip fractures are the second leading

cause of hospitalization in this group of patients with advancing age a significant predictor of increased mortality (Bergeron, Moore et al. 2009).

The aging population is living a more physically active lifestyle with increased activity augmenting injury rate. This aging population will represent significant obstacles for the allocation of finite health resources and planning for acute and chronic resources. During the past decade, falls were the most frequent mechanism of injury in geriatric patients accounting for 49.2% of trauma related admissions (Sampalis, Nathanson et al. 2009). Falls will occur in one third of patents more the 65 and in half of patients more than 80 years of age (Stone, Barbaro et al. 2007). The volume of elderly patients with single injuries treated at hospitals will continue to increase and present unique obstacles to health care planning and the allocation of sparse resources.

There are relatively small differences in hip fracture rates between Canadian provinces with rates significantly lower than the United States (Leslie, O'Donnell et al. 2010). In the United States approximately 957.3 per 100,000 for women and 414.4 per 100,000 men will sustain hip fractures annually (Brauer, Coca-Perraillon et al. 2009). While mortality among patients 65 years and older with isolated hip fractures continues to decline, co-morbidities among patients have continued to increase.

Advancements in health care have resulted in more efficient treatments and quality of life while managing complex medical co-morbidities. Elderly patients commonly take multiple medications. Combined with reduced physiological reserves these patients are at increased risk for poor prognosis and long term sequelae following hip fractures. Functional decline and reduced quality of life and mortality are important factors to consider. With direct costs of treating hip fractures in the first year following injury approximately $34,946 in 2008, hip fractures are a considerable health care expenditure in Canada (Leslie, O'Donnell et al. 2010).

The appropriate care for the injured geriatric patient with low to moderate trauma will continue to play an important role in defining future health policy. It is estimated that approximately 39% of all trauma patients will be 65 years and older by 2050 (Adie, Harris et al. 2009). Conflicting theories exists on whether isolated hip fractures in this patient population are better treated at community hospitals versus larger trauma centers. This study sought to determine the total treatment costs for these fractures and compare treatment outcomes and complication rates. We also sought to determine whether this population can gain improved clinical care at the regional level or whether expensive trauma care is warranted.

Patients and Methods

Acquisition of Data

A retrospective cohort study was comprised of patients over 65 years of age treated for non-pathological isolated hip fractures in the Province of Quebec, Canada between January 1, 1998 and December 31, 2002. Data for the study was obtained from the Quebec Trauma Registry (QTR) which includes data from patients treated for injuries at 3 Level I, 29 Level II, and 21 Level III trauma centers and the *Régie de l'assurance maladie du Québec* (RAMQ), the Quebec health insurance database that is maintained by the provincial health insurance agency.

The QTR is inclusive and mandatory for all institutions ranging from urban Level I to rural community hospitals. The hospitals are officially designated as trauma centers of different levels by the Ministry of Health and are evaluated according to guidelines based on those of the American College of Surgeons. The integrated system covers the entire population of the province and data from the registry is available for all the centers in the Province.

The QTR and RAMQ databases were linked through an encrypted health insurance number which serves as a unique patient identifier. The QTR was searched to identify patients meeting the following inclusion criteria: sustained an isolated fracture of the femur or acetabulum defined by World Health Organization's Ninth Revision, International Classification of Diseases as ICD9

codes 820-820.9, 808.0, or 808.1, 65 years of age or older at the time of injury, treated between January 1, 1998 and December 31, 2002. Those who were dead on arrival at the hospital were excluded from the study. The admission data was defined as the index date for each fracture case. Duplicate admissions were randomly deleted. To ensure only isolated hip fractures, final sample size was selected using patients with Abbreviated Injury Scale (AIS) codes 852808.3, 851810.3, 851812.3, and 851818.3.

Three patient cohorts were subdivided according to treatment at Level 1, Level II and Level III trauma centers. Outcome variables were hospital length of stay (LOS), and length of intensive care unit (ICU) stay. The principle objective was a cost analysis study with total treatment cost per episode defined as hospital costs associated with patient care from time of arrival at the hospital to discharge.

Data regarding patient characteristics (age, gender), injury parameters [location of trauma, mechanism of injury, Injury Severity Score, presence of head trauma, ICU treatment, length of ICU stay, length of hospital stay, surgery, and incidence of complications] and discharge status were obtained from the QTR.

Cost analysis was performed based on the mean LOS, ICU admission rate and mean ICU LOS. Demographics are summarized by various descriptive and frequency statistics: mean and standard deviation. A calculation of the per diem hospital cost was determined based on the rate charged to residents without provincial health insurance. The per diem cost was available for general ward and

ICU for all Level 1 trauma centers. A multiplier ratio was used to calculate the ICU per diem cost of Level 2 and 3 centers. Rates were discounted 200 percent to approximate for resident rates. Costs attributable to co-morbidity and adverse events were excluded.

