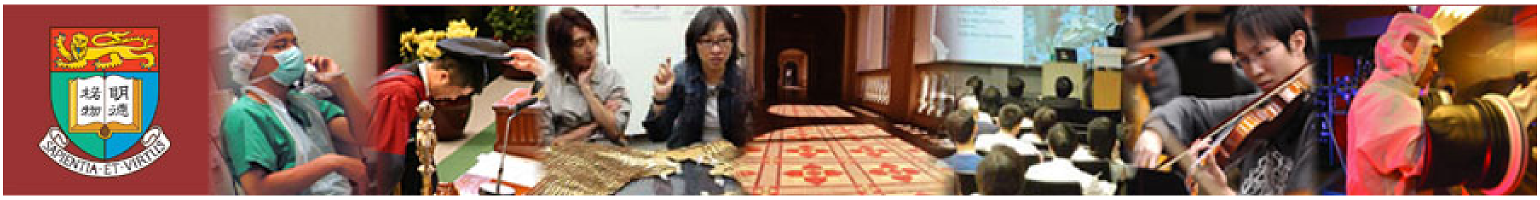

Title	Severe Spastic Contractures and Diabetes Mellitus Independently Predict Subsequent Minimal Trauma Fractures Among Long-Term Care Residents
Author(s)	Lam, KUEN; Leung, MF; Kwan, CW; Kwan, SKJ
Citation	Journal of the American Medical Directors Association, 2016, v. 17 n. 11, p. 1025-1030
Issued Date	2016
URL	http://hdl.handle.net/10722/238675
Rights	This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.

JAMDA 17 (2016) 1025–1030

JAMDA

journal homepage: www.jamda.com

Original Study

Severe Spastic Contractures and Diabetes Mellitus Independently Predict Subsequent Minimal Trauma Fractures Among Long-Term Care Residents

Kuen Lam FRCP(Edin), FHKAM(Medicine) [a,*], Man Fuk Leung MRCP(UK), FHKAM(Medicine) [b], Chi Wai Kwan PhD [c], Joseph Kwan MPhil, MD, FRCP (UK) [d,*]

[a] *Cheshire Home, Shatin, Hong Kong*
[b] *Department of Medical and Geriatrics, United Christian Hospital, Hong Kong*
[c] *Department of Statistics and Actuarial Science, The University of Hong Kong, Hong Kong*
[d] *Department of Medicine, The University of Hong Kong, Hong Kong*

Keywords:
Contractures
minimal trauma fracture
spasticity
long-term care
diabetes mellitus
risk factors

A B S T R A C T

Objective: The study aimed to examine the epidemiology of hypertonic contractures and its relationship with minimal trauma fracture (MTF), and to determine the incidence and predictors of (MTF) in long-term care residents.
Design: This was a longitudinal cohort study of prospectively collected data. Participants were followed from March 2007 to March 2016 or until death.
Setting: A 300-bed long-term care hospital in Hong Kong.
Participants: All long-term care residents who were in need of continuous medical and nursing care for their activities of daily living.
Measurements: Information on patients' demographic data, severe contracture defined as a decrease of 50% or more of the normal passive range of joint movement of the joint, and severe limb spasticity defined by the Modified Ashworth Scale higher than grade 3, medical comorbidities, functional status, cognitive status, nutritional status including body mass index and serum albumin, past history of fractures, were evaluated as potential risk factors for subsequent MTF.
Results: Three hundred ninety-six residents [148 males, mean ± standard deviation (SD), age = 79 ± 16 years] were included for analysis. The presence of severe contracture was highly prevalent among the study population: 91% of residents had at least 1 severe contracture, and 41% of residents had severe contractures involving all 4 limbs. Moreover, there were a significant proportion of residents who had severe limb spasticity with the elbow flexors (32.4%) and knee flexors (33.9%) being the most commonly involved muscles. Twelve residents (3%) suffered from subsequent MTF over a median follow-up of 33 (SD = 30) months. Seven out of these 12 residents died during the follow-up period, with a mean survival of 17.8 months (SD = 12.6) after the fracture event. The following 2 factors were found to independently predict subsequent MTF in a multivariate Cox regression: bilateral severe spastic knee contractures (hazard ratio = 16.5, $P < .0001$, confidence interval 4.8–56.4) and diabetes mellitus (hazard ratio = 4.0. $P = .018$, confidence interval 1.3–12.7).
Conclusions: Severe spasticity and contractures are common morbidities in long-term care residents, and bilateral severe spastic knee contractures and diabetes mellitus are 2 independent predictors of subsequent MTF. Spasticity management and prevention of contractures, combined with educational programs for caregivers to identify the high-risk residents and apply proper handling techniques during routine care, may be helpful in reducing the risk of MTF in long-term care residents. Further large-scale longitudinal studies are needed to confirm these findings.

