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Functional Improvement in Geriatric Hip Fractures: Does Vitamin D Deficiency Affect the Functional Outcome of Patients With Surgically Treated Intertrochanteric Hip Fractures

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Abstract

Introduction: The "Integrated Care Pathway" for geriatric intertrochanteric (IT) fractures in Singapore's Tan Tock Seng Hospital has shown significant functional recovery in patients' activities of daily living. However, the influence of preoperative vitamin D on functional recovery remains equivocal. This retrospective study therefore aims to determine whether patients with preoperative vitamin D deficiency have poorer functional outcomes. **Method:** A total of 171 patients who had surgical treatment for IT fractures were recruited in the study. They were categorized into group A (vitamin D deficient) and group B (normal vitamin D). Charlson Comorbidity Index (CCI) score and nutritional parameters including hemoglobin, albumin, and adjusted calcium levels on admission were recorded. The Modified Barthel Index (MBI) score was used to measure functional recovery at the following time intervals: at pre-fall, at discharge after surgery, at 6 months, and at 1-year follow-up. **Results:** The mean age of both the groups (A: 79.7 years, n = 45; B: 83.0 years, n = 126) was statistically different ($P < .05$). However, the mean CCI (A: 9.42 and B: 10.13), hemoglobin (A: 12.4 and B 11.1), adjusted calcium (A: 2.39 and B: 2.38), and mean albumin (A: 33.6 and B: 33.0) of the groups were not significantly different. Furthermore, the MBI scores were not significantly different for both groups at preinjury (A: 91.5 and B: 89.4), at discharge (A: 55.2 and B: 58.9), at 6 months (A: 70.9 and B: 75.1), and at 1 year (A: 75.8 and B: 79.4). **Conclusion:** In our cohort, patients with vitamin D deficiency were younger. However, vitamin D deficiency at time of injury had no significant influence on functional recovery in patients with surgically treated hip fracture in our Integrated Care Pathway. In addition, patients who had a normal vitamin D levels had similar functional scores and improvement postoperatively and at 1 year (A: 82.8% and B: 88.9%).

Keywords

systems of care, trauma surgery, osteoporosis, fragility fractures, geriatric trauma

Introduction

From 2012 to 2013, it was estimated that 7.4% of Singapore's population had progressed to above 65 years old and this number has been on the rise.[1] This can be attributed to the country's increasingly efficient health care system and life expectancy rates of 80.2 to 84.6 years.[1] Similar demographic shifts have been seen in other parts of Asia, Africa, and South America.[2]

The rise in the geriatric population has led to an increased incidence of fragility fractures, particularly hip fractures. This

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is linked to the physiological aging process of the bone, during which both bone mass and its capacity for healing diminishes and, if pronounced, progresses to osteoporosis. Recently, more attention has been paid to vitamin D levels as a modifiable risk factor for prevention of fracture.

Vitamin D is essential for bone health and muscle function and plays an important role in primary prevention of falls and fractures in the elderly population. 1,25-Dihydroxyvitamin D binds to vitamin D-specific nuclear receptors in muscle tissue that facilitates protein synthesis, promotes muscle cell growth, and improves muscle function.[3] It has been shown that performance speed and proximal muscle strength have a positive correlation with serum vitamin D levels and can potentially reduce the risk of falls by 22% in the geriatric population.[4]

However, to date, there remains limited evidence on the effects of vitamin D levels on functional recovery in our geriatric population after sustaining a hip fracture. In this context, we aim to investigate the significance of vitamin D levels on postoperative functional recovery using outcomes of our geriatric patients with intertrochanteric (IT) fractures who were treated with surgical fixation.

Method

Study Design and Study Population

All patients included in this study were part of the "Integrated Care Pathway" for geriatric IT fractures in Singapore's Tan Tock Seng Hospital (TTSH). The principles of this program include (a) timely admission, review, surgery, rehabilitation, and transfer (ARSRT); (b) a multidisciplinary approach (including the integration of a geriatrician in the comanagement with specialized nursing and rehabilitation support staff); and (c) the integration of a care manager. These 3 features are the fundamental pillars of our care pathway model with the goals of achieving the earliest possible surgical intervention, minimizing acquired complications, and maximizing rehabilitation efforts to restore preinjury functional status. This was modeled after the Tyrolean orthogeriatric comanagement model.[5]

As part of the Integrated Care Pathway, all patients, regardless of their vitamin D levels, received calcium (900 mg) and vitamin D (400 IU) supplementation, unless contraindicated. Compliance was emphasized during the first year of regular follow-up of all patients with hip fractures.

