# COLOR DOPPLER SONOGRAPHY IN THE DETECTION OF PARATHYROID ADENOMAS

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**Abstract:** *Background.* Various diagnostic modalities have been utilized to aid in the detection of abnormal parathyroid tissue; however, its localization is not always easy. The purpose of this study was to determine whether the evaluation of potential hemodynamic changes in thyroid arteries could aid in the detection of parathyroid adenomas.

*Methods.* Twenty−eight patients with laboratory evidence of hyperparathyroidism were examined with color Doppler sonography. Data were collected for the superior and inferior thyroid arteries separately. These findings were compared with data for a control group of 14 healthy subjects.

*Results.* Retrospective analysis of the data indicated that peak systolic velocities in the inferior thyroid arteries ipsilateral with the parathyroid adenomas were significantly higher than in normal controls ($p < .001$). Peak velocity values in the superior thyroid arteries ipsilateral with parathyroid adenomas located in the upper position were also significantly increased compared with those in control subjects ($p < .02$). Conversely, peak velocities in the inferior and superior thyroid arteries contralateral with the adenomas, as well as velocities in the superior thyroid arteries ipsilateral with lower position adenomas, did not differ significantly from those in control subjects. The localization of both side and level site of the adenomas presented an accuracy of 86.6%, sensitivity reached 96.5%, and specificity 83.1%.

*Conclusion.* Our results suggest that color Doppler sonography can be used to improve diagnostic accuracy in detecting parathyroid adenomas. © 1999 John Wiley & Sons, Inc. *Head Neck* **21:** 648–651, 1999.

**Keywords:** color doppler; parathyroid adenoma; thyroid artery

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A great number of diagnostic modalities have been demonstrated to be useful in the evaluation of parathyroid adenomas. Invasive diagnostic procedures such as superselective angiography and selective venous catheterization with sampling for parathormone assay[1] as well as noninvasive methods including high resolution sonography,[2] computed tomography, scintigraphy, and magnetic resonance imaging or various combinations of these modalities have been utilized to aid in the localization of abnormal parathyroid tissue.[3]

It is reported that 5% of parathyroid adenomas are ectopic, either in the neck or in the mediastinum; however, parathyroid glands usually obtain their blood supply from branches of the thyroid artery.[4] The goal of our study was to determine whether the evaluation of potential hemodynamic changes in these major supply arteries could aid in the detection of parathyroid adenomas.

## MATERIALS AND METHODS

During a 29-month period from November 1995 through April 1998, we examined with color Doppler sonography using an ATL-UM 9 device (Advanced Technology Laboratories, Bothell, WA) and a 5-MHz linear transducer 31 patients, referred with clinical and laboratory diagnoses of primary hyperparathyroidism.

All cases were verified by surgical operation

and pathologic examination. No patient had recurrent or persistent postoperative hyperparathyroidism.

Three patients (9.6%) had incomplete Doppler records because of technical problems: an anomalous origin of the inferior thyroid artery in 1 patient and interference of carotid artery pulsation in the others, preventing the sampling of clean spectra. In these cases the results were excluded from the general analysis yielding a total of 28 patients for the retrospective study. The study group consisted of 6 men and 22 women aged 24–66 years (54 ± 23 years, mean ±1 SD). Fourteen healthy subjects, matched with the patients for age, served as controls.

Color flow sensitivity was set at 11 cm/sec, wall filter at 50 Hz, and color versus echo write priority at 34. This setup was utilized to achieve maximal flow but minimal artifacts. For spectral Doppler, the sample volume was set as small as 1.5 mm and wall filter at 50 Hz. The sample volume was centered in and completely incorporated the vessel. The angle of insonation was kept at 60° or less, and the angle correction cursor was parallel to the direction of flow.

Each patient's neck was hyperextended and scanned in both longitudinal and transverse planes, from the clavicle to the angle of the jaw and anteriorly at midline to lateral to the internal jugular vein. Measurements of peak systolic velocities were made in inferior and superior thyroid arteries bilaterally.

The peak systolic velocity was recorded at three different sites in each examined vessel, and an average measurement per vessel and across patients was made. Respective coefficients of variation for peak systolic velocity measurements were also calculated.

Student's $t$ test was used to retrospectively compare the measured hemodynamic data for the study group with those for the control group. A two-tailed $p$ value of less than .05 was considered significant.

## RESULTS

Of the patients with surgically proved parathyroid adenomas, 12 (43%) had a parathyroid hypoechoic solid lesion identifiable by sonography surrounded by a continuous or discontinuous vascular arc, but 16 (57%) presented no sonographic evidence of an adenoma. Verification based on surgical pathologic findings showed that 6 (21%) of the abnormal glands were located at the right upper position, 10 (36%) at the right lower position, 4 (14%) at the left upper position and 8 (29%) at the left lower position. The size of the parathyroid adenomas ranged from 0.5 to 2.1 cm (1.47 ± 0.61 cm, mean ±1 SD).