Statistical Analysis

Descriptive statistics for baseline characteristics, injury patterns and outcomes that included estimates of the means, standard deviations (SD), and 95% confidence intervals of the mean for continuous variables and frequency distributions for categorical variables were produced for the 3 study cohorts.

Statistical analysis comprised of categorical variables between patient groups were performed using ANOVA for categorical and continuous variables. Means and standard deviations were calculated for the continuous variables. Statistical analyses involving proportions were calculated using the χ^2 test. Values of $p < 0.05$ were considered significant. All analyses were conducted using SPSS for Windows 19 (SPSS Inc., Chicago, IL).

Results

Population Profile

A total of 11,364 patients were initially identified in the trauma registry. After excluding for duplicate admissions (n = 343) and selected cases based on AIS codes for hip fractures, there were 11,009 patients who met the inclusion criteria for admission for isolated hip fractures between 1998 and 2002 (Table 1). There were 8507 females (77.3%). Median age was 82.1 (range 65 to 105). The majority of trauma occurred in the residence (51%) with no significant difference amongst these patients admitted to trauma and non-trauma institutions (Table 2). The major mechanism for trauma was due to falls (97%) in community dwellings occurring in Quebec's urban settings (77%) The average Injury Severity Score for our entire study population was 9.2 ± 1.2 SD (Table 3).

Length of Stay, ICU Admission and Mortality

Surgery was performed in the majority of patients admitted for isolated hip fractures (89%) with no significant difference amongst the various study cohorts (Table 4). The average length of stay was 15.4 (CI 95%: 2-55) days which was slightly less at Level 1 Centers (13.8; 95% C.I. 13.4-14.1 days) when compared to Level 2 (15.9; 95% C.I. 15.5-16.3 days) and Level 3 (15.4; 95% C.I. 17.4-20.4 days). The patients treated at Level 1 centers had a lower percentage of ICU admission (6%) when compared to Level 2 (9%) and Level 3 (12%) centers.

There were no significant differences amongst mean ICU length of stay (3 days). The 30 day mortality of these patient was 7% and not significantly different amongst the trauma center cohorts.

Complication Rate

A small minority of patient admitted for isolated hip fractures suffered one or more complication (Table 5). Across the various institutions, 14% sustained at least one with 12% suffering only a single complication. There were no significant differences between the number of complications sustained between the various trauma institutional cohorts. The most frequent complications were minor and included urinary tract infection (9%) and pneumonia (3%).

Discharge Destination

Following trauma, patients are discharged either to home, a rehabilitation center or a short or long term care facility (Table 6). The majority of patients (38%) are discharged home. A greater percentage of individuals treated at Level 1 Trauma Centers are discharge to rehabilitation centers (59%) when compared to their respective Level 2 (17%) and Level 3 (24%) cohorts. Patients treated at Level 2 (27%) and Level 3 (32%) centers are most likely to be discharged to short term care facilities.

Cost Benefit Analysis

A cost-benefit analysis was performed for a simulated cohort of 1000 patients admitted to each institutional trauma level (Table 7). The number of expected ICU admission were calculated and determined to be 60 for Level 1; 90 for Level 2; and 120 for Level 3 centers. We applied a mean per diem cost of $4,089 and $1,882 for ICU and General Floor respectively for Level 1, $2,822 and $1,300 for Level 2 and $1,175 and $541 for Level 3 centers.

Based upon the mean length of stay, percent ICU admission and mean ICU length of stay, the total cost of treatment were determined. We found mean costs of $26.7 million at Level 1 Centers versus $21.4 and $10.7 million at Level 2 and 3. This amounts to a 20% savings for treatment at Level 2 when compared to Level 1 and 60% for Level 3 compared to Level 1 and 50% when compared to Level 2 centers.

Discussion

In Canada and the United States, trauma is the leading cause of death for individuals up to 45 years of age and the fourth leading cause overall (Peden, McGee et al. 2002). These costs will drastically increase over the next decade as injury is predicted to by 2020 become the third largest global burden of disease (Fakhry, Couillard et al. 2010).

Trauma is considered to be a disease primarily of the young. Isolated hip fractures are primarily a geriatric disease and treatment of these patients at Level 1 Trauma Centers is not cost-effective. As the population ages, the number of fractures is predicted to double and these patients will represent a heavy burden for the health care system in general and specifically trauma-designated hospitals (Alolabi, Bajammal et al. 2009).

By 2050, the worldwide incidence of hip fractures is projected to increase 310% in men and 240% in women (Byszewski, Lemay et al. 2011). Hip fractures are currently predominantly in the female subgroup. Females have a higher incidence of fracture at any age in addition to a higher life expectancy (Hepguler, Cetin et al. 2011).

The rising cost of healthcare combined with the growing number of geriatric patients presents unique obstacles which must be prepared for well in advance. The elderly in Quebec, Canada currently consume 41% of healthcare expenditures

while only accounting for 11% of the total population (Tousignant, Hebert et al. 2003; Dodge and Dion 2011). This equates to the per capita expenditures on healthcare far exceeding that of personal income per capita. Considering the financial efficiency and costs of providing trauma care, measures must be taken to preserve the viability of the system.

