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A review of gender differences in hip fracture anatomy, morbidity, mortality and function

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Summary. Hip fractures are a significant cause of morbidity and mortality in the elderly. Many of the previous studies on hip fractures have focused on women, primarily because the annual incidence of hip fractures in females is more than twice the incidence in males. However, there is evidence that post-operative mortality after hip fractures is significantly higher for men. Furthermore, there may be a difference in functional outcome between the two genders. The purpose of this review study was to characterize the gender differences in men and women with a hip fracture in terms of anatomy and biomechanics, morbidity, mortality and functional outcomes.
Key words: elderly, gender differences, hip fractures, mortality, anatomy.

Fratture del femore: una review delle differenze di genere nell'anatomia, morbilità, mortalità e risultati funzionali

Riassunto. Le fratture del terzo prossimale di femore rappresentano un'importante causa di morbilità e mortalità nei pazienti anziani di entrambi i sessi. La maggior parte degli studi pubblicati in letteratura su questo tipo di lesioni focalizza l'attenzione principalmente sul genere femminile. È infatti noto che l'incidenza annuale delle fratture del terzo prossimale di femore nella popolazione femminile con più di 75 anni sia più di due volte quella maschile di pari età. D'altro canto, la mortalità postoperatoria sia ad uno che a due anni dall'evento fratturativo è significativamente più elevata per gli uomini. Nonostante ciò non sembrano esserci importanti differenze tra i due sessi in termini di risultati funzionali e ritorno alle attività della vita quotidiana. Lo scopo di questo studio è di fornire una review della letteratura circa le differenze di genere tra uomini e donne con fratture del terzo prossimale di femore in termini di anatomia e biomeccanica, morbilità, mortalità e risultati funzionali.
Parole chiave: anziano, differenze di genere, fratture del femore, mortalità, anatomia.

Introduction

Hip fractures are an established health problem in Western countries and are increasingly becoming a growing problem in the Eastern world. With rising life expectancy around the globe, the number of elderly people is increasing in every geographical region, and it is estimated that the incidence of hip fracture will rise from 1.66 million in 1990 to 6.26 million by 2050[1]. Moreover, these fractures result in significant 1-month and 1-year mortality (5% and 20%, respectively). About 30% of hip fracture patients are estimated to become permanently disabled, while 40% of them lose the ability to walk independently, and 80% are unable to perform independently activities of daily living after the fracture has occurred[2,3].

Most clinical trials and research studies on hip fracture outcomes have focused on women, particularly white women, as this is the demographic with the highest incidence of hip fracture[4]. In a study based on the hospitalization rate due to hip fractures in Italy from 2000 to 2009, Piscitelli et al.[3] found a similar increase in the incidence in both men and women over the ten-year period (14.5% in men and of 12.1% in women). However, when looking at the different age groups, the risk of being hospitalized due to hip fracture was much higher in women. In particular, in the age group > 75 years of age, risk was more than double. Women aged 85 and over accounted for 30.8% of total hospitalizations, though accounting for only 1.8% of the population.

Whereas incidence of hip fracture is said to be higher in women, gender-related differences exist in terms of anatomical and biomechanical aspects, morbidity and mortality and functional recovery. All these aspects are analysed in this review of the current literature regarding gender differences in patients with hip fracture.

Anatomical and biomechanical differences

Anatomic studies of hip anatomy, specifically on the femoral side, have shown gender-specific anatomic differences. Women tend to have a shorter femoral neck, a thinner femoral shaft, a lower cervicodiaphyseal (CCD) angle, a lower femoral offset, and greater anteversion of the femoral neck[5,6]. Biomechanically, a lower offset and lower CCD angle results in a lower distribution of forces at the hip level. If these stresses accumulate in *loci minoris resistentiae*, they might lead to the fracture of the bone segment.

Gender differences in the diameter of the long bone, the thickness of the cortex, and the distance

the cortical shell is placed from the neutral axis of the femoral neck are determined by the absolute and relative movements of the periosteal and endocortical surfaces during growth and during aging[7]. In men, greater periosteal apposition than in women offsets their greater endocortical bone loss, maintaining the bending strength of bone. Smaller femoral neck diameter in men with hip fractures suggests that reduced periosteal apposition during growth or aging may contribute to the pathogenesis of femoral neck fragility. In women, a larger femoral neck diameter in young adulthood results in a structural disadvantage, as endocortical resorption erodes the cortex in which modest periosteal apposition fails to compensate increasing fracture risk by increasing the risk of buckling. Therefore, periosteal bone formation throughout life plays an important role in determining bone strength in old age within a population of the same sex, between individuals of the opposite sex, and perhaps between individuals differing by racial or ethnic origin[7].