The authors declare no conflicts of interest.
* Address correspondence to Kuen Lam, FRCP(Edin), FHKAM(Medicine), Cheshire Home, 30 A Kung Kok Shan Rd, Shatin, Hong Kong; or Joseph Kwan, MPhil, MD, FRCP(UK), Department of Medicine, The University of Hong Kong, Hong Kong.
E-mail addresses: lam_kuen@yahoo.com.hk (K. Lam), jskkwan@hku.hk (J. Kwan).

http://dx.doi.org/10.1016/j.jamda.2016.06.029
1525-8610/

Minimal trauma fractures (MTFs) or spontaneous bone fractures occur mostly in debilitated and dependent long-term care residents, without the degree of trauma that usually causes a bone break.[1–8] They are also called "care-related fractures," as these incidents occur mostly during basic care procedures. The prevalence of MTF according to 3 prospective cohort studies ranges from 0.4 to 0.84 per 100 persons per year.[1,4,7] MTF are devastating events in long-care residents, causing pain and suffering, and increasing morbidity and mortality.[2–4] Moreover, there may be medico-legal issues raised after a MTF for the possibility of mistreatment and inadequate care procedures.[1,2] Despite their impact, reports on MTF are scarce, and currently there has been only 1 prospective cohort study that explored the predictors of MTF.[1] Kane et al[1] followed 1903 residents in 11 skilled nursing care facilities for 1 year, and 16 MTFs occurred. They found no predictive factors of MTF other than severely impaired mobility. However, their study did not examine the contribution by spasticity and contractures or other medical comorbidities. On the other hand, the authors of a review article proposed several risk factors for MTF according to 3 previous studies,[1,3,4] and these factors were age older than 80 years, female sex, prolonged period of immobility (2 years or more), neurologic disease including advanced dementia, and prior fracture history.[2] Nevertheless, except for the study by Kane et al[1] as mentioned before, the other 2 studies were either case series of patients with MTF[3] or follow-up study on the outcomes of only patients with MTF[4]; these study designs were not able to identify the independent predictors of MTF.

Spasticity and hypertonic contractures are also recognized as major causes of morbidity and sufferings (pain, pressure ulcers, skin infections, functional disability) among long-term care residents,[9–11] and are considered to be a potential cause of MTF.[7] Previous studies showed that the prevalence of contractures with or without hypertonia in nursing home residents ranged from 22% to 61%.[9–11] However, the relationship between limb spasticity or contractures and subsequent MTF has not yet been established. Takamoto et al[7] reported in their observational study that joint contractures were found adjacent to the fracture sites in 18 patients with reported MTFs; hence, the authors proposed that joint contractures might be one of the risk factors leading to MTF,[7] but no formal statistical analysis was presented.

We conducted this long-term cohort study to examine the epidemiology of spasticity and hypertonic contractures and their relationship with MTF among the most debilitated and dependent long-term care residents, and to determine the incidence and independent predictors of MTF in this vulnerable population.

Methods

In Hong Kong, long-term care residents who are in need of continuous medical and nursing care for their activities of daily living (such as bathing, toileting, feeding, grooming, and transfer) are placed on the central infirmary waiting list and admitted to special care units both in the public and private institutions.[12] The estimated total number of this population is over 57,000.[13] Cheshire Home (Shatin) is a 300-bed long-term care hospital that receives residents from the central infirmary waiting list. As such, its patient population provides a representative sample of the most debilitated and dependent long-term care residents in Hong Kong.

We analyzed the clinical data of all consecutive long-term care residents who were in the central infirmary waiting list in Hong Kong and were under care in the Cheshire Home (Shatin) from March 2007 to March 2016.

