

An Interpretable Risk Stratification Model Integrating Vitamin D and Hashimoto Thyroiditis in Papillary Thyroid Carcinoma

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Abstract

Artificial intelligence-assisted precision medicine requires interpretable and clinically accessible indicators for individualized cancer risk assessment. Serum 25-hydroxyvitamin D [25(OH)D] deficiency and Hashimoto thyroiditis (HT) have both been associated with papillary thyroid carcinoma (PTC), but their integrated value for risk stratification remains unclear. This retrospective study aimed to develop an interpretable risk stratification model integrating serum 25(OH)D level and HT status to evaluate aggressive clinicopathological features in PTC. A total of 113 patients with pathologically confirmed PTC were included. Patients were classified according to preoperative HT status and serum 25(OH)D deficiency. Clinicopathological variables, including tumor size, multifocality, lymph node metastasis, capsular involvement, extrathyroidal extension, neural invasion and vascular tumor emboli, were compared between groups. Serum 25(OH)D levels were generally low in the overall cohort, and vitamin D deficiency was common. Patients with PTC and HT tended to have lower serum 25(OH)D levels than those without HT. Vitamin D deficiency was not consistently associated with lymph node metastasis, tumor size or multifocality, but was associated with a higher frequency of local invasive features, particularly capsular involvement and extrathyroidal extension. HT status also contributed to risk heterogeneity in local tumor invasion. An interpretable model combining serum 25(OH)D deficiency and HT status showed better risk separation for capsular involvement and composite aggressive features than either indicator alone. These findings suggest that the integration of serum 25(OH)D level and HT status may provide a simple, explainable and clinically feasible strategy for AI-assisted risk stratification of local invasiveness in PTC. Further multicenter studies and external validation are warranted to confirm its predictive utility.

Keywords

Papillary Thyroid Carcinoma, Hashimoto Thyroiditis, Vitamin D, Interpretable Model, Risk Stratification, Precision Medicine, Artificial Intelligence