

Serum vitamin D levels among patients in a clinical oncology practice compared to primary care patients in the same community: a case–control study

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ABSTRACT

Objectives: Low serum vitamin D levels have been associated with risk for certain malignancies, but studies have not directly analysed levels between community oncology and primary care practices. The purpose of this study was to compare serum vitamin D levels in patients at a community oncology practice with non-cancer patients at a primary care practice.

Design: Retrospective case–control study. 25-Hydroxyvitamin D levels were ordered for screening in both cancer and non-cancer patients. Levels were compared in univariate and multivariate analyses adjusted for age, body mass index and season of blood draw.

Setting: A community-based radiation oncology centre and a community-based primary care practice: both located in Northeastern Pennsylvania, USA.

Participants: 170 newly diagnosed cancer patients referred for initial consultation at the community oncology centre from 21 November 2008 to 18 May 2010, and 170 non-cancer patients of the primary care practice who underwent screening for hypovitaminosis D for the first time from 1 January 2009 to 31 December 2009.

Primary and secondary outcome measures: The primary outcome measure was mean serum vitamin D level, and the secondary outcome measures were frequencies of patients with vitamin D levels <20 ng/ml and levels <30 ng/ml.

Results: The oncology patients had a significantly lower mean serum vitamin D level (24.9 ng/ml) relative to a cohort of non-cancer primary care patients (30.6 ng/ml, $p<0.001$) from the same geographical region. The relationship retained significance after adjustment for age, body mass index and season of blood draw in multivariate analysis ($p=0.001$). Levels <20 and <30 ng/ml were more frequent in the oncology patients (OR (95% CI)=2.59 (1.44 to 4.67) and 2.04 (1.20 to 3.46), respectively) in multivariate analysis.

Conclusions: Cancer patients were found to have low vitamin D levels relative to a similar cohort of non-cancer primary care patients from the same geographical region.

ARTICLE SUMMARY

Article focus

- Our study sought to analyse vitamin D levels in large outpatient oncology and primary care centres.

Key messages

- Multiple levels of evidence suggest an association between low vitamin D and cancer.
- Our findings of low vitamin D among the oncology patients add practical relevance to this association since we analysed patients at community clinics.
- Providers caring for cancer patients should be aware of an increased incidence of hypovitaminosis D at the community level.

Strengths and limitations

- Limitations include a relatively small sample size, lack of data on comorbid conditions of the primary care group, lack of data on vitamin D measurement and lack of data on supplementation or treatment that may have affected vitamin D levels.
- Strengths include a community-based sample in both primary care and oncology patients and control of age, body mass index, latitude, time and season of blood draw and geographical region of both patient groups.

INTRODUCTION

Vitamin D, obtained through the diet, supplementation and sunlight, is converted to 25-hydroxyvitamin D in the liver.¹ 25-Hydroxyvitamin D is the major circulating form of vitamin D and undergoes hydroxylation in the kidney to 1,25-dihydroxyvitamin D, the most active metabolite.¹ Production of 1,25-dihydroxyvitamin D is tightly regulated by the parathyroid glands in response to calcium.¹ Levels of 25-hydroxyvitamin D are

relatively stable and can be measured to determine the vitamin D status of a patient.¹ However, the definition of normal circulating vitamin D levels is debatable.^{1–2} Values <20 ng/ml have been traditionally considered deficient (in accordance with the latest Institute of Medicine guidelines), whereas values <30 ng/ml have been suggested to be suboptimal.^{1–7}

Non-skeletal actions of vitamin D have gained interest in research, particularly in the field of oncology. Low serum vitamin D levels have been associated with risk for carcinomas of the breast, prostate and colon in epidemiological studies.^{1–8–11} Research dating back to the 1980s has proposed that variations in cancer by latitude may be associated with vitamin D through differences in ultraviolet B exposure.^{12–14} Subsequent laboratory experiments have found that many cell types, in addition to renal and intestinal cells, possess vitamin D receptors and 25-hydroxyvitamin D 1-alpha-hydroxylase, the cellular machinery required to metabolise vitamin D.^{1–9–15–19} In vitro studies have further demonstrated that vitamin D regulates genes involved with cellular proliferation and differentiation.^{1–9–16–20} Taken together, this body of evidence suggests a potential role for vitamin D in the aetiology of cancer.