All 28 parathyroid adenomas were evaluated by color Doppler sonography, and the flowmetry results are reported in Table 1.

No significant differences were observed between measurements made in the right and left thyroid arteries of normal controls, so data in the control group are expressed as an average between the two sides. Coefficient of variation for peak systolic velocity measurements was 6.8 ± 3.7%. (mean ±1 SD).

Retrospective evaluation of the data showed that peak systolic velocities in the inferior thyroid arteries, ipsilateral with the parathyroid adenomas, were significantly higher than in control subjects ($p < .001$).

Peak velocity values in the superior thyroid arteries, ipsilateral with parathyroid adenomas located in upper position, were also significantly increased compared with those in normal controls ($p < .02$).

Conversely, peak velocity measurements recorded in inferior and superior thyroid arteries contralateral with the adenomas, as well as measurements made in superior thyroid arteries ipsilateral with lower position adenomas, were not significantly different compared with normal controls. When a threshold of 40 cm/sec for peak velocity measurements was used, an accuracy of

**Table 1.** Peak velocities in thyroid arteries.*

| | Control subjects | Ipsilateral side with an adenoma | | Contralateral side with an adenoma |
|---|---|---|---|---|
| | | In upper position | In lower position | |
| | $n = 14$ | $n = 10$ | $n = 18$ | $n = 28$ |
| ITA | 30.7 ± 7.6 | 57.2 ± 14.8 (<.001) | 62.7 ± 11.2 (<.001) | 32.5 ± 6.4 (NS) |
| STA | 26.2 ± 6.9 | 39.3 ± 17.4 (<.02) | 30.4 ± 8.1 (NS) | 28.3 ± 9.2 (NS) |

*Abbreviations: NS, p value not significant; ITA, inferior thyroid artery; STA, superior thyroid artery.*
**Data are reported as mean ± 1SD (cm/sec).*

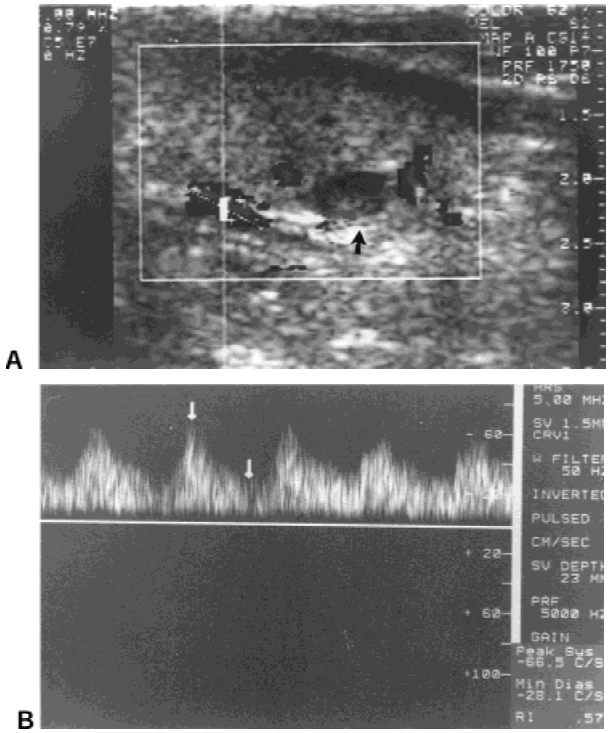

**FIGURE 1.** Parathyroid adenoma in left inferior position: **(A)** color Doppler imaging demonstrates a discontinuous vascular arc around the periphery of the adenoma (arrow); **(B)** respective increased peak velocity measured in the inferior thyroid artery.