Upon admission to the Cheshire Home (Shatin), all residents received a baseline comprehensive multidisciplinary assessment. The medical team assessed the residents' medical comorbidities, medications list, history of previous fractures, and any recent acute hospitalizations. Blood tests, including serum albumin, hemoglobin, and renal and liver function tests, were routinely taken. The nursing team assessed the demographic data and nutritional status, including the body mass index, mobility, mental status, type of restraints used (if any), communication abilities, baseline skin integrity and pain assessment, urinary continence, and bowel habits. The occupational therapists assessed the cognitive function using the Rancho Los Amigos Scale-Revised,[14] activities of daily living using the Barthel index, limb power and function, any contractures or limb spasticity, and seating assessment. The physiotherapists assessed the musculoskeletal system including limb power and function, ambulation status using the Modified Functional Ambulation Classification, respiratory condition, both active and passive range of movement (AROM and PROM) of joints as measured by goniometer in the resting position, and assessment of limb spasticity using the Modified Ashworth Scale (MAS).[15] From 2007 onward, the physiotherapists measured the AROM and PROM of knee and elbow extension, and used the MAS for knee and elbow flexors in all residents. Severe contracture was defined as a decrease of 50% or more of the normal PROM of the joint, whereas severe spasticity was defined as MAS score higher than 3. From 2011 onward, the assessments were extended to include the AROM and PROM of finger extension and the MAS of the finger flexor and shoulder and hip abduction and abductors. The medical social workers assessed the family support and financial condition, types of social activities that the resident was engaged in, and their psychological well-being.

Residents were then followed up for the occurrence of any subsequent MTFs either until death or the end of the data collection period. Any resident who was noted to have pain, deformity, or swelling of limbs was assessed by the physician and with X-ray imaging. Residents who were suspected to have bone fractures or who were found to have a bone fracture on their X-rays were transferred to an acute care unit for an urgent orthopedic consultation. Computed tomography imaging was performed at the discretion of the orthopedic surgeon if there was a high clinical suspicion of bone fracture, but the X-ray imaging did not clearly reveal any bone fracture. The final diagnoses of bone fractures were determined by the orthopedic surgeon's opinion and confirmed by X-ray or computed tomography imaging. For all confirmed new bone fractures, the multidisciplinary team reviewed the mechanism of injury. MTF was diagnosed where there was no obvious history of fall or major trauma.

Ethical approval for this study was obtained from the Clinical Research Ethics Committee.

Statistical Analysis

A descriptive analysis according to the different parameters [distribution, mean, and standard deviation (SD)] was conducted. We performed the univariate analysis first to identify any predictive factor for the occurrence of MTF. Factors when associated with a P value of .1 or less in the univariate analysis were put into the multivariate Cox regression model to identify any independent predictor of subsequent MTF. Since the occurrence of MTF was rare, a penalized maximum likelihood estimation method by Firth was used.[16,17] Effects were considered to be significant when associated with a P value of .05 or less. Data was analyzed using the SPSS v 20.0 statistical package (Chicago, IL) and SAS v 9.4 (Cary, NC).

Results

Baseline Characteristics

Clinical data of 396 residents (148 males, mean age = 78.9, SD = 16 years) with a median follow-up of 33 (SD = 30) months were included for analysis. Their baseline characteristics are shown in Tables 1–3. Our cohort had high level of comorbidity and disability. Almost all residents were either bed-bound or chair-bound, with a high Charlson Comorbidity Index (mean = 2.7, SD = 1.8). Furthermore,

Table 1
Baseline Characteristics of Consecutive Patients (N = 396)

Characteristics	N = 396
Age, mean ± SD (years)	78.9 ± 15.7
Sex, male, n (%)	148 (37.4%)
MFAC: Category	
Bed-bound, n (%)	298 (78.8%)
Wheelchair-bound, n (%)	74 (19.6%)
Walker-aided, n (%)	6 (1.6%)
Follow-up duration, mean ± SD (months)	33.4 ± 30.4
Charlson Comorbidity Index, mean ± SD	2.7 ± 1.8
Rancho Los Amigos Scale-Revised (level ≤5), n (%)	207 (71.4%)
Enteral feeding, n (%)	218 (55.1%)
Double incontinence, n (%)	314 (81.1%)
BMI, mean ± SD (kg/m^2)	21.3 ± 4.2
Serum albumin (normal range: 36–48 g/L), mean ± SD (g/L)	35.1 ± 4.3
Serum lymphocytes (normal range: 19%–47%), mean ± SD (%)	22.6 ± 10.0
Serum hemoglobin (normal range: 11.5–14.3 g/dL), mean ± SD (g/dL)	12.3 ± 1.8
Medical history	
Stroke, n (%)	271 (68.4%)
Diabetes mellitus, n (%)	102 (25.8%)
Hypertension, n (%)	222 (56.1%)
Chronic renal impairment, n (%)	14 (3.5%)
Previous history of bone fracture, n (%)	68 (17.2%)
Physical restraint	
No restraint or hand mitten only, n (%)	313 (82.4%)
Limb restraint, n (%)	43 (11.3%)
Truncal restraint, n (%)	17 (4.5%)
Magnetic safety belt, n (%)	7 (1.8%)

MFAC, Modified Functional Ambulation Classification.