It has been previously demonstrated that elderly patients respond differently to trauma due to increased comorbidities and decreased physiological reserves; however, few studies focus specifically on these patients sustaining isolated mild injury as defined by low injury severity scores (Lewis, Abouelenin et al. 2007). Glance, Osler et al. (2012) demonstrated that less severely injured patients have a similar outcome when treated at Level I and II trauma centers. The National Study on Costs and Outcomes of Trauma (NSCOT) specifically focused on Level 1 vs. non-Trauma center outcomes (MacKenzie, Rivara et al. 2006; Mackenzie, Rivara et al. 2007).

While there is strong evidence for the effectiveness of trauma care for the younger severely injured patient, our study demonstrates that this doctrine does not hold true for the elderly hip fracture patient subgroup.

The accuracy of triage criteria among different age groups continues to be debated in the literature with some studies demonstrating undertriage of older patients

sustaining falls with little physiological derangement at the scene (Peden, McGee et al. 2002).

The common predictors of hospital outcome can be quantified based on ISS, percent mortality, hospital length of stay, intensive care admission, emergency department physiological presentation, requirement for fluids or blood transfusions and requirement for emergency operation (Keller, Sciadini et al. 2012). The hospital bed is considered the most expensive item on a hospital bill with surgery noted to be the second most expensive cost (Hepguler, Cetin et al. 2011).

Our study uniquely outlines insignificant treatment differences in LOS and complication rate when isolated hip fractures are treated at intermediate levels of trauma care such as Level 2 and 3 centers. Sartorelli et al (Sartorelli, Rogers et al. 1999) described how the primary predictors of trauma center cost were LOS and ICU LOS and outlined the obstacles involved in providing trauma care to the geriatric population which most often results in a net financial loss for hospital institutions (Champion, Copes et al. 1989). Furthermore, Alzahrani et al (Alzahrani, Gandhi et al. 2010) also demonstrated no difference in mortality of hip fracture patients admitted to academic versus community hospitals in Ontario, Canada.

It is through evidence based approaches that we are able to demonstrate that increased morbidity and mortality is a direct effect of the underlying functional decline and translated rates of postoperative complications and not a function of the level of trauma care provided.

Our approach represents an accurate model of detailing the additional hospital costs attributed to treating these patient cohorts at trauma-designated hospitals. All hospitals are given a global budget and a large proportion of hospital costs are fixed regardless of patient volume (Hemmila, Jakubus et al. 2008). A proportion of this overhead is distributed amongst the various trauma related services and a function of the total number of occupied patient beds in the unit.

This approach does not apply to the costs of surgery, surgical implants, radiology, laboratory testing, medications prescribed and rehabilitation services which are not included in the hospital budget and are should not vary significantly across all hospitals (Letarte, Longo et al. 2002; Chen, Lee et al. 2007). The direct and indirect overhead and direct hospital capital costs are what would be expected to account for the price difference between tertiary trauma centers and community hospitals.

Despite a reduction in the length of hospital stay for hip fracture patients in the last decade, recent studies report a median length of stay of 21 days in the acute care setting (Bergeron, Lavoie et al. 2005). Correlation between mean length of

stay and total hospitalization costs has been demonstrated throughout the literature (Fakhry, Couillard et al. 2010; Gomez, Haas et al. 2010). It has been shown that the presence of dementia is associated with the highest added costs (Fallon, Rader et al. 2006; Chen, Lee et al. 2007; Bergeron, Moore et al. 2009).

It has also been demonstrated that certain trauma centers have a slightly higher rate of complication when compared to non-trauma centers. Conversely, some studies demonstrate that admission of elderly hip fracture patients to a critical care services results in reduced mortality and mean LOS (Stone, Barbaro et al. 2007; Ang, Rivara et al. 2009). The overwhelming consensus remains that these patients have higher resource utilization and overall poorer outcomes when compared to the younger age trauma cohorts.

Recent attention has focused on whether isolated hip fracture patients should be included in trauma registries. The notion that these patients influence risk-adjusted outcomes is beyond the scope of this study; however, it is imperative to grasp the burden these patients have on trauma care and thoroughly address the global economic burden of the problem (Gomez, Haas et al. 2010).

It has been shown that among patients aged 65 years and older, up to 47% of admissions were as a result of isolated hip fractures (Gomez, Haas et al. 2010). Trauma studies allow the statistical modeling of resource utilization and patient

outcomes and thus these patients deserve careful consideration. Seniors are less likely to fracture their hips today than in the past.

The large number of elderly patients admitted to acute care institutions for falls will drastically increase in the future and multifactorial plans of action are required to prepare for this delicate patient cohort. Falls in the geriatric population contribute to a significant burden in healthcare delivery in addition to a disproportionate amount of injury related healthcare expenses (Hartholt, Polinder et al. 2012).

