J Bone Miner Metab (2011) 29:744–751
DOI 10.1007/s00774-011-0279-3

ORIGINAL ARTICLE

The incidence and residual lifetime risk of osteoporosis-related fractures in Korea

Chanmi Park · Yong-Chan Ha · Sunmee Jang · Suhyun Jang · Hyun-Koo Yoon · Young-Kyun Lee

Received: 2 November 2010 / Accepted: 27 April 2011 / Published online: 7 June 2011

Abstract Although the Korean population does not have high risk for osteoporosis, the numbers of osteoporosis-related fractures represent a considerable economic burden to society. The purpose of this study was to determine the incidence and residual lifetime risk of osteoporosis-related fractures in Korea, using data from the Health Insurance Review and Assessment Service (HIRA), which includes nationwide information compiled by the Korean government. All new visits or admissions to Korean clinics or hospitals for fractures were recorded prospectively in a nationwide cohort by the Korean HIRA using the International Classification of Diseases, 10th revision, codes and procedure codes. These data were retrospectively evaluated to determine the incidence and residual lifetime risk of osteoporosis-related fractures (hip, spine, distal radius, and humerus fractures), in men and women aged 50 years or more between 2005 and 2008. The annual incidences of osteoporosis-related fractures were 1,661, 1,646, 1,623, and 1,614 per 100,000 person-years in men and women aged 50 years or more from the year 2005 to 2008. The annual incidence of osteoporosis-related fracture in women was three times that of men. The incidence of osteoporosis-related fractures increased with advancing age. In Korea, at the age of 50 years, the residual lifetime probabilities of osteoporosis-related fractures are 59.5% for women and 23.8% for men. This study presents the baseline data for treatment and research on osteoporosis and provides an estimate of osteoporosis-related fractures in Korea.

Keywords Osteoporosis · Osteoporotic fracture · Lifetime risk · National health insurance claims data · Korea

C. Park · S. Jang · S. Jang
Health Insurance Review and Assessment Service, 168 Hyoryeong-ro, Seocho-gu, Seoul 137-706, South Korea

Y.-C. Ha
Department of Orthopaedic Surgery, Chung-Ang University College of Medicine, 224-1 Heukseok-dong, Dongjak-gu, Seoul 156-755, South Korea

H.-K. Yoon
Department of Medicine, Cheil General Hospital and Women's Healthcare Center, Kwandong University College of Medicine, 1-19 Mukjeong-dong, Jung-gu, Seoul 100-380, South Korea

Y.-K. Lee (✉)
Department of Orthopaedic Surgery, Seoul National University Bundang Hospital, 166 Gumi-ro, Bundang-gu, Seongnam 463-707, South Korea
e-mail: ykleemd@gmail.com

Introduction

Although osteoporosis is a silent disease, it is an important public health concern around the world. Osteoporosis-related fracture is one of the leading causes of significant morbidity and disability in old patients, and it increases economic burden on the health care system [1–4].

It is important to determine the incidence of osteoporosis-related fracture and trace its trends, because they are the first step in providing baseline data for establishing policy in public health care.

Several studies have suggested that incidences of osteoporosis-related fractures (hip, spine, distal radius, and humerus) vary across the world. Although Korea might be expected to be at low risk for osteoporosis because it is an Asian country, there are few data available to confirm this in terms of the incidence of osteoporosis-related fractures in Korea. In addition, comparisons with other countries have not been established.

For comparisons across countries and regions, the determination of residual lifetime risk is also an epidemiologically useful tool. The WHO definition of osteoporosis, which is based on bone mineral density (BMD), has shortcomings with regard to risk assessment and as a basis for treatment decisions; analysis of osteoporosis-related fractures has been proposed as an alternative that overcomes these drawbacks [5]. Gender- and age-specific lifetime absolute risk of osteoporosis-related fractures are reported in studies from other region of the world [6–12], but no such estimations are published regarding the Korean population [13].

The purpose of this study was to determine the incidence and lifetime risk of major osteoporotic (hip, spine, distal radius, and humerus) fractures in a nationwide cohort study of the Korean population, using data from the Health Insurance Review and Assessment Service (HIRA).