The reduction of bone density is another factor influencing the gender difference of hip fractures. As stated by Cooper et al.[8] from conception to epiphyseal closure, there is a progressive increase in cortical and cancellous bone mass that is accelerated during the pre-pubertal growth spurt. This growth phase produces 90% of the peak bone mass attained during adult life with no significant difference in bone density between the sexes after puberty. Net bone loss commences soon after reaching peak bone mass and certainly by age 40 years or so. Both cortical and cancellous bone loss is biphasic, with a slow phase of loss that occurs throughout life in both sexes (with rates of between 0.3% and 1% of peak bone mass each year), and a superimposed rapid phase of loss (with rates as high as 5%-7% of peak bone mass each year) during the postmenopausal decade in women. This reduction in bone mass and disruption of bone architecture, defined as osteoporosis, result in increased risk of fragility fractures which are the main clinical consequence of the disease. Although hip fractures account for less than 20% of all osteoporotic fractures, they are a useful surrogate for determining the international burden of osteoporosis[9]. Almost 83% of hip fractures were found to have been experienced by patients 75 years of age or older, in accordance with the higher prevalence of osteoporosis in this age group[2,3]. Approximately 6% of men and 21% of women aged 50–84 years are classified as having osteoporosis. The prevalence of osteoporosis in women over the age of 50 years is 3–4 times greater than in men—comparable to the difference in lifetime risk of an osteoporotic femoral fracture in men and women[10]. These findings confirm the crucial role of osteoporosis, which is the most frequent underlying cause of hip fractures in the elderly, especially in women[11].

However, it is not just a matter of entity of bone density reduction; the quality of this reduction also plays a role in the gender distribution of hip fractures. In a population-based cross-sectional study Khosla et al.[12] found that while decreases with age in trabecular bone volume/tissue volume are similar in men and women, the structural basis for the decrease in trabecular volume is quite different between the sexes. Therefore, over life, women undergo a loss of trabeculae with an increase in trabecular separation, whereas men begin young adult life with thicker trabeculae and primarily sustain trabecular thinning with no net change in trabecular number or trabecular separation. Since decreases in trabecular number have been shown to have a much greater impact on bone strength compared with decreases in trabecular thickness, these findings may help explain the lower life-long risk of fractures in men.

Morbidity differences

As reported in the majority of studies where patients with hip fractures were stratified by gender, men are younger than women by an average of 2 to 6 years at the moment of trauma (Table 1). Despite this, men are sicker as demonstrated by a higher American Society of Anesthesiologists rating of preoperative risk[4,13-16].

In a study by Kannegaard et al.[13] on more than 41,000 patients with hip fracture from the Danish National Hospital Discharge Register, men were 4 years younger at the time of fracture than women. However, men were significantly more likely to suffer from most comorbidities than women. This was especially pronounced for malignancy, cardiac heart failure, chronic obstructive pulmonary disease (COPD) and all forms of arterial disease. Similar results were reported by Endo et al.[14]. In their retrospective analysis on 983 consecutive patients (206 males and 777 females) who sustained a non-pathologic hip fracture, the authors found no gender difference in the number of preoperative comorbidities. Men, however, were sicker than women according to the ASA classification of preoperative risk ($P < 0.001$, odds ratio [OR] 1.9, 95% confidence interval [CI] 1.4–2.6). White et al.[17] observed that a greater percentage of men were rated ASA grade III/IV than women among hip fracture patients in Canada.

In a study by Holt et al.[15] from the Scottish Hip Fracture Audit, men had a younger mean age at presentation of 77 years (60 to 101) compared with 81 years (50 to 106) for women. Despite this, men were more likely to have a higher ASA score, indicating greater pre-fracture co-morbidity. In a retrospective chart review study comprising of 759 consecutive elderly patients suffering traumatic hip fracture Mizrahi et al.[16] found men

to have a higher prevalence of comorbidities (diabetes, hypertension, ischemic heart disease, previous stroke, Parkinson's disease), but no difference in term of age was reported.

Mortality differences

There is evidence that the postoperative mortality after hip fractures is significantly higher for men. In studies with large samples, the 1-year mortality for men ranged from 9.4% to 37.1%, compared with a range of 8.2% to 12.4% in women[4,13,14,18](Table 1). This is probably due to the higher number of comorbidities in men as seen in the previous chapter.

In their population-based study, Panula et al.[19] revealed gender-specific differences in the cause of death after hip fracture. In particular, men were more likely than women to die from respiratory diseases. According to the authors, one explanation for the greater male mortality is the assumption that men are more prone to exacerbation of respiratory problems after hip fracture surgery (decreased secretion in the airways, impaired activities of daily living, and subsequent chest complications). In addition, smoking may be related to another finding of their study. Malignant neoplasms were more likely the cause of death for men than for women. A recent cancer survey in Europe concluded that differences in cancer mortality between genders and European countries may be explained by smoking habit[20].

Roche et al.[21] showed by multivariate analysis that men have an increased risk of postoperative heart failure (OR, 1.8) and chest infection (OR, 2), and that these patients have an increased mortality risk (OR, 5 and 2.4, respectively).