To date, studies have not directly compared vitamin D levels in community oncology and primary care practices in the same region. Analysing vitamin D levels in this manner may elucidate trends not previously apparent. Therefore, the purpose of this study was to compare vitamin D levels in patients at a community oncology practice with non-cancer patients at a primary care practice.

MATERIALS AND METHODS

The study was a retrospective case–control design, and local institutional review board approval was obtained. The cases (cancer patients) consisted of a consecutive series of patients seen for initial radiation oncology consultation from 21 November 2008 to 18 May 2010 at a community-based oncology centre in Northeastern Pennsylvania, USA. Serum 25-hydroxyvitamin D levels were ordered at the initial visit. Data for the cases were collected through a manual review of medical records. The controls (primary care patients) were a random sample of patients with no history of cancer who were screened for the first time for hypovitaminosis D from 1 January 2009 to 31 December 2009 at a community-based primary care practice in Northeastern Pennsylvania, USA. Data for the controls were obtained by retrieval from an electronic health record. 25-hydroxyvitamin D levels were measured at outpatient laboratory centres, and three major companies were retrospectively identified: two using a chemiluminescent assay and one using an enzyme immunoassay.

MYSTAT 12 (Systat Software Inc., Chicago, Illinois, USA) and StatPlus 2009 Professional 5.8.4 (AnalystSoft Inc., Alexandria, Virginia, USA) were used for statistical analyses with significance defined as $\alpha < 0.05$. Origin 8.5

(OriginLab Corp., Northampton, Massachusetts, USA) was used to generate histograms and best-fit Gaussian distributions. Student t test was performed to compare vitamin D levels between oncology and non-cancer patients. Multiple linear regression was used to adjust the mean difference for age, body mass index (BMI) and season of blood draw. In multiple linear regression, vitamin D levels were set as the dependent variable (continuous), and the independent variables were set as case–control status (dichotomous), age (continuous), BMI (continuous) and season of blood draw (dichotomous). The coefficient for case–control status represented the mean difference in serum vitamin D levels between the oncology and primary care patients, after adjustment for age, BMI and season of blood draw.

The prevalence of vitamin D deficiency (<20 ng/ml) and vitamin D insufficiency (<30 ng/ml) were examined with respect to case–control status by calculating the OR and computing Pearson's χ^2 test. Multiple logistic regression was used to adjust associations for age, BMI and season of blood draw. In multiple logistic regression analyses, frequencies of patients with vitamin D levels less than the cut-off value (20 or 30 ng/ml) were set as the dependent variable (dichotomous) and the independent variables were set as case–control status (dichotomous), age (continuous), BMI (continuous) and season of blood draw (dichotomous). In all multivariate analyses, season of blood draw was adjusted as a dichotomous variable defined as summer months (June, July or August) versus all other months. Patients with missing data were excluded from the multivariate analyses.

RESULTS

One hundred and seventy cancer patients had levels drawn within 6 months of consultation at the community radiation oncology centre. The most common primary cancer sites were as follows: breast (40), prostate (35), thyroid (25) and lung (12). The distribution of the American Joint Committee on Cancer (AJCC) stages of cancer was as follows: stage 0 (6), stage I (47), stage II (52), stage III (32), stage IV (25) and unknown stage (8). One hundred and seventy non-cancer patients screened for hypovitaminosis D for the first time had vitamin D levels drawn at a large, community-based primary care practice. The baseline patient characteristics are outlined in [table 1](#). The cancer patients were an average of 6.8 years older ($p < 0.001$), but both groups had a similar mean BMI ($p = 0.637$). The frequency distribution of vitamin D levels in the primary care and oncology groups is shown in [figure 1](#).