55% were on enteral feeding, whereas 81% had double incontinence; 68% had stroke; 26% had diabetes mellitus; 56% had hypertension; and 4% had chronic renal impairment. In addition, 17.2% of the study population had a history of previous bone fractures at baseline.

Spasticity and Contractures

As shown in Table 2, there was a significant proportion of residents who had severe spasticity at baseline, defined as MAS score higher than 3, with the elbow flexors and knee flexors being the most commonly involved muscles. When involvement of one side was counted, the prevalence of severe spasticity ranged from 10% in the shoulder joints to 33.9% in knee joints. When bilateral involvements of the same joint were counted, the percentage ranged from 6% in the shoulder joints to 26.5 % in the knee joints.

Table 2
Baseline Prevalence of Severe Spasticity and Contractures (N = 396)

Part of Body Involved	Severe Contracture* n (%)	Severe Spasticity† n (%)	Severe Spastic Contracture‡ n (%)
(1) Shoulder	Abduction	Adductor	
Either one side	106 (75.2%)	13 (10.0%)	13 (9.8%)
Both sides	73 (53.7%)	6 (4.4%)	5 (3.7%)
(2) Elbow	Extension	Flexor	
Either one side	68 (19.3%)	111 (32.2%)	22 (6.3%)
Both sides	18 (5.0%)	75 (21.6%)	3 (0.8%)
(3) Finger	Extension	Flexor	
Either one side	8 (6.6%)	14 (11.0%)	5 (3.7%)
Both sides	5 (4.0%)	7 (5.3%)	2 (1.4%)
(4) Hip	Abduction	Adductor	
Either one side	79 (57.7%)	23 (17.4%)	21 (15.7%)
Both sides	64 (46.4%)	19 (14.1%)	16 (11.7%)
(5) Knee	Extension	Flexor	
Either one side	99 (29.0%)	111 (33.9%)	30 (8.6%)
Both sides	50 (14.4%)	88 (26.5%)	15 (4.2%)

*Decrease of 50% or more of the normal passive range of motion of the joint.
†MAS higher than grade III.
‡Presence of both severe contracture and severe spasticity in a joint.

Table 3
Distribution of Severe Contractures* at Baseline (N = 396)

	Prevalence Rate
≥1 severe joint contracture present	90.5%
≥1 severe joint contracture in upper limbs	85.4%
≥1 severe joint contracture in lower limbs	74.6%
Severe joint contractures involved ≥1 limb	81.5%
Severe joint contractures involved ≥2 limbs	63.7%
Severe joint contractures involved all 4 limbs	44.9%

*Decrease of 50% or more of the normal passive range of motion of the joint.

Contractures were highly prevalent among our study cohort (Table 2). At baseline, the presence of severe contracture, defined as a decrease of 50% or more of the normal PROM of the joint, was prevalent in the major joints, ranging from 6.6% in fingers joints to 75.2% in shoulder joints when involvement of 1 side was counted. When bilateral involvements of the same joint were counted, the percentage ranged from 4% in the finger joints to 53.7% in the shoulder joints.

As shown in Table 3, almost all patients (90.9%) had at least 1 severe contracture, with 59.4% having severe contractures involving more than 2 extremities, and 40.5% having severe contractures involving all 4 extremities. The prevalence of contractures in the upper extremities (85.4%) was similar to that of contractures in the lower extremities (75%).

The presence of severe spastic contractures, defined as a decrease of 50% or more of the normal PROM of the joint with coexisting severe spasticity with an MAS score higher than 3, was also found in a small proportion of the study population (Table 2). The prevalence of severe spastic contractures ranged from 3.7% in the finger joints to 15.7% in hip joints when involvement of 1 side was counted. When bilateral involvements of the same joint were counted, the percentage ranged from 0.8% in the elbow joints to 11.7% in the hip joints.