Conflicting theories of thought exist as to whether advanced age with no physiological criteria is a valid criterion for trauma activation. The presence of mild to moderate injury as defined by Injury Severity Score, a purely anatomical scoring system, and the absence of head trauma and grossly abnormal vitals are critical components to this argument (Finelli, Jonsson et al. 1989; Scalea, Simon et al. 1990; Knudson, Lieberman et al. 1994; Aschkenasy and Rothenhaus 2006; Pfeifer, Tarkin et al. 2009). Some studies argue that elderly trauma patients with similar injury severity scores do worse than there younger cohorts and this argument can fully justify admission to Level 1 Centers. However, limited data exists to comment specifically on treating isolated hip fractures at these centers (Shifflette, Lorenzo et al. 2010).

The use of our retrospective study demonstrates these patients receive similar care at primary and secondary institutions. The growing cost of healthcare supplements the argument that it is not cost-effective and logistically sound to involve the activation of the trauma team for all geriatric cases and some form of triage is necessary to achieve a delicate balance preventing over triage while identifying high risk individuals.

Geriatric patients hospitalized for hip fractures are older with more severe co-morbidities and require specialized care which can only be achieved through a structured, multidisciplinary approach (Stewart, Chantrey et al. 2011; De Rui, Veronese et al. 2012). Approximately 80% of geriatric patients have at least 1 chronic condition and 50% have at least 2. These have been shown to correlate with increased rate of perioperative complications, increased length of stay and increased mortality (Thompson, Rivara et al. 2010).

Stone et al (Stone, Barbaro et al. 2007) argue that trauma-critical care surgeons are best suited to coordinate consultation services, manage treatment plans, and provide tailored care to the geriatric patient at increased risk of poor outcomes due to diminished physiological reserve (Schwab and Kauder 1992). Geriatric patients require systemic treatment to account for polypharmacy, dehydration, comorbidities and nutritional optimization (Sirois, Cote et al. 2009). It has been shown that the specialized perioperative medical optimization in elderly patients

with hip fractures improves mortality and functional outcome and reduced time to surgery (Leung, Lam et al. 2011).

Aging is a variable process and there must be integration of orthopedic, geriatric and rehabilitation services to provide quality care for these fragile patients (Deiner, Silverstein et al. 2004; Fisher, Davis et al. 2006; Friedman, Mendelson et al. 2009; Bennett, Scarborough et al. 2010). The traditional concept of over triaging and bypassing the nearest hospital directly to the Level 1 center may not the most ideal treatment modality as these patients can be effectively managed in most facilities staffed with specialists in surgery, anesthesiology, intensive care and geriatrics.

Evidence based studies have documented that patients should undergo surgery within 3 days of injury to minimize hospital length of stay in addition to perioperative complications such as pressure sores and venous thrombo-embolism (Adie, Harris et al. 2009; Hung, Egol et al. 2012). Previous studies have shown that surgery after 48 hours is associated with increased mortality. Other epidemiological studies have documented that surgery performed during normal working hours is associated with lower complication rates. Mortality may also be improved by optimization of patients with comorbidities such as protein malnutrition (Neuman, Speck et al. 2010).

The optimal preoperative assessment of geriatric patients has been extensive debated over the last few decades. A collaborative effort between the American College of Surgeons National Surgical Quality Improvement Program and the American Geriatrics Society (Figure 2) have shown that screening tests produce low rates of abnormal values in asymptomatic patients and thus do not correlative with adverse outcomes (Chow, Rosenthal et al. 2012). The low yield of preoperative screening and the associated increased accumulated costs in the preoperative setting strongly favours not delaying the time to definite surgical intervention.

The use of a Geriatric Day Hospital has already been instituted at the Sherbrooke Geriatric University in Quebec using a multidisciplinary approach to minimize the potential complications facing elderly individuals (Tousignant, Hebert et al. 2003; Ho, Kwan Dai et al. 2009). The regional differences in the allocation of finite resources and healthcare centers further complicate the provincial management and allocation of sparse healthcare resources. A standardized model of care which is co-managed with geriatricians has been shown to have a modest cost reduction with shorter lengths of stay (Kates, Mendelson et al. 2011).

These hip fracture programs are continually associated with expedited admission, rapid assessment, multi-disciplinary care and reduced time to surgery and recovery. It has been demonstrated that these approaches consistently reduce unnecessary medical tests resulting in reduced radiology, cardiology, and

laboratory charges (Kates, Mendelson et al. 2011). These programs may be better suited to assess and minimize fall risk factors post discharge and allow follow up in specialized clinics emphasizing orthogeriatric collaboration.

Limitation of the current study may include fluctuation in the total case volume of hip fractures and the average total cost per case across urban and rural settings. It is also difficult to adjust for the heterogeneity of the population pre-fracture and account for health status, living situation and mental health which have been shown to act as confounding variables in treatment outcomes (Aharonoff, Koval et al. 1997; Braithwaite, Col et al. 2003; Hepguler, Cetin et al. 2011). It is also impossible to quantify loss of independence which is a great clinical concern in this delicate population.

