—Case Reports—

Usefulness of Ultrasonographic Detective Flow Imaging for Detecting Parathyroid Tumors: A Report of Two Cases

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Parathyroid tumors (PTs) are sometimes difficult to diagnose because they are small and have low-velocity blood flow, which can be missed by current imaging modalities. PTs consist of parathyroid adenoma (PA), parathyroid cyst, and parathyroid carcinoma (PC). Detective flow imaging (DFI) is a new imaging technology that displays low-velocity blood flow. Herein, we report two cases in which DFI was useful for diagnosis of PTs. One patient had a PA and a parathyroid cyst in close proximity, and the other had a PC. To our knowledge, this is the first report to demonstrate the usefulness of DFI in the diagnosis of PTs. (J Nippon Med Sch 2023; 90: 460–464)

Key words: detective flow imaging, parathyroid tumor, parathyroid carcinoma, superb microvascular imaging, color doppler ultrasonography

Introduction

Detective flow imaging (DFI) is a new imaging technology that is based on Doppler ultrasonography. DFI enables the display of low-velocity blood flow, which was previously difficult to visualize. It uses a proprietary algorithm to visualize blood flow in detail, with high resolution and sensitivity. An advantage of DFI is that blood flow can be evaluated without the use of contrast enhancement. Nevertheless, no study has evaluated diagnosis using DFI, except for one on the use of pancreatic endoscopy to depict microcirculation in pancreatobiliary lesions[1].

The parathyroids are located in the neck, behind the thyroid, and have four small endocrine glands. They are responsible for calcium homeostasis through the synthesis and release of parathyroid hormone (PTH), which regulates serum calcium levels by affecting bone metabolism. Parathyroid tumors (PTs) are rare endocrine neoplasms that affect 0.1-0.3% of the general population[2]. Almost 99% of PTH-secreting adenomas grow slowly; however, approximately 1% consist of atypical parathyroid adenomas (PAs) and very rare malignant carcinomas[3]. Primary hyperparathyroidism (PHPT) is a pathological idiopathic condition caused by persistent PTH hypersecretion, independent of serum calcium levels. PHPT is caused by PTs in approximately 85% of cases, by multiple hyperplastic parathyroids in approximately 15% of cases, and by parathyroid carcinoma (PC) in a small fraction of cases[4,5].

Color Doppler ultrasonography (CDU) is often used to visualize blood flow inside tumors; however, it is not sufficiently sensitive to detect small vessels with slow blood flow inside tumors[6,7]. Therefore, we hypothesized that DFI might be useful for diagnosis of PTs. Rickes et al.[8] reported that specific sonographic findings, namely a polar feeding vessel, significantly increased the specificity

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of PA detection in 98 patients with primary hyperparathyroidism. Among suspected PA cases in which feeding vessels were demonstrated on CDU, the abnormal gland was correctly identified 93% of the time. However, in the 40% of suspected PAs in which feeding ducts were not delineated, localization was correct only 39% of the time. Lane et al.[9] used CDU to prospectively image 51 PAs in 44 patients and reported that identification of a polar feeding artery improved the sensitivity and accuracy of ultrasound by 10% and 54%, respectively.

In cases of hyperparathyroidism, ultrasonography is routinely performed to evaluate the location of PTs. DFI was performed as part of the preoperative screening test. We previously used DFI to evaluate one case of parathyroid carcinoma. We report two cases of PTs in which DFI was useful for diagnosis, including that case.

Ultrasonography was performed using an ARIETTA 750VE device (FUJIFILM Healthcare Corporation, Tokyo, Japan) with an L64 linear ultrasound probe (5-18 MHz), and DFI data were obtained. Ultrasonography was performed by a medical doctor (M.M.) and double-checked by a board-certified fellow and senior fellow of thyroidology of the Japan Society on Ultrasonics (T.J.). Each patient was placed in the supine position with their neck in hyperextension, and transverse and longitudinal views were recorded.

Case Presentation

Case 1 was a 56-year-old Japanese woman with PA and parathyroid cyst in close proximity. The serum intact parathyroid hormone (i-PTH) value was high (98.8 pg/mL); however, serum calcium was within the normal range (10.1 mg/mL) owing to administration of cinacalcet (calcium receptor agonist). MIBI scintigraphy revealed accumulation near the lower pole of the right lobe of the thyroid gland. Initially, the nodule appeared to be a lesion in B-mode; however, there was no blood flow on CDU or DFI (**Fig. 1A**). Moreover, ultrasonography revealed another nodule, with a regular smooth shape, on the lower right, and CDU and DFI indicated blood flow into the tumor (**Fig. 1B and C**). After parathyroidectomy, the pathological diagnosis was parathyroid cyst and PA, which was consistent with DFI findings.

