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ORIGINAL STUDY

Vitamin D deficiency in orthopaedic patients
A single center analysis

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Vitamin D is essential to bone health and is a major regulator of calcium homeostasis. Many recent reports demonstrated worldwide high rates of vitamin D deficiency, but few studies have been published on the vitamin D status of orthopaedic patients. The present study aimed to investigate the extent of hypovitaminosis D of orthopaedic patients and possible variations in vitamin D status according to the body region which was scheduled to undergo surgery.

We measured the vitamin D level of 1119 patients consecutively admitted to an orthopaedic surgery department of a university hospital in Germany in 2011. The prevalence of normal (≤ 30 ng/ml), insufficient (20-30 ng/ml) and deficient (≤ 20 ng/ml) 25-OH-D levels was determined. Serum Vitamin D levels and rates of insufficiency and deficiency were compared between the different cohorts using two-tailed tests. The level of significance was set at $p \leq 0.05$.

The serum 25-OH-D levels for all participants were normally distributed, with a mean of 20.57 ng/ml. Overall, we noted an alarmingly high rate of vitamin D insufficiency or deficiency among orthopaedic patients. No significant difference was found related with the various body regions scheduled to undergo surgery.

Given the well-known effects of vitamin D on bone metabolism and muscle health, vitamin D insufficiency may negatively affect patients.

Keywords : hypovitaminosis D ; vitamin D deficiency ; orthopaedic patients ; vitamin D.

INTRODUCTION

Vitamin D is essential to bone health and is a major regulator of calcium status (*17*). Inadequate low serum or plasma level of 25-hydroxyvitamin D (25-OH-D) leads not only to rickets, osteoporosis and osteomalacia, but, as several recent studies suggest, may also increase the risk of type 2 diabetes (*18*), cardiovascular disease (*8*) and mental illness (*20*). However, a causal relationship has not been established yet for most diseases. The relationship between Vitamin D and bone health is strong. Understanding

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the direct and indirect actions of the vitamin on bone is complex (*2*). Most impressive is the healing of rickets by a treatment with vitamin D (*25*). Defining the optimal level of 25-OH-D to maintain bone health is still in discussion, but a 25-OH-D level of around 30 ng/ml is widely accepted as safe and effective (*2*). Several studies showed an epidemic worldwide spread of vitamin D deficiency (*21*). An estimated 1 billion people worldwide do not reach a 25-OH-D level of 30 ng/ml, and are therefore at risk for osteomalacia (*28*). Not only the elderly are at risk for hypovitaminosis D. Several studies showed high rates of vitamin D deficiency in young and healthy cohorts. In a Northern Irish study, up to 36% of healthy adolescents were vitamin D deficient (*10*). Fifty-two percent of black and Hispanic adolescents in Boston were found to be vitamin D deficient (*6*). Despite the multitude of studies concerning the prevalence of hypovitaminosis D in the general population (*6,21,25,26,28*) or in special subgroups (*12, 18,20,27*), there is only one study focusing on hypovitaminosis D in adult orthopaedic surgery patients, irrespective of sex and age (*4*). Bogunovic *et al* demonstrated in their study of 723 orthopaedic patients a prevalence of up to 66% of abnormal (insufficient or deficient) 25-OH-D levels. They also identified patients with dark skin tone to be at higher risk for hypovitaminosis D than those with lighter skin tones. Given the critical role of vitamin D in bone health and muscular function, data revealing the prevalence of vitamin D deficiency in European orthopaedic patients may be of value.

The purpose of this observational study was to assess the extent of vitamin D deficiency and insufficiency among orthopaedic surgery patients of all ages. We hypothesized that rates of vitamin D would vary according to the body region scheduled to undergo surgery, as well as between patients receiving joint prosthesis and other patients. Furthermore we tried to demonstrate a possible correlation between patient´s medication history and a low vitamin D level.

PATIENTS AND METHODS

In the year 2011 the serum 25-OH-D levels of every patient consecutively admitted to the Orthopaedic Department of the Johannes-Gutenberg-University Hospital in Mainz, Germany (in total 1119 patients) was measured after admission. The city of Mainz is located at 50° northern latitude, comparable to cities like Paris, Vancouver or Kiev. Blood was generally taken on the day of admission. Patients from the following orthopaedic sections were included in the study : elbow/shoulder, hip, knee, foot/ankle, spine and bone tumour.