The study included data primarily from the Quebec Trauma Registry which could result in additional limitations. The data used is from the year 2002 and may not be generalizable to current epidemiological trends. The data also failed to include the mortality rate 1 year follow up in addition to the total treatment cost for rehabilitation. Further studies could examine the fate of this delicate cohort post-discharge and attempt to quantify the decline in pre-fracture level of physical functional status.

The scope of this analysis includes primarily acute care costs which account for the majority of the difference in healthcare related costs. The study does not include additional fees including home and social care and other indirect costs (Hepguler, Cetin et al. 2011). The mean costs directly attributable to hip fractures in the first year post discharge has been shown to be $36, 939 for women and $39, 479 for men in a recent Ontario study (Nikitovic, Wodchis et al. 2012). These costs translate into an annual expenditure of $282 million in Ontario and $1.1 billion in Canada. These costs are known to exceed the acute care fees in the long term.

Understanding the pathophysiology of comorbidities such as osteoporosis and their added treatment costs could also present unique findings (Boonen and Singer 2008; Leslie, O'Donnell et al. 2009; Tanner, Kloseck et al. 2010; Tanriover, Oz et al. 2010; Hepguler, Cetin et al. 2011; De Rui, Veronese et al. 2012). Osteoporosis remains an under-recognized and under-treated comorbidity and adequate treatment of osteoporosis has been shown to reduce the risk of subsequent fractures and mortality (Byszewski, Lemay et al. 2011; Gosch, Roth et al. 2011). There may a greater role for the preventative management and treatment of osteoporosis and targeting high risk population subgroups.

The study did not explore surgical implant costs which are commonly negotiated by the individual hospital. The study also failed to demonstrate long term follow-up and include the LOS and costs for sub-acute and other rehabilitation. The study

also fails to take into account the patient's prefecture status which is the major prognostic factor in poor outcome. The major limitation lies in the retrospective nature of the study and future multi-center prospective studies should serve as framework for future research.

The concept of dedicated hip fracture units has been postulated to minimize costs and improve the postoperative and long-term outcome of these patients. Evidence based practices demonstrate the following: 1) Hip fracture patients require multidisciplinary approach to manage decreased physiological reserve and potential complications 2) Surgical fixation should optimally be performed within 24 and 48 hours of injury 3) Patients benefit from early mobilization and rehabilitation (Bergeron, Lavoie et al. 2006; Fisher, Davis et al. 2006; Lewis, Abouelenin et al. 2007; Chudyk, Jutai et al. 2009; Egol and Strauss 2009; Simunovic, Devereaux et al. 2010; Larsson and Holgers 2011).

The creation of these distinct units outside of dedicated trauma centers has the potential to provide multidisciplinary care and prevent these patients from consuming expensive trauma-based resources. Interdisciplinary intervention including post-treatment rehabilitation has been shown to reduce the likelihood of poor recovery in older patients with lower pre-fracture functional abilities, reduce the incidence of delirium and improve cognition (Tseng, Shyu et al. 2012; Wyller, Watne et al. 2012).

One of the main goals of treatment pertains to discharge planning and the assessment of the ideal rehabilitation program. Early surgical intervention and mobility has been associated with better clinical outcomes and reduced mortality (Pioli, Frondini et al. 2012).

Planning for early discharge not only reduces hospital length of stay but results in better overall clinical outcomes. This requires considering inpatient rehabilitation (short or long term facilities) versus home-based supported options (De Rui, Veronese et al. 2012). This may be seen at Level 1 Trauma Centers with a slightly lower length of stay and increased placement in rehabilitation centers.

The key strength of trauma registry studies involves the evaluation of patient outcomes and planning for the allocation of resources (Bergeron, Lavoie et al. 2005). This study demonstrated that geriatric hip fracture patients constitute a large portion of patients treated at all trauma levels in Quebec. The long-term resource utilization in these patients is costly. The care received do not differ significant at the urban or rural; trauma or non-trauma center. Distinct opportunities exist for the improvement of care and the outcome of treatment through sending isolated hip fractures directly to Level 2 or Level 3 Trauma Centers.

Conclusions

Trauma is no longer a disease of the young. With the aging baby boomer generation, the proportion of geriatric trauma patients will rise steadily. The gradual increase in the prevalence of geriatric hip fractures will present unique challenges to health care economics. Care is best delivered as patient centered with protocol driven standardized care employing the most recent evidence based data available.

Treatment at Level II and III vis-à-vis Level I centers are associated with similar patient outcomes and reduced costs. Therefore, treatment of Isolated Hip Fractures at Level 1 Trauma Centers is not cost effective. Geriatric hip fracture patients require multidisciplinary care and have higher resource use and poorer outcomes then traditional trauma patients. Geriatric trauma will continue to be a hot topic for clinical and epidemiological research. Future research is necessary to study the 1) establishment of a geriatric triage protocol and 2) the creation of dedicated hip fracture units.