Incidence and Prognosis of MTF

Twelve MTFs and no traumatic fractures occurred during the study period (Table 4); therefore, the incidence rate of MTF in our cohort is 1.1 per 100 persons per year. The most common site of fracture was the femur (67%), followed by the humerus (17%). One resident had a fracture in the right foot, and another resident had a fracture in the left superior pubic ramus of the pelvic bone. Among these 12 residents, only 2 (17%) received orthopedic surgery for the fractures, and the remainder were treated conservatively.

Seven out of 12 residents (58%) died during the follow-up period; the mean survival after the MTF event for these 7 residents was 18 months (SD = 12.6). For the other 5 surviving residents with MTF,

Table 4
Characteristics of Subsequent MTF Cases (N = 12)

Sex	
Male, n (%)	5 (41.7%)
Female, n (%)	7 (58.3%)
Age, mean ± SD (years)	79.4 ± 13.6
Fracture site	
Femur, n (%)	8 (66.7%)
Humerus, n (%)	2 (16.7%)
Foot (1st MTPJ), n (%)	1 (8.3%)
Pelvis, n (%)	1 (8.3%)
Treatment: Received operation, yes, n (%)	2 (16.7%)
Mortality	
Died, n (%)	7 (58.3%)
Survival time after fracture (months), mean ± SD	17.9 ± 12.6
Died within 12 months, n (%)	2 (16.7%)
Died within 24 months, n (%)	5 (41.7%)
Died within 36 months, n (%)	6 (50.0%)

MTPJ, metatarsophalangeal joint.

Table 5
Univariate Analysis of Factors Associated With Subsequent MTFs (N = 396)

Factors	HR*	95% CI†	*P* Value
Age	1.01	0.98–1.05	.548
Sex (male vs female)	1.34	0.42–4.24	.617
Body mass index	0.96	0.83–1.11	.594
History of previous bone fractures	2.77	0.75–10.19	.126
MFAC (bed-bound vs not bed-bound)	1.12	0.31–3.99	.863
Rancho Los Amigos Scale-Revised (level ≤5)	1.18	0.25–5.54	.835
Enteral feeding	0.83	0.26–2.66	.754
Double incontinence	1.18	0.28–4.99	.826
Low serum albumin (<36 g/L)	1.86	0.52–6.60	.338
Low serum hemoglobin (<11.5 g/dL)	1.71	0.45–6.50	.434
Medical diseases			
Chronic renal impairment	4.46	0.73–27.21	.105
History of stroke	1.17	0.35–3.94	.795
Hypertension	1.29	0.41–4.07	.663
Diabetes mellitus	3.92	1.26–12.23	**.019**
Use of physical restraints	1.34	0.37–4.87	.660
Severe bilateral knee contractures	3.93	1.19–13.03	**.025**
Severe bilateral spastic knee contractures	14.73	4.34–50.02	**<.0001**

NOTE. $P \leq 0.1$ are shown in bold.
CI, confidence interval; MFAC, Modified Functional Ambulation Classification.
*HR estimated from Cox proportional hazard regression model.
†CI of the estimated HR.

the mean follow-up time from the fracture event until the end of the study was 27 months (SD = 17.6).

Predictors of MTF

We found that the following factors were predictive of subsequent MTF in the univariate Cox regression (Table 5): (1) the presence of bilateral severe knee contractures [*P* = .025, hazard ratio (HR) = 3.93] and (2) diabetes mellitus (*P* = .019, HR = 3.92). When spasticity was combined to bilateral severe knee contracture, the resulting factor (bilateral severe spastic knee contractures) became the strongest predictor for subsequent MTF (*P* < .0001, HR = 14.73). Other factors including age, sex, nutritional status, cognitive status, mobility, incontinence, enteral feeding, other coexisting medical diseases, or previous bone fractures did not predict subsequent MTF.

Multivariate Cox regression analysis revealed 2 independent predictors of subsequent MTF (Table 6): (1) bilateral severe spastic knee contractures (*P* < .0001, HR = 16.50) and (2) diabetes mellitus (*P* = .018, HR = 4.03).