Records of geriatric patients with hip fracture between 2011 and 2012 were retrieved from TTSH's orthopedic department via the Cluster Patients Records System and Computerized Patient Support System databases. The eligibility criteria were as follows: patients would (1) have to be 60 years or older, in tandem with the definition of geriatric,[6] (2) have been admitted for hip fractures verified by radiologic scans, (3) need to have preoperative 25-OH vitamin D values, (4) need to have had specifically IT fractures, and (5) have been treated with surgical internal fixation alone.

Data Collection

Data were collected and tabulated in Microsoft Excel by 2 independent reviewers. The consensus reached beforehand was to record preoperative laboratory values of the independent variable 25-hydroxyvitamin D (vitamin D), bone mineral density (BMD) scores, and the nutritional parameters such as hemoglobin, albumin, and adjusted calcium. An attempt to measure serial vitamin D levels was made to determine the efficacy of calcium and vitamin D supplementation. Alongside this, relevant preoperative medical history, as outlined by the Charlson's Comorbidity Index (CCI), was collected.

Since there are no universally accepted guidelines for grading callus formation, determining the rate of healing by comparing serial X-ray films, though attempted, was difficult. The use of composite assessment scores has become a standard of outcome reporting and has been used for both research and clinical evaluation for decades. As such, we employed the Modified Barthel Index (MBI) as a measure of functional outcome and rate of healing. Patients' functional outcomes (the dependent variable) were ascertained via telephone or follow-up clinic visits at the time of discharge and the intervening 6-month and 12-month periods. The MBI includes parameters of muscle strength, for example, transfers, mobility and stair climbing, as well as parameters regarding the general functional well-being, for example, feeding and continence (see Figure 1 for the Barthel Index components).[7] Wherever possible, patients themselves were surveyed to maintain the accuracy of information. However, dealing with a primarily geriatric population meant the inclusion of proxies for communication like first-degree relatives and caregivers.

Statistical Analysis

The cohort was classified into 2 groups—population group A (vitamin D deficient) and group B (normal vitamin D). Although there is no consensus on the optimal level of serum 25-OH vitamin D, most experts define vitamin D deficiency as less than 20 ng/mL.[4] We thus characterized group A as having 20 ng/mL or less and group B as having 20 to 50 ng/mL of 25-OH vitamin D, 50 ng/mL being our upper limit.

Age, nutritional parameters, BMD scores, and CCI were identified as possible confounders to functional recovery and MBI scores. As such, the means of these parameters were compared between group A and group B using a t test.

Results

Cohort Size and Characteristics

Between 2011 and 2012, there were 210 patients who sustained an IT fracture with a mean age of 82.1 (range 62-108). Patients who were managed conservatively and were not successfully followed up for 1 year were excluded from the study. The cohort size that remained for statistical analysis was 171 patients with IT fracture with a mean age of 80.3 (range 62-108). After grouping according to vitamin D levels, we

Barthel Index Activity	Score
FEEDING 0 = unable 5 = needs help cutting, spreading butter, etc., or requires modified diet 10 = independent	
BATHING 0 = dependent 5 = independent (or in shower)	
GROOMING 0 = needs to help with personal care 5 = independent face/hair/teeth/shaving (implements provided)	
DRESSING 0 = dependent 5 = needs help but can do about half unaided 10 = independent (including buttons, zips, laces, etc.)	
BOWELS 0 = incontinent (or needs to be given enemas) 5 = occasional accident 10 = continent	
BLADDER 0 = incontinent, or catheterized and unable to manage alone 5 = occasional accident 10 = continent	
TOILET USE 0 = dependent 5 = needs some help, but can do something alone 10 = independent (on and off, dressing, wiping)	
TRANSFERS (BED TO CHAIR AND BACK) 0 = unable, no sitting balance 5 = major help (one or two people, physical), can sit 10 = minor help (verbal or physical) 15 = independent	
MOBILITY (ON LEVEL SURFACES) 0 = immobile or < 50 yards 5 = wheelchair independent, including corners, > 50 yards 10 = walks with help of one person (verbal or physical) > 50 yards 15 = independent (but may use any aid; for example, stick) > 50 yards	
STAIRS 0 = unable 5 = needs help (verbal, physical, carrying aid) 10 = independent	

Figure 1. Barthel Index parameters.[5]

Table 1. Summary of Outcomes of Groups A and B.