Table 1: Description of Patient Population by Age and Gender

Variable	**Level 1 (n = 3376)**	**Level 2 (n = 7059)**	**Level 3 (n = 574)**	**Total (n = 11009)**	*P* Value
Age (yrs), mean ± SD	82.3 ± 7.6	81.9 ± 7.5	82.0 ± 7.5	82.1 ± 7.5	N.S.
Age category (yrs), n (%)					N.S.
65-69	230 (7)	509 (7)	36 (6)	775 (7)	
70-74	382 (11)	837 (12)	68 (12)	1287 (12)	
75-79	656 (19)	1440 (20)	117 (20)	2213 (20)	
80-84	791 (23)	1672 (24)	145 (25)	2608 (24)	
85-89	768 (23)	1599 (23)	112 (20)	2479 (23)	
90-94	430 (13)	788 (11)	75 (13)	1293 (12)	
>95	119 (4)	214 (3)	21 (4)	354 (3)	
Gender, n (%)					N.S.
Female	2650 (78)	5413 (77)	444 (77)	8507 (77)	
Male	726 (22)	1646 (23)	130 (23)	2502 (23)	

Table 2: Description of Patient Population by Location and Mechanism of Trauma

Variable	**Level 1 (n = 3376)**	**Level 2 (n = 7059)**	**Level 3 (n = 574)**	**Total (n = 11009)**	*P* Value
Location of Trauma, n (%)					
Residence	1625 (48)	3665 (52)	374 (65)	5664 (51)	N.S.
Nursing Home	923 (27)	1682 (24)	85 (15)	2690 (24)	
Mechanism of Injury, n (%)					
Fall	3284 (97)	6879 (97)	560 (98)	10723 (97)	N.S.
MVC	50 (1)	78 (1)	7 (1)	135 (1)	
Urban or Rural, n (%)					
Urban	3096 (92)	5084 (72)	342 (60)	8522 (77)	N.S.
Rural	280 (8)	1975 (28)	232 (40)	2487 (23)	

Table 3: Injury Severity Score (ISS) and Trauma to Head for Patient Admitted by Trauma Level

Variable	**Level 1 (n = 3376)**	**Level 2 (n = 7059)**	**Level 3 (n = 574)**	**Total (n = 11009)**
ISS (1-75)				
Mean ± SD	9.3 ± 1.8	9.1 ± 0.8	9.2 ± 1.2	9.2 ± 1.2
Median	9.0	9.0	9.0	9.0
Mode	9.0	9.0	9.0	9.0
Trauma to Head, n (%)	109 (3)	77 (1)	5 (1)	191 (2)

Table 4: Length of Stay, ICU Admission and Mortality by Trauma Level

Variable	**Level 1 (n = 3376)**	**Level 2 (n = 7059)**	**Level 3 (n = 574)**	**Total (n = 11009)**
Surgery Performed, n (%)	3273 (97)	5996 (85)	520 (91)	9789 (89)
ICU admission, n (%)	199 (6)	606 (9)	71 (12)	876 (8)
LOS Total (days), mean ± SD	13.8 ± 10.0	15.9 ± 17.7	18.9 ± 18.7	15.4 ± 15.9
LOS ICU (days), mean ± SD	3 ± 3	3 ± 5	3 ± 3	3 ± 5
Mortality (30 Days), n (%)	196 (6)	502 (7)	29 (5)	727 (7)

Table 5: Description of Complications by Trauma Level

Variable	**Level 1 (n = 3376)**	**Level 2 (n = 7059)**	**Level 3 (n = 574)**	**Total (n = 11009)**
Any Complication, n (%)	614 (18)	838 (12)	98 (17)	1550 (14)
Single Complication, n (%)	512 (15)	733 (10)	91 (16)	1336 (12)
Multiple Complications, n (%)	102 (3)	105 (1)	7 (1)	214 (2)
Intra-Abdominal Sepsis	1 (0)	0 (0)	0 (0)	1 (0)
Lung Failure	6 (0)	0 (0)	0 (0)	6 (0)
Other Sepsis	2 (0)	3 (0)	1 (0)	6 (0)
Cardiac Arrest	3 (0)	7 (0)	0 (0)	10 (0)
Shock	8 (0)	12 (0)	1 (0)	21 (0)
Sepsis	19 (0)	21 (0)	3 (1)	43 (0)
Coagulopathy	24 (1)	26 (0)	0 (0)	50 (0)
Pulmonary Embolism	18 (1)	31 (0)	1 (0)	50 (0)
Renal Failure	29 (1)	48 (1)	2 (0)	79 (1)
Wound Infection	43 (1)	59 (1)	8 (1)	110 (1)
Myocardial infarction	48 (1)	88 (1)	4 (1)	140 (1)
Pneumonia	125 (4)	144 (2)	7 (1)	276 (3)
Urinary Tract Infection	415 (12)	525 (7)	79 (14)	1019 (9)