Materials and methods

Subjects

We analyzed data from the nationwide claims database of the HIRA of Korea, which is comprised of adjusted medical and pharmacy claims for all Korean citizens, between the years of 2005 and 2008. In Korea, 97.0% of the population is legally obliged to enroll in the Korea National Health Insurance Program. Patients pay an average of 30% of the total medical costs to clinics or hospitals that manage almost all diseases, except for those not covered by insurance, such as cosmetic surgery or some new unproven therapies. All clinics and hospitals then submit claims data for inpatient and outpatient care, including diagnoses [in International Classification of Diseases, 10th revision (ICD-10)], procedures, prescription records, demographic information, and direct medical costs, to the Korean HIRA to obtain 70% reimbursement of the total medical cost from the government. The remaining 3% of the population not insured by the Korean National Health Insurance Program are either covered by a Medical Aid Program or are temporary or illegal residents. The claims data covered by the Medical Aid program were also reviewed by the HIRA. Therefore, virtually all information about patients and their medical records is available from the Korean HIRA database, which has been used on several occasions for epidemiological studies [14–18]. All new visits or admissions to Korean hospitals for osteoporosis-related fracture were recorded prospectively in a nationwide cohort by the above-described system using ICD-10 codes and procedures. Each patient has a unique identifier, making it feasible to track a specific patient over time. The total number of men and women over the age of 50 in the Korean population was obtained from the web site of the Statistics Korea (http://www.kosis.kr/), which is the central government organization for statistics [19].

To identify osteoporosis-related fractures, selected ICD-10 codes and a cut-off value of 50 years of age were used [14, 16, 20].

Fractures were identified on the basis of selected ICD-10 codes; hip [ICD-10 codes S72.0 (fracture of the femoral neck), S72.1 (pertrochanteric fracture) and 7 procedures (open reduction of fractured extremity-femur, closed pinning-femur, external fixation-pelvis/femur, closed reduction of fractured extremity-pelvis/femur, bone traction, skin traction, hemiarthroplasty-hip)]; spine [S22.0 (fracture of the thoracic spine), S22.1 (multiple fractures of the thoracic spine), S32.0 (fracture of the lumbar spine), M48.4 (fatigue fracture of vertebra) and M48.5 (collapsed vertebra, NEC)]; distal radius [S52.5 (fracture of the distal radius) and S52.6 (combined fracture of the distal radius/ulna)]; humerus [S42.2 (fracture of the proximal humerus) and S42.3 (fracture of shaft of humerus)]; and overall fractures.

When an individual had more than one fracture with the same encoding, the patient was followed from the first encoding and recounted if a further encoding occurred six months or later after the first event [14, 21]. In overall fractures, we counted plural ICD-10 codes occuring on the same date as a single event.

These data were retrospectively evaluated to determine the trend of annual incidence and lifetime risk of osteoporosis-related fractures (hip, spine, distal radius, and humerus fracture), in men and women aged 50 years or more between the years of 2005 and 2008.

The study was subject to control by the National Board of the HIRA, and approved by the institutional review board.

Statistical analysis

To determine the recent trends of fracture incidences, the patients were divided into groups according to their age (subdivided into 5-year increments), gender, and fracture site (hip, spine, distal radius, and humerus). The age-adjusted and gender-specific incidence rates (per 100,000 person years) were calculated based on the general population of Korea during each year. Cochran–Armitage test for trends was performed to evaluate whether the incidence rate changed from 2005 to 2008. The age-adjusted and gender-specific incidences from 2005 to 2008 were used for this analysis. P values of <0.05 were considered significant.

To compare the incidence of the osteoporosis-related fractures between Korea and other geographic areas [20, 22–28], we used age-standardized incidence rates, which

are weighted averages of the age-specific incidence rates of people in the corresponding age groups in a standard population, which in this case was estimated for the population in the United States on 2008 [29, 30].

The residual lifetime risks of osteoporosis-related fractures were estimated by simple approximation using the age- and gender-specific incidence rate in 2008 and life tables for the Korean population in 2008 released by Statistics Korea.