Case 2 was an 80-year-old Japanese woman with low-velocity tumor blood flow on DFI (**Fig. 1D**). Serum calcium and i-PTH values were high (11.3 mg/mL and 853.0 pg/mL, respectively). MIBI scintigraphy showed no accumulation in any tissue. CDU and DFI findings were consistent with a vascular-rich tumor of irregular shape. Partial thyroidectomy was performed because of suspected PC, which was later confirmed by pathological diagnosis. The characteristics of these two cases are summarized in **Table 1**.

Discussion

The usefulness of CDU for detecting PA has been reported[9,10]; however, detecting feeding vessels in small PA is challenging. DFI provides more detailed microvascular flows than CDU. A previous report[1] showed that DFI could detect a feeding artery that was sometimes not detected by classical ultrasonic methods. In one of our two cases, two nodules were located quite close to each other, and DFI showed PA and parathyroid cysts, depending on the presence or absence of low-velocity blood flow into the tumor. In the other case, the PC was located near the thyroid gland, and DFI revealed many micro-vessels within the tumor. The findings from these two cases suggest that DFI is useful in diagnosing PTs.

Superb microvascular imaging (SMI) (Canon Medical Systems Inc., Tochigi, Japan), which has functions similar to DFI, was commercialized earlier than DFI and applied as a relatively new noninvasive blood flow imaging mode. As compared with conventional ultrasonography, SMI can detect low-velocity blood flow with greater sensitivity and display more microvascular information[11]. Diagnostic application of SMI has been reported in thyroid nodules[11–18] and breast cancer[19–21], although there are no published studies involving PTs. Lu et al.[13] reported that SMI was significantly more effective than CDU and/or power Doppler ultrasonography (PDU) in detecting microvascular flow signals in 52 thyroid nodules (TNs) comprising 13 benign and 39 malignant nodules. Zhu et al.[18] reported that SMI revealed noticeable variation between malignant (n = 39) and benign (n = 13) TNs ($p < 0.001$), and that malignant nodules tended to have richer vascularity than benign nodules. Studeny et al.[14] examined whether SMI could reliably reproduce blood flow in thyroid nodes, which could lead to accurate diagnosis of malignancies, based on vascularization properties. This study revealed a significant positive correlation ($r = 0.56$, $p = 0.025$) between SMI and immunohistochemical evaluation of CD34 staining. As compared with CDU and/or PDU, SMI detects more small branches of the microvasculature and provides more detailed information on the distribution inside nodules and adjacent thyroid parenchyma.

As for DFI, Yamashita et al.[1] described a new method, called detective flow imaging endoscopic ultrasonogra-