Discussion

This study is the first long-term cohort study to demonstrate that severe spastic contractures and diabetes mellitus could independently predict subsequent MTF. Although many previous studies have examined the predictors of fall-related bone fractures among nursing home residents,[18–21] MTFs are caused by a different mechanism, and occur in the subgroup of long-term care residents who are more dependent and immobile.[1,2,7,8] It is considered that in addition to a dramatic decrease in bone mass and bone quality, torsion torques during care-related maneuvers may also contribute to the occurrence of MTF in long-term care residents.[2,4]

Table 6
Multivariate Analysis of Factors Associated With Subsequent MTFs

Factors	HR*	95% CI†	*P* Value
Diabetes mellitus	4.03	1.28–12.70	**.018**
Severe bilateral spastic knee contractures	16.50	4.83–56.42	**<.0001**

CI, confidence interval.
*HR estimated from Cox proportional hazard regression model.
†CI of the estimated HR.

Our study showed that bilateral severe knee contractures independently predicted (*P* = .005, HR = 6.19) subsequent MTF. This may be explained by the fact that daily care procedures such as positioning, transferring, turning, grooming, and change of incontinence pads are more difficult for the very frail and debilitated residents with bilateral severe knee contractures, which may lead to added torque during these routine care procedures. This finding is consistent with a previous study that found that joint contractures may act like a point of leverage to exert any external force to the nearby fragile bone and thereby cause fractures.[7] In our study, we propose that for residents who have bilateral severe knee contractures and concurrent high-grade spasticity (MAS >3) in the knee flexors, their risk of subsequent MTF is 2–3 times higher (*P* < .0001, HR = 16.5) because of the highly increased torque generated during care-related maneuvers.

Our study provides a detailed and comprehensive description of the PROM of all major joints and the associated muscle spasticity among long-term care residents, and our findings are consistent with previous studies that there is a high prevalence of severe contractures among functionally dependent long-term care patients.[9–11] We note that the prevalence rate of severe contractures in our study (90.9%) is higher than those found in previous studies (61.2% in Wagner et al[9] and 22% in Dehail et al[11]). This is likely a result of the fact that our study included long-term care residents who were extremely frail and most dependent with over 98% of them being either bed-bound or chair-bound. According to the definition of the CSHA Clinical Frailty Score, all residents in this cohort would have been classified as stage 7 to 9 (7 = severely frail, 8 = very severely frail, and 9 = terminally ill).[22] This might also partially account for the higher incidence rate of MTFs in our cohort (1.1 per 100 persons per year) compared with previous studies (0.4–0.84 per 100 persons per year).[1,4,7]

We propose that preventing contractures at an earlier stage may reduce the risk of subsequent MTF because severe spastic contractures may contribute to subsequent MTF. Long-term care residents are particularly susceptible to contracture formation because of immobilization, increased muscle tone, and the prolonged adoption of a fixed abnormal flexion posture attributable to neurologic impairment. Two randomized controlled studies have shown that chemodenervation therapies (intramuscular injection of botulinum toxin A or chemical neurolysis of motor nerves with phenol) when combining with passive stretch are safe and effective treatments to decrease limb spasticity and improve PROM of the affected joints in long term care residents.[23,24] Moreover, in 1 randomized controlled study comparing botulinum toxin A and placebo (saline) as a supplement to conventional physiotherapy and occupational therapy to treat upper limb spasticity in 55 debilitated long-term care residents, there were fewer MTF in the patients receiving botulinum toxin, although this did not reach statistical significance.[23] Despite the evidence showing the potential benefits of these treatments to long-term care residents with spasticity and contracture problems, many long-term care residents have only limited access to these treatments. In their survey, Dehail et al[11] found that there was a lack of knowledge of potential therapies for acquired deforming hypertonia care management in the clinicians who were caring for the nursing home residents. Moreover, because of limited resources, physical therapy services can be lacking in long-term care units; it may, therefore, be difficult to provide an intensive stretching program for every resident. We propose 2 possible options to solve this problem. First, family members or physical therapy assistants can be taught the proper techniques by the physical therapists to provide simple passive movements to residents if deemed appropriate. Second, long-term care services can implement of a restorative nursing care approach and to educate and train all staff to promote residents' functional independence in daily activities might be a useful way to apply regular stretch as part of residents' active and daily routines.[9]

For those residents who have already developed irreversible contractures, caregivers should be made aware of the higher risks of MTF in these patients and be educated on the proper handling techniques to minimize the force and/or torque on long bones exerted during routine nursing care and rehabilitation therapy, such as positioning, transferring, and turning.[2,8] We agree with Sherman et al[8] that caregivers should be directly observed to assess whether they are using the least traumatic methods of patient movement in nursing homes, and we propose that new techniques of performing daily care procedures to minimize torque be developed for long-term care residents with bilateral severe spastic knee contractures who are at higher risk of subsequent MTF. These techniques include slower and gentler movements with closer observation of any verbal or nonverbal expression of pain/discomfort of the resident during daily care procedures and to stop the procedure or adjust the force before a fracture occurs.[2] Moreover, training and education on the proper use of transfer equipment should be promoted.[2]