Measurement of serum 25-0H-D was standardized, the hospital laboratory used the ARCHITECT 25-OH Vitamin D assay (Fa Abbott Laboratories, Germany). Laboratory results were collected by means of a retrospective chart review.

Patient demographic variables and background data were collected by means of a chart review of patient records.

As yet there is no universally accepted classification of vitamin D levels. We defined sufficient vitamin D status as a serum 25-OH-D level of above 30 ng/ml. Vitamin D inadequacy was defined as a serum 25-OH-D level of under 30 ng/ml and was further divided into vitamin D insufficiency (20 to 30 ng/ml) and vitamin D deficiency (under 20 ng/ml) as described previously (*13,24*).

All patients with valid 25-OH-D measurement were included in the statistical analysis. The distribution of 25-OH-D and the percentages of patients with insufficient (20 to 30 ng/ml) and deficient (under 20 ng/ml) 25-OH-D level were determined for each individual service.

Serum Vitamin D levels and rates of insufficiency and deficiency were compared between the different cohorts using two-tailed tests. The level of significance was set at $p \leq 0{,}05$.

To determine if there is a correlation between the different pain medications the patients received and hypovitaminosis D multivariate analysis, using the vitamin D level as a continuous variable, was performed. The medication had at least to be taken for the last 3 months before measurement of serum vitamin D level. All collected medications (proton pump inhibitors, acetylsalicylic acid, metamizole, diclofenac, iso-butyl-propanoic-phenolic acid, N-acetyl-p-aminophenol, indomethacin) were included. The level of significance was set at $p \leq 0.05$.

RESULTS

A total of 1119 patients participated in this study, of which 56.4% were women, 43.5% men. Ages ranged from 6 to 97 years, with a mean age of 58 years.

Table I. — Multivariate Analyses of potential risk factors for vitamin D insufficiency and deficiency in relation with drug consumption

	Mean Vitamin D Level (ng/ml)	Significance (P)	95% Confidence Interval
Proton pump inhibitors (n = 659)	16.6 (+/-9.4)	0.257	9.27 to 23.28
Acetylsalicylic acid (n = 140)	17.0 (+/-11.3)	0.746	10.1 to 24
Metamizole (n = 365)	16.5 (+/-9.7)	0.097	9.58 to 23.38
Diclofenac (n = 284)	17.4 (+/-13.9)	0.749	10.46 to 24.4
Iso-butyl-propanoic-phenolic acid (n = 71)	18.2 (+/-10.7)	0.261	10.94 to 24.1
N-acetyl-p-aminophenol (n = 312)	17.3 (+/-10.3)	0.982	10.36 to 24.2
Indomethacin (n = 449)	15.6 (+/-11.3)	0.456	5.82 to 25.52

The body region-specific patient census was as follows : 286 patients (25.5% of all patients) were scheduled to undergo back surgery (spondylodesis or kyphoplasty). 242 (21.6%) presented for knee surgery, 167 (14.9%) foot and ankle, 165 (14.7) hip, 143 (12.7%) shoulder and elbow. 116 (10.3%) patients were scheduled to undergo cancer associated surgery of different body regions.

The serum 25-OH-D levels for all participants were normally distributed, with a mean of 17.3 ng/ml. Lowest measured level was <8 ng/ml, highest measured level was 78.5 ng/ml. Statistical analyses failed to disclose any relationship between vitamin D level and body region scheduled to undergo surgery. All tested patient subgroups showed low vitamin D levels.

Multivariate analyses showed no significant correlation between medication history and hypovitaminosis D (Table I).

DISCUSSION

In this sample of 1119 consecutive patients admitted to the orthopaedic department of a university hospital between January 2011 and January 2012, 25-OH-D levels were low in every subgroup, with an overall high prevalence of severe vitamin D deficiency, irrespective of the body region scheduled to undergo surgery. None of the tested subgroups reached a sufficient mean level of serum 25-OH-D. Our findings indicate a high prevalence of low vitamin D levels and widespread vitamin D insufficiency in orthopaedic patients. These results are consistent with those of similar studies investigating the prevalence of vitamin D deficiency in trauma patients and other population subgroups. Schilling demonstrated a prevalence of hypovitaminosis D in nearly 90% of all tested patients in a geriatric department (*26*). Bee *et al* showed in their study of patients undergoing fracture repair a high rate of vitamin D insufficiency in winter (71%) as well as in summer time (62%) (*1*).