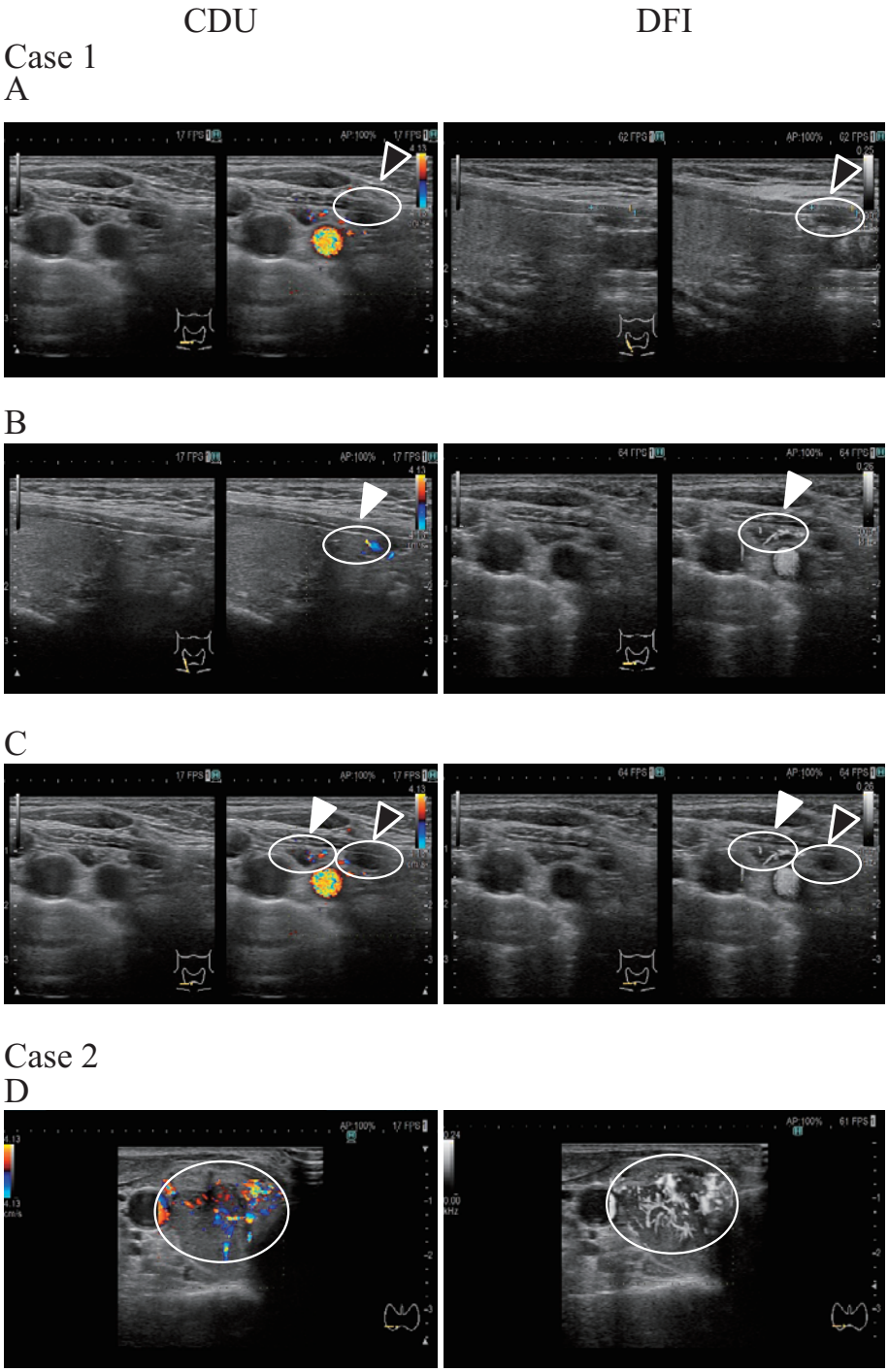

Fig. 1 Ultrasonography imaging comparing CDU and DFI
A finer blood flow is visualized in DFI than in CDU. Case 1: (A) (B) (C); blood flow is present in the parathyroid adenoma (white arrowheads) but not in the parathyroid cyst (black arrowheads) located near the parathyroid gland. Case 2: (D).
CDU, color doppler ultrasonography; DFI, detective flow imaging

phy (DFI-EUS), to visualize and detect fine vessels and low-velocity blood flow without the use of ultrasound contrast agents. DFI-EUS is a novel EUS imaging technique for depicting microcirculation in pancreatobiliary lesions and is particularly useful for visualizing low microvascular flow.

This is the first report to demonstrate the usefulness of DFI for diagnosis of PTs on the basis of quantitative analysis of low-velocity blood flow in tumors by the technique.

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Table 1 Characteristics and ultrasonographic findings of the two cases

	Case 1	Case 2
Characteristics		
Age at surgery, year	56	80
Gender	F	F
Tumor diameter (mm)	10.6	20.9
Tumor location	Rt, L	Rt, L
Ca (mg/mL)	10.1	11.3
Alb (g/dL)	4.4	4.1
i-PTH (pg/mL)	98.8	853.0
CT	not performed	D
MIBI scintigraphy	D	UD
Operation method	PTx	PTx+Lo
Pathological diagnosis	PA	PC
Ultrasonographic findings		
Shape	regular	irregular
Border	smooth	smooth
Internal echo	hypo ～ iso	hypo ～ iso
Feeding vessels	D	D

Ca: calcium, Alb: albumin, i-PTH: intact parathyroid hormone, CT: computed tomography, MIBI: methoxyisobutylisonitrile, F: female, Rt: right, L: lower, PTx: parathyroidectomy, Lo: thyroid lobectomy, PA: parathyroid adenoma, PC: parathyroid carcinoma, D: detectable, UD: undetectable

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