Our study also showed that residents with diabetes mellitus were at higher risk of developing MTF (P = .018, HR = 4.03) than those without diabetes mellitus. Though the link between diabetes and fall-related fractures has been widely recognized,[25] the link between diabetes and MTF is a new finding that has never been reported previously. Diabetes can induce diabetic osteodystrophy,[25] which may predispose long-term care residents to increased risk of bone fractures upon minimal trauma exerted by normal care procedures. Previous studies have shown that there is greater bone fragility among patients with diabetes, and which could be a result of increased cortical porosity,[26] accumulation of advanced glycation end products in diabetic bone collagen, impaired vascular supply, and neuropathy.[25–27] Moreover, some diabetes medications, including insulin, thiazolidinediones, and SGLT1 and SGLT2 inhibitors, may also contribute to fracture risk by altering bone metabolisms.[25,28]

Limitations of the Study

First, this was a single-center study. Second, this cohort included most frail and debilitated long-term care residents in need of intensive medical and nursing care, and the results may not be generalizable to all nursing home residents who are more mobile and cognitively intact. Third, 45% of the residents already had multiple contractures with limb spasticity in baseline, and most of them could not cooperate with the process of measuring PROM and MAS because of severe cognitive impairment; therefore, the accuracy of these measurements may be affected. Moreover, PROM of finger extension and shoulder and hip abduction were only assessed after 2011. Therefore, we could not use these data in the Cox regression analysis for subsequent MTF. It may be possible that severe spastic contractures in these joints may also be associated with subsequent MTF. Fourth, we did not document the prevalence of osteoporosis or measure the bone mineral density (BMD) or blood vitamin D level of the residents in this study. Low BMD and vitamin D level has been shown to be risk factors for fall-related fractures.[29,30] Nevertheless, since there is a high prevalence of osteoporosis among long-term care residents who are immobilized for years and it is a routine practice to prescribe vitamin D and calcium supplement to residents in our hospital, measuring BMD or blood vitamin D level may not provide significant additional predictive power for the occurrence of MTF in this study population.

Conclusions

Severe spasticity and contractures are prevalent among long-term care residents, and bilateral severe spastic knee contractures and diabetes mellitus independently predict subsequent MTF. We propose that spasticity management and prevention of contractures, combined with effective education of caregivers to identify the high-risk residents and apply proper handling techniques during routine care, may be helpful in reducing the risk of MTF among long-term care residents. Further large-scale longitudinal studies are needed to confirm these findings.

Acknowledgments

The authors thank all the clinical staff in Cheshire Home (Shatin) who contributed to the multidisciplinary assessment of the residents in this study. The authors also thank Mr Sau Ming Wong and Ms Fion Ying for their assistance in statistical analysis.