The cancer patients had a significantly lower mean serum vitamin D level, and this relationship retained significance after adjustment for age, BMI and season of blood draw. [Table 1](#) outlines the unadjusted mean values and adjusted mean difference of serum vitamin D levels between cancer and non-cancer patients. The primary care patients had a mean serum vitamin D level of 30.6 ng/ml, while the cancer patients had a mean serum

Table 1 Baseline patient characteristics and serum vitamin D levels in oncology patients and non-cancer primary care patients

	Oncology	Primary care	p Value	OR (95% CI)*
Sample size (n)	170	170	—	—
Age (±SD), years	63.3 (±14.8)	56.5 (±16.3)	<0.001	—
BMI (±SD), kg/m ²	29.3 (±7.1)†	28.9 (±5.8)	0.637	—
Blood drawn in summer months, count (%)	44 (25.9)	31 (18.2)	0.089	—
Vitamin D levels				
Mean (SD), ng/ml	24.9 (11.4)	30.6 (12.5)	<0.001‡	—
Adjusted mean difference, ng/ml	5.4		0.001§	—
Patients <30 ng/ml, count (%)	126 (74)	94 (55)	0.008*	2.04 (1.20 to 3.46)
Patients <20 ng/ml, count (%)	56 (33)	29 (17)	0.002*	2.59 (1.44 to 4.67)

BMI, body mass index.

*Multiple logistic regression adjusted for age, BMI and season of blood draw.

†BMI for cancer patients was based on data of 110 patients.

‡Student t test.

§Multiple linear regression adjusted for age, BMI and season of blood draw.

vitamin D level of 24.9 ng/ml ($p < 0.001$). After adjustment for age, BMI and season of blood draw, the mean difference in serum vitamin D levels was 5.4 ng/ml ($p = 0.001$).

Vitamin D deficiency, defined as < 20 ng/ml, was more common in the oncology practice (OR (95% CI) = 2.39 (1.43 to 3.99), $p = 0.001$); vitamin D insufficiency, defined as < 30 ng/ml, was also more common in the oncology practice (OR (95% CI) = 2.32 (1.47 to 3.66), $p < 0.001$). The relationships retained significance in multivariate analysis after correction for age, BMI and season of blood draw, as shown in table 1. Vitamin D deficiency and vitamin D insufficiency were more common in the oncology patients in multivariate analysis (OR (95% CI) = 2.59 (1.44 to 4.67) and 2.04 (1.20 to 3.46), respectively).

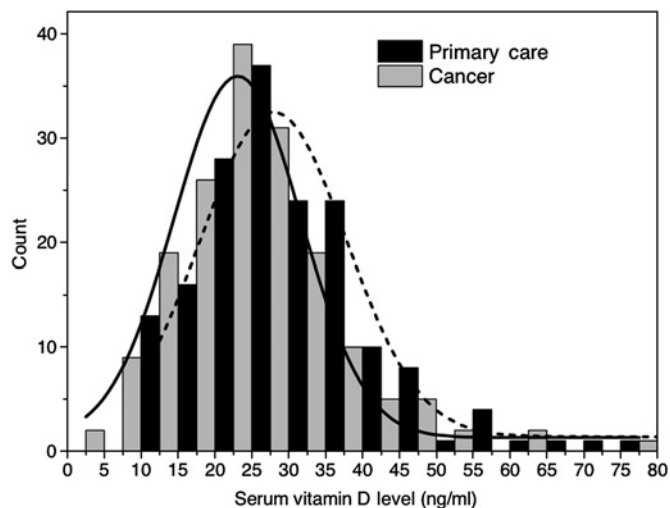


Figure 1 Frequency distribution of 25-hydroxyvitamin D levels in primary care patients (dark grey bars) and oncology patients (light grey bars). The mean (SD) vitamin D levels were 24.9 (11.4) ng/ml for oncology patients and 30.6 (12.5) ng/ml for primary care patients. The best-fit Gaussian distributions are represented as a solid curve for oncology patients and a dashed curve for the primary care patients.