Extremely low vitamin D levels have been associated with osteomalacia and impaired muscle function (*14*). Lips suggested vitamin D deficiency to play a role in the development of osteoporosis due to the induction of a secondary hyperparathyroidism, mobilizing calcium from the bone (*16*). In 3270 elderly French women living in nursing homes, the daily supplementation of vitamin D and calcium reduced the number of hip fractures by 23% and normalized bone turnover markers by 28% after 3 years (*5*). LeBoff *et al* documented a more than 50% prevalence of vitamin D deficiency among postmenopausal women with acute hip fracture (*15*). Several studies confirmed this high rate of vitamin D deficiency among hip fracture patients (*3*). Our results confirm a high prevalence of hypovitaminosis D in orthopaedic patients scheduled to undergo surgery of the hip. Furthermore, we showed that hypovitaminosis D is not correlated with orthopaedic problems in specific body regions. Hypovitaminosis D is seen in orthopaedic patients no matter which anatomic region is scheduled to undergo surgery.

Vitamin D deficiency has been shown to be associated with skeletal muscle myopathy (presenting as a proximal muscle weakness) in subjects of various ages, and body sway in osteoporotic and

fall-prone subjects (*7,23*). Improvement of serum 25-OH-D level to sufficient levels reversed the myopathy in tested patients (*30*). In 242 community-dwelling seniors receiving calcium and vitamin D supplementation, Pfeifer *et al* showed a significant decrease in the number of subjects with first falls. Significant improvements in quadriceps strength of 8%, a decrease in body sway of 28%, and a decrease in time needed to perform the „Time up and go" test of 11% were observed compared to patients without vitamin D supplementation. Combined calcium and vitamin D supplementation proved superior to calcium alone in reducing the number of falls and improving muscle function in community-dwelling older individuals (*23*).

Good muscle function and healthy bones, as well as analgesia, are essential for fast rehabilitation and positive outcome after orthopaedic surgery.

Musculoskeletal pain is one of the most common reasons for consultation of orthopaedic primary care or for negative outcome after orthopaedic surgery. Although vitamin D-related pain is not well understood, several studies have shown associations between vitamin D status and pain (*11,19*). Hirani showed in his study that symptoms of moderate/severe pain were associated with poor vitamin D status. Nationwide 2070 British adults were asked for their current symptoms of pain and their 25-OH-D level was taken. Findings from this study were consistent with former studies in which increased symptoms of pain were seen in severe vitamin D deficiency state. Another British study showed that patients with chronic widespread pain had a moderately increased odd of low serum vitamin D (*19,29*).

In a Thai study of 6 men and 3 women who had failed back surgery syndrome after lumbar surgery, all patients had deficient serum vitamin D levels. Vitamin D was given to improve serum levels. Six months after vitamin D supplementation the mean serum level improved significantly, as did the mean pain score and the mean JOA (Japanese Orthopaedic Association) score. The authors concluded that vitamin D may be used as an adjuvant treatment for patients with failed back surgery syndrome (*29*).

This study has several limitations. The majority of the tested patients in this study had white skin tones. Given the predisposition of darker skin-toned individuals toward lower 25-OH-D levels, hypovitaminosis D among darker skin-toned orthopaedic patients may be underrepresented in this study Furthermore, the geographical localisation of Mainz (50° northern latitude) limits our results to regions around this latitude (e.g. Paris 48°51' N, Vancouver (49°15' N), Calgary (51°3' N) or Kiev (50°27') or above 50° latitude.

In conclusion, findings from this study may alert orthopaedic surgeons to the widespread deficiency of vitamin D in their patients. Given the possible negative effects of hypovitaminosis D, our data suggests a possible way to improve the outcome after orthopaedic surgery by supplementing vitamin D. Data are yet insufficient to support this hypothesis, further studies are needed to examine whether correction of hypovitaminosis D positively affects the outcome after orthopaedic surgery. Nevertheless, heightened awareness is necessary, especially as vitamin D deficiency is preventable.

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