References

1. Kane RS, Burns EA, Goodwin JS. Minimal trauma fractures in older nursing home residents: The interaction of functional status, trauma, and site of fracture. J Am Geriatr Soc 1995;43:156–159.
2. Hommel E, Ghazi A, White H. Minimal trauma fractures: Lifting the specter of misconduct by identifying risk factors and planning for prevention. J Am Med Dir Assoc 2012;13:180–186.
3. Wong TC, Wu WC, Cheng HS, et al. Spontaneous fractures in nursing home residents. Hong Kong Med J 2007;13:427–429.
4. Martin-Hunyadi C, Heitz D, Kaltenbach G, et al. Spontaneous insufficiency fractures of long bones: A prospective epidemiological survey in nursing home subjects. Arch Gerontol Geriatr 2000;31:207–214.
5. Kane RS, Goodwin JS. Spontaneous fractures of the long bones in nursing home patients. Am J Med 1991;90:263–266.
6. Miller PR, Glazer DA. Spontaneous fractures in the brain-crippled, bedridden patient. Clin Orthop Relat Res 1976;120:134–137.
7. Takamoto S, Saeki S, Yabumoto Y, et al. Spontaneous fractures of long bones associated with joint contractures in bedridden elderly inpatients: Clinical features and outcome. J Am Geriatr Soc 2005;53:1439–1441.
8. Sherman FT. "Transfer" and "turning" fractures in nursing home patients. Am J Med 1991;91:668–669.
9. Wagner LM, Clevenger C. Contractures in nursing home residents. J Am Med Dir Assoc 2010;11:94–99.
10. Offenbächer M, Sauer S, Rieß J, et al. Contractures with special reference in elderly: Definition and risk factors: A systematic review with practical implications. Disabil Rehabil 2014;36:529–538.
11. Dehail P, Simon O, Godard AL, et al. Acquired deforming hypertonia and contractures in elderly subjects: Definition and prevalence in geriatric institutions (ADH survey). Ann Phys Rehabil Med 2014;57:11–23.
12. Hospital Authority General Infirmary Service. Available at: http://www.ha.org.hk/haho/ho/cs/v3/serviceguide_gis-en.htm. Accessed May 20, 2016.
13. Social Welfare Department of the Government of the Hong Kong Special Administrative Region: Services for the Elderly. Available at: http://www.swd.gov.hk/en/index/site_pubsvc/page_elderly/. Accessed May 20, 2016.
14. Hagen C, Durham P. "Levels of cognitive functioning". In: Professional Staff Association of Rancho Los Amigos Hospital, editor. Rehabilitation of the Head Injured Adult: Comprehensive Physical Management. Downey, CA: Rancho Los Amigos Hospital; 1987.
15. Bohannon RW, Smith MB. Interrater reliability of a modified Ashworth scale of muscle spasticity. Phys Ther 1987;67:206–207.
16. Firth D. Bias Reduction of maximum likelihood estimates. Biometrika 1993;80:27–38.
17. Heinze G, Schemper M. A solution to the problem of monotone likelihood in Cox regression. Biometrics 2001;57:114–119.
18. Girman CJ, Chandler JM, Zimmerman SI, et al. Prediction of fracture in nursing home residents. J Am Geriatr Soc 2002;50:1341–1347.
19. Chen JS, Sambrook PN, Simpson JM, et al. Risk factors for hip fracture among institutionalised older people. Age Ageing 2009;38:429–434.
20. Colón-Emeric CS, Biggs DP, Schenck AP, Lyles KW. Risk factors for hip fracture in skilled nursing facilities: Who should be evaluated? Osteoporos Int 2003;14:484–489.
21. Khatib R, Santesso N, Pickard L, et al. Fracture risk in long term care: A systematic review and meta-analysis of prospective observational studies. BMC Geriatr 2014;14:130.
22. Rockwood K, Song X, MacKnight C, et al. A global clinical measure of fitness and frailty in elderly people. CMAJ 2005;173:489–495.
23. Lam K, Lau KK, So KK, et al. Can botulinum toxin decrease carer burden in long term care residents with upper limb spasticity? A randomized controlled study. J Am Med Dir Assoc 2012;13:477–484.
24. Lam K, Wong D, Tam CK, et al. Ultrasound and electrical stimulator-guided obturator nerve block with phenol in the treatment of hip adductor spasticity in long-term care patients: A randomized, triple blind, placebo-controlled study. J Am Med Dir Assoc 2015;16:238–246.
25. Epstein S, Defeudis G, Manfrini S, et al, Scientific Committee of the First International Symposium on Diabetes and Bone. Diabetes and disordered bone metabolism (diabetic osteodystrophy): Time for recognition. Osteoporos Int 2016;27:1931–1951.

26. Heilmeier U, Carpenter DR, Patsch JM, et al. Volumetric femoral BMD, bone geometry, and serum sclerostin levels differ between type 2 diabetic postmenopausal women with and without fragility fractures. Osteoporos Int 2015; 26:1283–1293.
27. Viguet-Carrin S, Roux JP, Arlot ME, et al. Contribution of the advanced glycation end product pentosidine and of maturation of type I collagen to compressive biomechanical properties of human lumbar vertebrae. Bone 2006;39: 1073–1079.
28. Napoli N, Strotmeyer ES, Ensrud KE, et al. Fracture risk in diabetic elderly men: The MrOS study. Diabetologia 2014;57:2057–2065.
29. Broe KE, Hannan MT, Kiely DK, et al. Predicting fractures using bone mineral density: A prospective study of long-term care residents. Osteoporos Int 2000; 11:765–771.
30. Holvik K, Ahmed LA, Forsmo S, et al. Low serum levels of 25-hydroxyvitamin D predict hip fracture in the elderly: A NOREPOS study. J Clin Endocrinol Metab 2013;98:3341–3350.