According to Wehren et al.[22] men are twice as likely as women to die during the first and second year after hip fracture. The greatest increases in mortality, relative to the general population, were seen for septicemia (RR, 87.9; 95% CI, 16.5, 175 at 1 year and RR, 32.0; 95% CI, 7.99, 127 at 2 years) and pneumonia (RR, 23.8; 95% CI, 12.8, 44.2 at 1 year and RR, 10.4; 95% CI, 3.35, 32.2 at 2 years). The magnitude of increase in deaths caused by infection was greater for men than for women in both years.

In their meta-analysis, Haentjens et al.[23] found that older adults have a 5- to 8-fold increased risk for all-cause mortality during the first 3 months after hip fracture. Excess annual mortality persists over time for both women and men, but at any given age, excess annual mortality after hip fracture is higher in men than in women.

Kannegard et al.[13] found that being male to be a strong risk factor for death after fracture, with an impact comparable to a chronic comorbidity such as COPD. Furthermore, the authors confirm a trend towards both greater comorbidity and use of fewer medications in men. In the author's opinion, it might be that some comorbid conditions in men are underdiagnosed and thereby undertreated, leading to more acute postoperative complications that might be fatal.

Functional outcome differences

Gender differences in functional outcome after hip fracture have been studied previously, with inconsistent results.

In the study on gender differences during rehabilitation Dudkiewicz et al.[24] found no significant differences relating to functional level on discharge and functional achievement during rehabilitation. According to the authors, the lack of differences in functional gain might be explained by the similarity in admission functional and cognitive levels between the genders, which were found to be the most important

Table 1. Summary of differences in hip fracture incidence, age, and mortality.

	Country	Period	Number of patients	Women (%)	Men (%)	Average age – Women	Average age – Men	Mortality-Women	Mortality-Men
Hawkes et al.[18]	USA	1990-1991	674	77	23	81	79	12.4 (1 year)	31.1 (1 year)
Endo et al.[14]	USA	1987-2000	983	79	21	79	80	9.4 (1 year)	16.5 (1 year)
Kannegaard et al.[13]	Denmark	1999-2002	42,076	73	27	81	78	26.4 (1 year)	37.1 (1 year)
Holt et al.[15]	Scotland	1988-2005	25,649	78	22	81	77	18 (3 months)	27 (3 months)

factors affecting rehabilitation outcome. These results concur with Lieberman et al.[25] who did not observe differences in rehabilitation outcome (discharge FIM score, AFG, complications or length of rehabilitation) between genders in hip fracture patients.

While confirming that men were generally younger and suffered greater comorbidity at time of fracture, Hawkes et al.[18] found little difference in patterns of functional recovery following fracture between men and women.

Samuelsson et al.[26] found more men than women walking independently at 2 years when cognitive function was intact, but no difference when cognition was impaired.

On the contrary, in other studies male gender emerges as an advantage for better functional outcome.

In their prospective study, Kempen et al.[27] found that patients did not generally regain their pre-injury levels of functioning 12 months after their event. However, in contrast to women, men came closer to their pre-injury functional levels. Similarly, Folden et al.[28] reported that men had a higher functional level than women 3 months after discharge and were more likely to return to their pre-surgical functional level. Finally, Kennedy et al.[29] observed that although women's functional achievements were similar to men, the differences in starting and ending points and final results were worse.

Several reasons for gender differences in functioning have been hypothesized[27,30]. One hypothesis posits that the gender difference in functioning is due to women's greater prevalence of nonfatal but disabling conditions, such as arthritis and migraine headaches. Another hypothesis for the observed gender differences in functioning is differential reporting of functional problems by men and women. However, a previous study showed that both men and women report their disability accurately, and that women's higher prevalence of reported functional problems is probably a reflection of true disability[30]. Third, besides higher incidences and prevalence of pre-operative comorbidities in men, women report more psychological symptoms such as depressive feelings as well. However, it must be also considered that the most of the reports reflect the greater likelihood of mortality in men, which would presumably eliminate the sickest men, leaving a relatively higher functioning group.

Conclusion

Hip fractures have a well-defined and peculiar gender distribution. In light of the existing literature, women aged over 75 are the most exposed to this problem due to the physiological reduction of bone mass (osteoporosis), the quality of this reduction and anatomical and biomechanical disadvantages. Men are younger than women at the time of trauma, but they tend to be sicker, thus resulting in a higher mortality rate at 1/2 years post-operatively. However, the current literature is unable to draw any certain conclusions on gender differences in functional outcome after hip fracture.

Key messages

- Hip fractures are a significant cause of morbidity and mortality in the elderly.
- Women aged over 75 are the most exposed to hip fractures due to the physiological reduction of bone mass (osteoporosis), the quality of this reduction and anatomical and biomechanical disadvantages.
- Men are younger than women at the time of trauma.
- After hip fracture, men tend to be sicker, thus resulting in a higher mortality rate at 1/2 years post-operatively.
- There are no certain conclusions on gender differences in functional outcome after hip fracture.

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