To compute the residual lifetime risk for each ([k]) age, $Pr[k]$ was defined as the probability of having no osteoporosis-related fracture for entire lifetime starting at age of k. This probability may be discretely approximated using the following formula [27]:

$$\begin{aligned} Pr[k] = {} & d[k](1 - I[k]) + (1 - d[k])(1 - I[k])d[k + 1] \\ & (1 - I[k + 1]) + (1 - d[k])(1 - I[k])(1 - d[k + 1]) \\ & (1 - I[k + 1])d[k + 2](1 - I[k + 2]) + \cdots \end{aligned}$$

where $d[k]$ is the probability of dying at k-year-old, $I[k]$ is the probability of having a fracture at k-year-old, and so on.

The probability of not having an osteoporosis-related fracture during the remaining lifetime also can be written as follows:

$$Pr[k] = \sum_{s=k}^{100} \left[\left\{ \prod_{t=k}^{s-1} (1 - d[t])(1 - I[t]) \right\} d[s](1 - I[s]) \right]$$

These values were replaced with the corresponding incidence or mortality rates in this study. The residual lifetime risk of an individual aged k years experiencing an osteoporosis-related fracture is then estimated by $1 - Pr[k]$ [27]. We assumed that mortality is 1 in 100 years. Since the numbers of incidence and population data are not available, we calculated the incidence rate only for those in the ages of 95–100. All database management and analysis were performed using SAS statistical package version 9.1.3 (SAS Institute Inc., Cary, NC, USA).

Results

Among those aged 50 years or older, the crude overall incidence of osteoporosis-related fractures was 1,635 per 100,000 person years from 2005 to 2008, and the gender-specific incidence was 725 per 100,000 person years for men and 2,408 per 100,000 person years for women (Table 1).

Although the absolute number of osteoporosis-related fractures increased, age-adjusted incidence rates were stable for most fractures during the period of 2005–2008 (Table 1). However, the age-adjusted incidence of distal radius fracture decreased in women ($p = 0.0183$) (Table 2). Among those aged 50 years or older, the incidence of spine fractures was highest (969 per 100,000 persons), followed by distal radius (422), hip (157), and humerus (81) in 2008, sequentially.

Figure 1 shows the age- and gender-specific incidences for osteoporosis-related fracture from 2005 to 2008. For both genders, the incidence rate of most osteoporosis-related fractures increased with age. The gender ratio of the female to male incidence of osteoporosis-related fractures was >1.0 for all age groups, especially in the distal radius and the spine.

The incidence of hip fracture which is standardized to population in 2008 in the United States was lower than that of Japan in women, and the incidence of distal radius fracture was comparable with Switzerland in men and women (Table 3).

Figure 2 shows the residual lifetime risk of osteoporosis-related fracture for individuals aged 50 years or more in men and women. The residual lifetime risk of osteoporosis-related fracture for individuals with age 50 was estimated to be 23.8% for men and 59.5% for women.

Discussion

Although there were several epidemiologic studies on hip fractures in Korea, to the best of our knowledge this is the first nationwide, population-based, epidemiological study of osteoporosis-related fractures (hip, spine, distal radius, and humerus). Moreover, this is one of the few studies worldwide presenting the lifetime risks of osteoporosis-related fractures based on national health insurance claims data.

With regard to hip fracture, the incidence rate was stable during the period from 2005 to 2008 in Korea, and the reported incidence of hip fracture in this study is in the middle of the range observed in the previous cohort studies in Korea [31, 32]. Future studies will be necessary to determine the trends of hip fracture incidences over longer periods by using consistent protocols.

Several studies have presented a wide geographic variation in the incidence of osteoporotic fractures between different populations [13, 27, 33–35]. In general, populations in higher latitudes seem to show a higher incidence of osteoporotic fracture [13, 27, 33–35]. Asian populations, including the Chinese and Japanese, were considered to have low- to moderate-risk for osteoporotic fracture [13]. In this study, we could not directly compare the incidence of osteoporosis-related fractures in Korea with that of other countries, because the definition of osteoporosis-related fractures varied in each study. However, the incidence of hip fracture in Korean women was between those of Singapore and Thailand, which were considered countries with moderate risk for osteoporotic fracture (Table 3) [13, 27,

Table 1 Age-adjusted and gender-specific incidence (per 100,000 persons) of osteoporosis-related fractures in Korean over 50 years old