Parameters	Group A 45	Group B 126	*P* value
Age	79.7	83	.03
Nutritional parameters			
Hemoglobin	12.4	11.1	.06
Albumin	33.6	33	.38
Adjusted calcium	2.39	2.38	.39
Bone Mineral Density (BMD)			
Proximal femur	−3.15	−3.06	.49
Lumbar spine	−2.15	−1.9	.45
Charlson Comorbidity Index (CCI)	9.42	10.13	.13
Modified Barthel Index			
Premorbid	91.5	89.4	.4
Discharge	55.2	58.9	.13
6 months	70.9	75.1	.22
12 months	75.8	79.4	.32

were left with 45 and 126 patients in group A and group B, respectively.

The mean ages of the 2 groups A and B, A: 79.7 years, n = 45 and B: 83.0 years, n = 126, were statistically different. The mean hemoglobin (A: 12.4 and B: 11.1), adjusted calcium (A: 2.39 and B: 2.38), albumin (A: 33.6 and B: 33.0), BMD (Proximal Femur A:−3.15, B: −3.06; Lumbar Spine A:−2.15, B: −1.90), and CCI (A: 9.42 and B: 10.13) however, were not, thereby negating nutrition and mortality scores as confounders in this study (see Table 1). In all, 36% of patients in group A were using a walking aid compared to 39% in group B.

Modified Barthel Index and Vitamin D Deficiency

Modified Barthel Index scores were taken at discharge, 6 months, and 1 year after discharge. The mean MBI scores were at

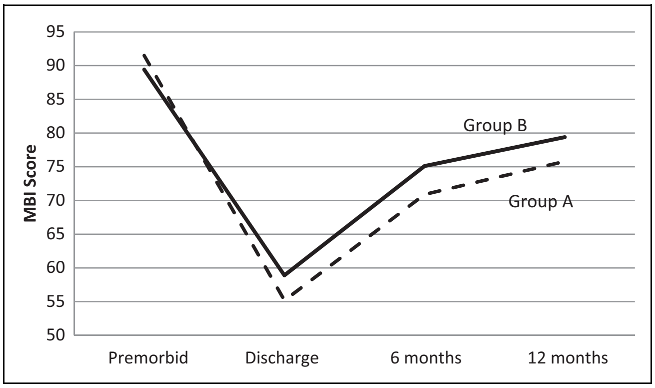

Figure 2. Trended Modified Barthel Index (MBI) scores of group A (vitamin-D Deficient) and group B (Normal vitamin D) at follow-up.

preinjury (A: 91.5 and B: 89.4), at discharge (A: 55.2 and B: 58.9), at 6 months (A: 70.9 and B: 75.1), and at 12 months (A: 75.8, B: 79.4). The average monthly rate of functional improvement for the 2 groups were not statistically different, 0 to 6 months: A = 2.62 and B = 2.70; 6 to 12 months: A = 0.82 and B = 0.72.

X-rays were also reviewed to determine evidence of callus formation and union. All our patients in the cohort displayed qualitative evidence of callus formation on serial X-rays.

An attempt was made to tabulate serial vitamin D levels for all our patients. Only 31% of patients with vitamin D deficiency had vitamin D levels reexamined between 1 and 2 years after treatment for their hip fractures. Of this small group of patients, 57% remained vitamin D deficient while the other 43% had normal vitamin D levels. It was noteworthy that 2 patients who had normal vitamin D levels developed a deficiency after 2 years. These results, however, were not statistically significant in view of the very small sample size.

Discussion

The complexity of hip fracture management cannot be overemphasized. All our patients in this study were managed under a multidisciplinary integrated care path where they had perioperative monitoring from an orthopedic surgeon, geriatrician, and frequent inputs from physiotherapists and occupational therapists which is well established to improve recovery of ambulatory ability.[8] Vitamin D deficiency is highly prevalent in our geriatric population with hip fracture. This is contributed by the fact that aging skin has a decreased ability to form previtamin D3 by up to two-fold when compared to skin from 8 to18 year olds.[9] Thus, all our patients were given vitamin D and calcium supplementation regardless of their preoperative vitamin D and calcium levels if there were no contraindications.

It is interesting to note that despite having vitamin D deficiency, patients in group A had higher premorbid MBI scores compared to group B. Given that the walking aid status, nutritional and biochemical parameters were not statistically different, we attribute the higher premorbid functional status of vitamin D-deficient patients to age (see Figure 2).

Postinjury, patients with vitamin D deficiency had poorer MBI scores throughout all phases of recovery though not statistically significant (see Figure 2). We suspect that calcium and vitamin D supplementation may have contributed to these results by masking the natural history of vitamin D deficiency on functional outcomes. However, one might infer from this that even after patients with vitamin D deficiency sustain a fracture, calcium and vitamin D supplementation may render them an equally good outcome as patients with normal vitamin D levels.