Table 6: Percentage of Each Discharge Destination by Trauma Cohort

Discharge Destination, (%)	**Level 1**	**Level 2**	**Level 3**
Primary Residence	31%	41%	34%
Rehabilitation Center	59%	17%	24%
Short Term Care Facility	4%	27%	32%
Long Term Care Facility	6%	15%	10%

Table 7: Cost Analysis for Treatment of 1000 Geriatric Patients Sustaining Isolated Hip Fracture Treatment At Level 1, 2 and 3 Trauma Centers in Quebec, Canada

	Level 1	**Level 2**	**Level 3**
Patients Treated	1000	1000	1000
ICU Admissions	60	90	120
Total Cost	$ 26,714,520	$ 21,439,914	$ 10,657,372
$ Difference			
vs. Level 1	–	$ 5,274,606	$ 16,057,148
Vs. Level 2	–	–	$ 10,782,543
% Difference			
vs. Level 1	–	20%	60%
vs. Level 2	–	–	50%

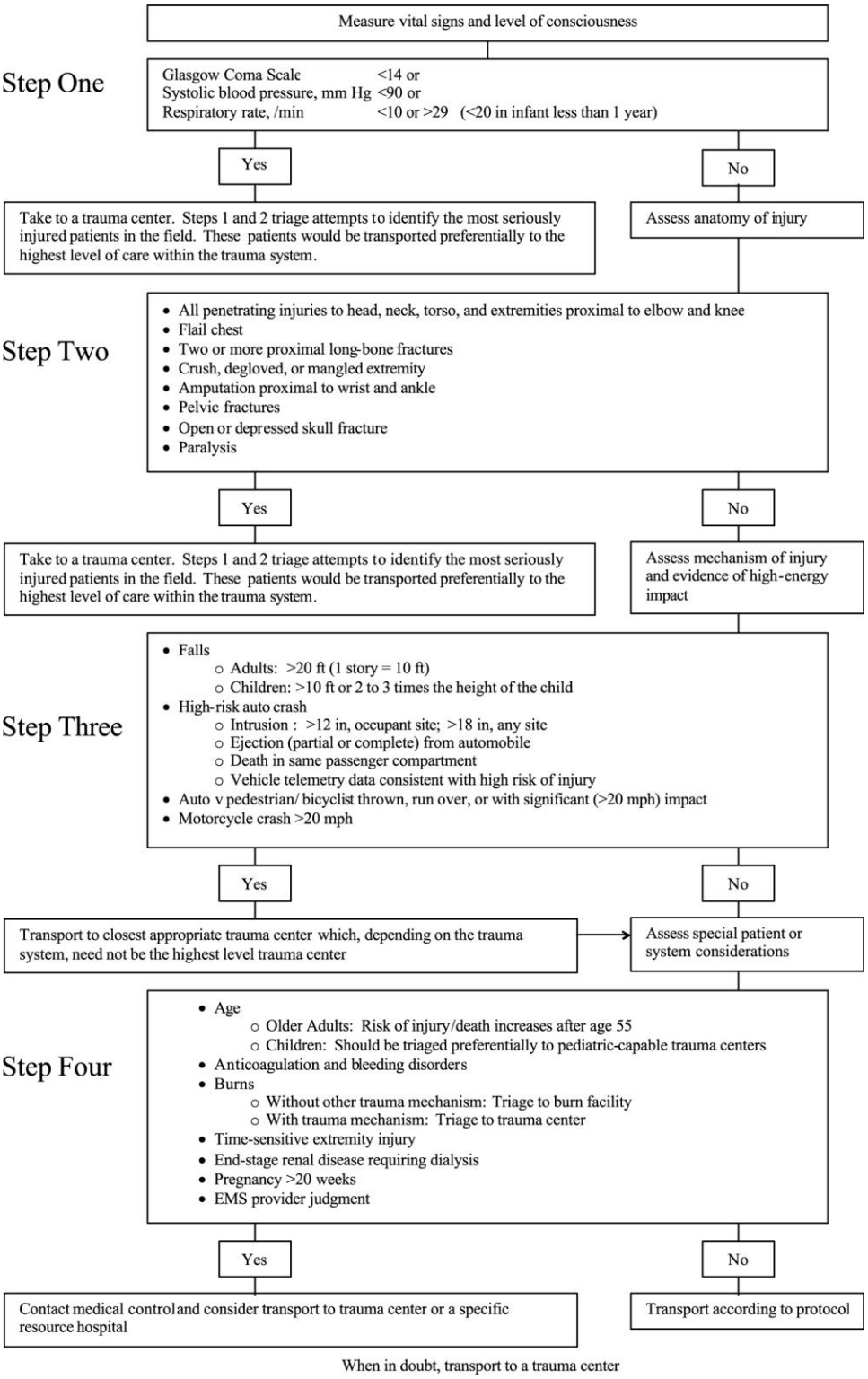

Figure 1: The 2006 ACSCOT Field Triage Decision Scheme. (Reprinted from: Resources for the Optimal Care of the Injured Patient. Chicago, IL, American College of Surgeons, 2006)