	2005			2006			2007			2008		
	Men	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total
Overall												
No. of fractures	37,622	152,234	189,856	39,540	157,098	196,638	41,659	160,861	202,520	43,963	166,629	210,592
Incidence of fractures	721	2,450	1,661	722	2,428	1,646	726	2,387	1,623	730	2,373	1,614
Age-adjusted incidence of fractures	721	2,450	1,661	719	2,427	1,643	718	2,379	1,611	719	2,360	1,597
Hip												
No. of fractures	4,945	11,921	16,866	5,134	12,843	17,977	5,243	13,367	18,610	5,894	14,538	20,432
Incidence of fractures	95	192	148	94	199	151	91	198	149	98	207	157
Age-adjusted incidence of fractures	95	192	148	93	196	149	89	194	145	94	199	151
Spine												
No. of fractures	21,533	89,771	111,304	23,355	95,431	118,786	25,107	99,425	124,532	25,997	100,449	126,446
Incidence of fractures	413	1,445	974	427	1,475	995	437	1,476	998	431	1,430	969
Age-adjusted incidence of fractures	413	1,445	974	424	1,473	991	431	1,468	989	424	1,419	956
Distal radius												
No. of fractures	8,999	45,300	54,299	8,867	43,175	52,042	9,048	41,855	50,903	9,628	45,407	55,035
Incidence of fractures	172	729	475	162	667	436	158	621	408	160	647	422
Age-adjusted incidence of fractures	172	729	475	162	670	437	158	626	410	160	653	425
Humerus												
No. of fractures	2,470	6,656	9,126	2,539	7,028	9,567	2,598	7,551	10,149	2,850	7,752	10,602
Incidence of fractures	47	107	80	46	109	80	45	112	81	47	110	81
Age-adjusted incidence of fractures	47	107	80	46	108	80	45	111	81	47	109	80

Age standardized to the Korean population in 2005

Table 2 Trend test of age-adjusted and gender-specific incidence of osteoporosis-related fractures from 2005 to 2008

	Trend test (p value)		
	Men	Women	Total
Overall	0.9533	0.1472	0.2107
Hip	0.8707	0.7609	0.9268
Spine	0.6630	0.6236	0.6873
Distal radius	0.4832	**0.0183**	0.0577
Humerus	0.9738	0.8469	0.9801

28, 31]. Although the residual lifetime risk of a hip fracture at age 50 was 5.23% in men and 12.31% in women, lower than that of Japan (Table 4) [27], the residual lifetime risk of osteoporosis-related fractures for individuals aged 50 is estimated to be 59.5% for women and 23.8% for men in Korea.

On the other hand, it was interesting that the age-adjusted incidence of the distal radius fracture was as great as that of Switzerland, a population with high risk for osteoporotic fractures [20] (Table 3). In addition, the residual lifetime risk of a distal radius fracture was also similar to that of Sweden, a population with high risk for osteoporotic fractures [8] (Table 4). We do not know the exact reason for the high incidence and lifetime risk of distal radius fracture in Korea, but there could be several explanations for these findings. First, in this study, ICD-10 codes for distal radius contained not only S52.5 (fracture of