Vitamin D deficiency is known to manifest as muscle weakness and myalgia and affect functional recovery.[4,10] Pfeifer et al demonstrated that the calcium and vitamin D supplementation led to a significant reduction in body sway, measured by sagittal diameter.[11] Dhesi et al also demonstrated in an observational study that vitamin D deficiency was a significant independent variable for postural stability and psychomotor function measure via choice reaction time.[12] Furthermore, performance speed and proximal muscle strength have also been shown to correlate with serum vitamin D levels.[4] Intuitively, one might expect that patients with normal vitamin D may therefore have a more significant improvement. However, this was not seen in our study. Bartoszewska et al showed that the effects of vitamin D on muscle weakness were reversible with calcium and vitamin D supplmentation.[13] This, apart from fracture healing, could explain why patients in both group A and group B made steady functional improvements as all of them received calcium and vitamin D replacement.

However, it must be emphasized that patients who have previous hip fractures are at 5- to 10-fold increase risk of a second hip fracture.[14] Patients with successfully treated hip fractures who return to the community however still have a significantly impaired balance, mobility, and quality of life compared to controls, and many of them do not return to their prefracture lifestyle.[15] Thus, the role of continued vitamin D supplementation is imperative in reducing the risk of recurrent falls in these patients with previous hip fractures.[2]

It is also interesting to note that group B (nondeficient) was significantly older (mean age of 83 years). Though they had a lower preinjury Barthel score when compared to the younger group A (vitamin D deficient), their recovery postoperatively was equal based on Barthel scores at discharge, 6 months, and 1 year and were able to achieve 88.9% of their premorbid scores at 1 year compared to 82.8% in group A. This thus supports the fact that age is not a factor that influences functional outcome as corroborated by other local studies.[16]

Our results, though limited, suggest that a proportion of our vitamin D-deficient patients remained deficient, despite calcium and vitamin D supplementation according to the Integrated Care Pathway. Perhaps the dosages given were subtherapeutic to many of our patients and could have been optimized to facilitate their functional recovery further. However, this result was only based on a very small sample size.

Our data also hinted that vitamin D deficiency is dynamic in that patients who were previously deficient recovered, and patients who had normal vitamin D levels developed a deficiency posthip fracture. Many hypotheses can be made to explain this. For example, Jingushi et al demonstrated a drop in plasma concentration of vitamin D levels between day 3 to day 10 after the fracture largely due to an increase in vitamin D consumption, especially at the callus of healing bone as demonstrated by isotopic autoradiography.[17] Although we are unable to draw any definitive conclusions from this preliminary data, this would be interesting to explore further in subsequent studies.

Conclusion

Our results suggest that geriatric patients with surgically treated IT hip fractures and vitamin D deficiency have as good a recovery as patients with normal vitamin D levels under our Integrated Care Pathway.

Limitations

The biggest limitation in this retrospective study is that all patients were given calcium and vitamin D supplementation. Thus, the natural history of vitamin D deficiency on functional outcomes may very well have been masked. We would like to suggest that a more definitive way of determining whether vitamin D deficiency affects the functional outcome of patients with surgically treated IT hip fractures would be to conduct a prospective study of a similar design but withholding calcium and vitamin D supplementation in group A. This, however, may not be ethically feasible.

Another limitation of this study is the fact that our Integrated Care Pathway did not include serial vitamin D level measurements to check whether vitamin D deficiency resolved in our patients. A subgroup analysis of patients with vitamin D deficiency who responded to treatment versus those who remained vitamin D deficient may have been more appropriate in determining the effects of vitamin D deficiency on functional outcome.

Although the MBI scores are useful in holistically determining the quality of life through the activity of daily living, its use in measuring hip function is perhaps limited, as it only includes measurements such as walking, transfers, and stair climbing. The other measurements are only indirectly associated with hip function such as toilet use, showering, and dressing. Other indices of functional outcome such as the Time-up and Go (TUG) test as a measure of mobility and balance as well as the Western Ontario and McMaster Universities Arthritis (WOMAC) Index could have also been used.

A subgroup analysis comparing vitamin D levels with quantitative measurements of callus formation would have been interesting to explore but was beyond the scope of this article. Further categorization of the cohort into the type of IT fracture (i.e., 2-part, 3-part, reverse oblique, etc) and type of fixation (Dynamic hip screw vs Proximal Femoral Nail Anti-rotation) for a direct comparison was also initially considered, but the numbers were too small for significant analysis.

Authors' Note

All procedures followed were in accordance with ethical standards.

Declaration of Conflicting Interests

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