Checklist for the Optimal Preoperative Assessment of the Geriatric Surgical Patient

In addition to conducting a complete history and physical examination of the patient, the following assessments are strongly recommended:
☐ Assess the patient's **cognitive ability** and **capacity** to understand the anticipated surgery.
☐ Screen the patient for **depression**.
☐ Identify the patient's risk factors for developing postoperative **delirium**.
☐ Screen for **alcohol** and other **substance abuse/dependence**.
☐ Perform a preoperative **cardiac** evaluation according to the American College of Cardiology/American Heart Association algorithm for patients undergoing noncardiac surgery.
☐ Identify the patient's risk factors for postoperative **pulmonary** complications and implement appropriate strategies for prevention.
☐ Document **functional status** and history of **falls.**
☐ Determine baseline **frailty** score.
☐ Assess patient's **nutritional status** and consider preoperative interventions if the patient is at severe nutritional risk.
☐ Take an accurate and detailed **medication history** and consider appropriate perioperative adjustments. Monitor for **polypharmacy**.
☐ Determine the patient's **treatment goals** and **expectations** in the context of the possible treatment outcomes.
☐ Determine patient's **family** and **social support system**.
☐ Order appropriate preoperative **diagnostic tests** focused on elderly patients.

Figure 2: The Evidence Based Recommendations for improving the preoperative management and assessment of geriatric surgical patients. (Reprinted from: Chow, W. B., R. A. Rosenthal, et al. (2012). "Optimal preoperative assessment of the geriatric surgical patient: a best practices guideline from the american college of surgeons national surgical quality improvement program and the american geriatrics society." J Am Coll Surg **215**(4): 453-466.)

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Appendix

Table 8: Number of patients treated for isolated hip fractures in Quebec ranked by institution and trauma level (n>5)

Number of Patients Treated	Trauma Level	Hospital Name
1074	Level 1	Hopital de l'Enfant-Jesus
1045	Level 1	Sacre-Coeur de Montreal
791	Level 2	Hotel Dieu de Saint-Jerome
765	Level 1	Montreal General Hospital
601	Level 2	Centre hospitalier régional de Trois-Rivières
590	Level 1	Hôpital Charles Lemoyne
513	Level 2	Reseau Sante Richelieu-Yamaska
486	Level 2	Hospital Santa Cabrini
430	Level 2	Hospital Jean Talon
353	Level 2	Centre Hospitalier Universitaire de Sherbrooke (CHUS)
353	Level 2	C.H. Régional Rimouski
342	Level 2	Centre Hospitalier des Vallées de l'Outaouais (CHVO)
340	Level 2	C.H. Hôtel-Dieu d'Amos
322	Level 2	Hopital Du Haut-Richelieu
321	Level 2	Complexe Hospitalier de la Sagamie
302	Level 3	C.H. Régional du Suroit
300	Level 2	Hotel Dieu D'Arthabaska
290	Level 2	Hôpital de Saint-Eustache
281	Level 2	Centre hospitalier Beauce-Etchemin
277	Level 2	L'Hôtel Dieu de Lévis
237	Level 3	CH Anna-Laberge
202	Level 2	l'Hôpital Pierre-Le Gardeur
199	Level 2	Centre Hospitalier de Granby

190	Level 2	Centre Hospitalier Regional du Grand-Portage
163	Level 3	Centre Hospitalier Hotel Dieu De Sorel
136	Level 2	Centre hospitalier Hotel-Dieu de Roberval
127	Level 2	Centre Le Jeannois Pavillon Hotel Dieu D'alma
72	Level 2	Centre hospitalier régional de Sept-Îles
57	Level 3	CH Baie-des-Chaleurs
56	Level 2	Hôpital Sainte-Croix
42	Level 3	Centre Hospitalier De Chandler
36	Level 3	CH-CHSLD de Matane
20	Level 3	Centre Hospitalier Regional Baie-Comeau
6	Level 3	Reseau De Sante Du Temiscouata, Notre-Dame-du-Lac
6	Level 3	C.H. Laurentien
5	Level 3	Centre hospitalier de Gaspe

Table 9: Calculation of Per Diem Hospital Costs

	Non-Resident Costs			Quebec Resident Costs	
Trauma Level	ICU ($)/day	General Floor ($)/day	Multiplier Ratio	ICU ($)/day	General Floor ($)/day
1	$ 8,178.00	$ 3,765.00	2.17	$4,089.00	$ 1,882.50
2	$ 5,644.17	$ 2,601.00	2.17	$2,822.09	$ 1,300.50
3	$ 2,350.11	$ 1,083.00	2.17	$1,175.06	$ 541.50