DISCUSSION

While the definition of an acceptable range of serum vitamin D levels is debatable,^{1 2} patients seen at the oncology clinic displayed significantly reduced serum levels of 25-hydroxyvitamin D relative to a geographically similar group of non-cancer patients (table 1 and figure 1). While the primary care patients had a mean around 30 ng/ml, a value deemed sufficient by many experts,¹ 55% of patients fall below this value as indicated by the positive skew in the histogram. The vitamin D levels in oncology patients also display positive skew, with a visibly lower mean of approximately 25 ng/ml. The combined best-fit Gaussian distribution curves illustrate a lower distribution of vitamin D levels in the oncology patients relative to the primary care patients.

The reduced serum vitamin D levels seen in the cancer patients may be either a cause or effect relationship. Multiple studies have found increased cancer risk in individuals with decreased serum vitamin D levels and may explain the association in our data.^{1 8–11} However, it is also possible that a diagnosis of cancer promotes reduced vitamin D levels due to poor oral intake or decreased sun exposure. Regardless of the mechanism, these data suggest that increased clinical suspicion of vitamin D deficiency in cancer patients may be reasonable among the primary care community.

There are several limitations that should be considered while interpreting the data. First, the laboratory used to determine 25-hydroxyvitamin D levels in both the cancer patients and the non-cancer patients was not controlled. Patients received orders for 25-hydroxyvitamin D and had levels drawn at outpatient laboratories, most of which used either a chemiluminescent assay or enzyme immunoassay for 25-hydroxyvitamin D determination. These two methods are thought to be comparable in accuracy and precision.²¹ Since patients at either clinic resided in the same geographical location, it is unlikely that there were important differences in measurement of vitamin D between or within the groups. Second, conditions that may affect vitamin D

levels, such as treatment in cancer patients or comorbid conditions in primary care patients, were not accounted for in the analysis. Third, BMI data were available for only 110 of the 170 oncology patients. Since patients with missing data were excluded from multivariate analyses, the sample size was reduced among the oncology patients. Finally, gender, supplement use and race were not controlled for in the analysis, although the vast majority of the patient pool was Caucasian.

Considering the limitations, there are several strengths to the analysis. The oncology and primary care practices serve the same geographical area; therefore, latitude and regional trends were similar between the groups. In addition, the cancer and non-cancer patients had levels drawn during a similar time frame in 2009 (only 12 cancer patients had levels drawn outside of 2009). Thus, the reduced levels seen in the oncology patients relative to the non-cancer patients were independent of age, BMI, latitude, time and season of blood draw and geographical region. Finally, our data may have practical relevance to physicians in private practice since both of our patient populations were derived from community-based practices.

CONCLUSIONS

Low levels of 25-hydroxyvitamin D were observed in both the community oncology practice and the primary care practice. However, the cancer patients had significantly lower levels of circulating vitamin D. A heightened awareness for vitamin D deficiency among cancer patients may be appropriate based on the results of this study.

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Competing interests None.

Ethics approval This study was approved by the Scranton Temple Residency Program Institutional Review Board.

Contributors TMC participated in data collection through chart review, intellectual analysis of data and writing of paper. SLL participated in data acquirement, intellectual analysis of data and editing of paper. HDB participated in intellectual planning of project, recruitment of patients and

editing of paper. MK participated in intellectual planning of project, data collection and editing of paper. PED participated in intellectual analysis of data, production of figure and editing of paper. CAP participated in intellectual planning of project, recruitment of patients, intellectual analysis of data and editing of paper.

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