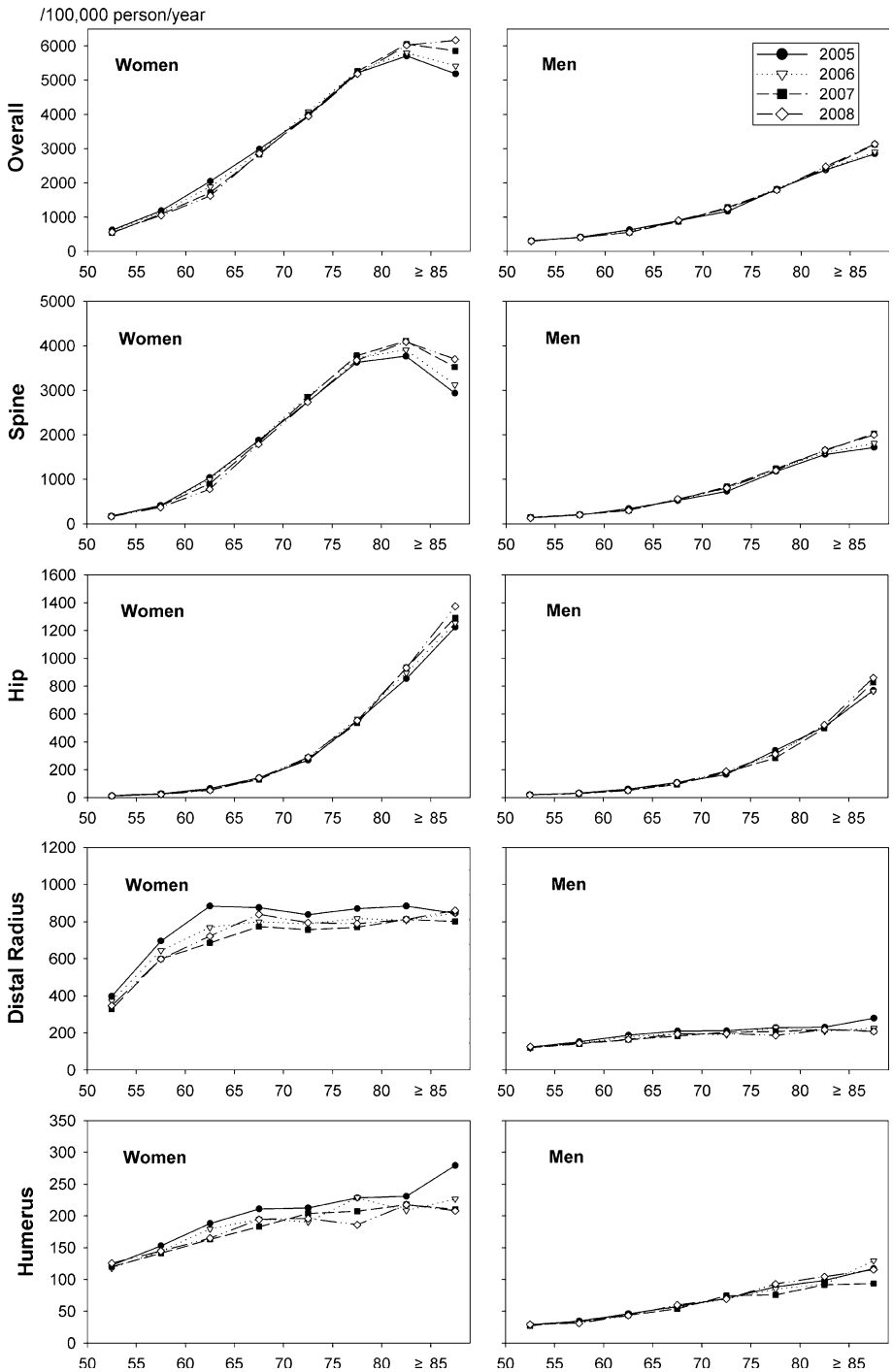

Fig. 1 Age-specific incidences of osteoporosis-related fractures in men and women between 2005 and 2008

the distal radius) but also S52.6 (combined fracture of the distal radius/ulna), and this made it possible to count cases of distal radius fracture that were missed in other studies. Second, not all distal radius fracture is due to osteoporosis.

Understanding osteoporosis as a problem predominantly occuring in elderly women, it can be also well understood from the study that women show consistently higher incidence of osteoporosis-related fractures than men; this is comparable to previous studies performed in other countries [6, 8, 36].

Based on these results, the incidence rate of the osteoporosis-related fractures increased with age after age 50, and the residual lifetime risk decreased after the age of 70. Considering the lifetime risk as a more intuitive parameter, a concentrated management for osteoporosis is necessary to reduce the incidence and socio-economic burden of the

Table 3 Age-adjusted incidence (per 100,000) of osteoporosis-related fractures over 50 years old in different populations

Author	Region	Study periods	Hip		Distal radius	
			Men	Women	Men	Women
Falch et al. [22]	Norway	1988–1989	382	885	–	–
Lippuner et al. [20]	Switzerland	2000	235	576	173	632
Ho et al. [23]	USA	1988–1989	204	535	–	–
Sanders et al. [24]	Australia	1996	193	490	44	270
Balasegaram et al. [25]	England	1997	177	488	–	–
Lau et al. [26]	Hong Kong	1997–1998	195	468	–	–
Hagino et al. [27]	Japan	2006	128	413	–	–
Lau et al. [26]	Singapore	1997–1998	154	395	–	–
Park et al. (current study)	Korea	2008	136	274	164	661
Lau et al. [26]	Thailand	1988–1989	112	241	–	–
Lau et al. [26]	Malaysia	1997–1998	83	195	–	–
Yan et al. [28]	China	1994	99	84	–	–

Standardized to the US population in 2008, sorted by descending order of incidence of hip fracture in women

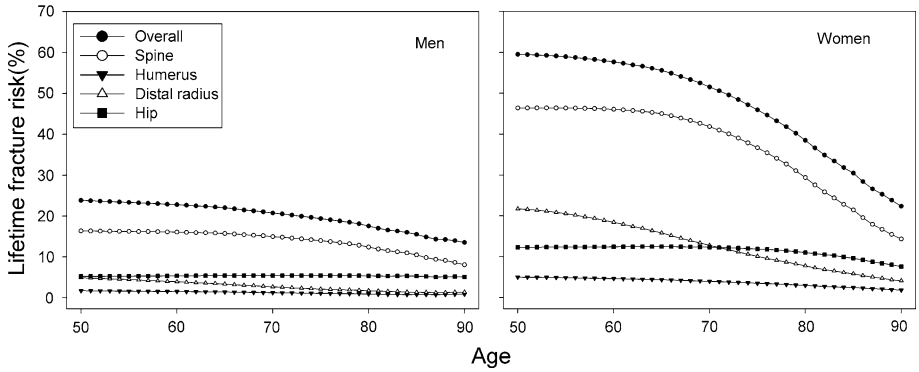

Fig. 2 The residual lifetime risk of osteoporosis-related fractures in men and women by age

Table 4 Comparison of gender-specific residual lifetime risk (%) of hip and distal radius fractures across countries at age 50 years

	Study periods	Hip		Distal radius	
		Men	Women	Men	Women
Norway [6]	1995–2004	18.3	30.4	6.2	32.7
Belgium [7]	1984–1996	–	29.0	–	18.1
Sweden [8]	1987–1993	10.7	22.9	4.6	20.8.
Switzerland [20]	2000	7.0	22.6	–	–
Japan [27]	2004–2006	5.6	20.0	–	–
USA [9]	1985–1989	5.2	15.6	2.4	15.0
Korea (current study)	2008	5.2	12.3	4.9	21.7
UK [10, 11]	1988–1998	3.1	11.4	2.9	16.6
Australia [12]	1991–1998	2.0	7.0	5.0	12.0

Sorted by descending order of residual lifetime risk of hip fracture in women

osteoporosis-related fractures in Korea, especially in these populations of elderly women.

Our study has some limitations. First, patients that had multiple osteoporosis-related fractures during the observational period were not specifically identified in the present survey, which may have affected the result of the overall fractures. This was why total numbers of overall fractures are different from summations of each fracture. Second, all patients with osteoporosis-related fractures may not be coded in this nationwide database. For example, many patients with asymptomatic spine fracture may not visit medical institutions in Korea. This can cause

incidence figures based on the HIRA database to be underestimated. Third, when identifying osteoporotic fracture by means of ICD-10 codes, it is difficult to distinguish a new fracture from deterioration of an old one. Prevalent spine fractures, especially, might be counted as new fractures, and this might give misleading results. Forth, BMD of patients was not available in this study due to our study design based on the National Claim Registry. It was possible that fractures due to high-energy trauma were included in this study, because the distinction between high and low-energy fractures could not be made by using the ICD-10 coding system. However, we used the additional criteria of "aged 50 years or more" to exclude non-osteoporotic fractures. In addition, these inclusion criteria including ICD code and age without BMD measurement could be found in several studies on osteoporosis-related fractures [8, 11, 12]. Therefore, our study without BMD measurement could be justified.

Despite these limitations, the results of this study show that age-adjusted incidence rates were stable for most fractures during the study period. In terms of residual lifetime risk, Korea was comparable with countries with moderate risk for osteoporosis-related fracture such as Japan.

Acknowledgments This study was supported by the Korean Health Insurance Review and Assessment Service (HIRA) and conducted using data from the Korean National Health Insurance Claims Database.

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