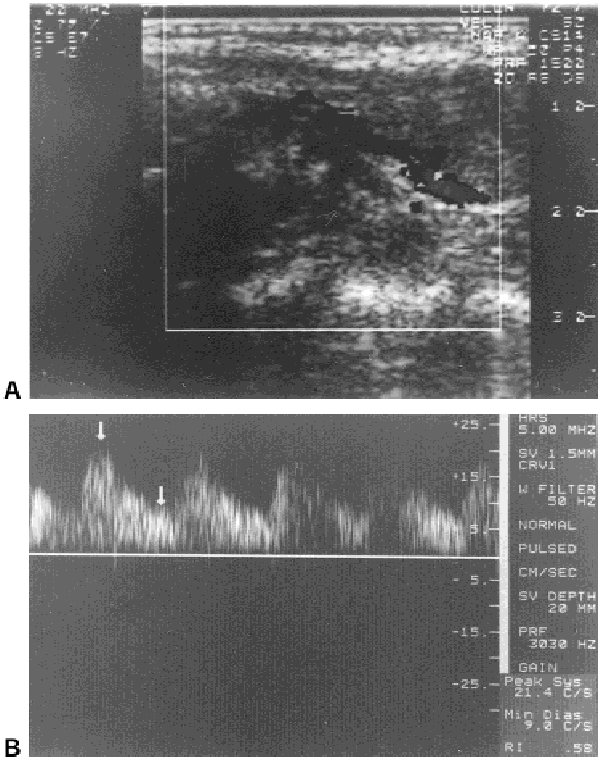

**FIGURE 2. (A)** Longitudinal color Doppler sonogram of the normal left superior thyroid artery and upper pole thyroid tissue of a patient; **(B)** respective normal peak velocity measurement in the superior thyroid artery.

86.6% (95% confidence interval 79%–91.7%) for the localization of the site (both side and level) of the adenomas was obtained. Respective sensitivity reached 96.5% (95% confidence interval 71%–99.3%) and specificity 83.1% (95% confidence interval 69.1%–89.6%).

## DISCUSSION

Surgical removal of abnormal parathyroid tissue is usually fairly easy and safe; however, its localization is not always so.[5] Preoperative localization is of substantial importance not only because operative time is reduced and risk for complication is decreased but also because it creates more favorable conditions for the operation.[6] On the other hand, critics of preoperative parathyroid sonography may focus their claim on the diagnostic pitfalls that have been reported in patients with ectopic adenomas or concomitant thyroid abnormalities.[7–9]

Color Doppler sonography was found to be helpful in the parathyroid adenoma identification by some authors, who described the presence of various vascular arcs surrounding the parathyroid adenomas[4] and seemed to match the respective angiographic sign reported by Doppman and colleagues.[10]

In our study, various patterns of discontinuous vascular arcs (Figure 1A) were present in all parathyroid adenomas that were sonographically discernible (43%), but this sign could not be applied in the rest of the adenomas (57%) that presented no identifiable sonographic evidence.

Color flow measurements in the examined thyroid arteries in the cases of parathyroid adenomas demonstrated significantly increased peak velocity values (Figure 1B) versus control subjects (Figure 2).

Our experience indicated that, especially when the precise anatomic location of the parathyroid adenoma is not sonographically accessible, the detection of increased peak velocity values in the thyroid arteries of the referred patients can be a useful trace for the surgeon. In fact the detection of increased peak velocity values in the inferior arteries seems to indicate the side of the adenomas, whereas superior thyroid artery measurements could be helpful in the localization of the level site. The localization of both side and level site of the adenomas was achieved in our

patients with a diagnostic accuracy of 86.6%, when a threshold of 40 cm/sec for peak velocity values was used. This approach based on purely hemodynamic criteria is not dependent on the visualization of the adenoma and could be potentially helpful in detecting small size or in inaccessible site adenomas.

The limitations of the method include the presence of an ectopic adenoma that is deprived of the thyroid artery blood supply, which is a relatively rare but diagnostically difficult entity. Increased thyroid artery velocities also have been reported in hyperthyroidism and other abnormalities of the thyroid.[11] This can cause results that are difficult to interpret in the case of concomitant parathyroid and thyroid lesions.

Undoubtedly, more experience will be necessary, derived from a larger series of patients, to define the ultimate role of color Doppler imaging in the detection of parathyroid adenomas. On the basis of our knowledge, we think that a routine use of color Doppler studies may be recommended in the diagnostic approach of primary hyperparathyroidism because of the potential improvement in diagnostic accuracy at a minimal cost.

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## EDITORIAL COMMENTS

The paper on color Doppler sonography in the detection of parathyroid adenomas by Konstantinos Varsamidis and colleagues is a helpful addition to the availability of preoperative localization studies in these patients. Although a number of diagnostic modalities are available, most parathryroid surgeons feel that initial neck exploration can be accomplished successfully without preoperative localization studies. Localization studies have been reserved for patients who are being reoperated on for missed parathyroid adenomas. The techniques available inlclude Sestamibi scans, conventional ultrasound studies, CT scans, MRIs, angiography, and venous sampling. In this most difficult group of patients, the results are no better than 50% to 75% positive for localization. The addition of color flow Doppler studies to conventional ultrasound may decrease the number of failed explorations, particularly if they are in the neck. The technique also may lend valuable information as to the possibility of having double adenomas or adenomas on both sides of the neck or on the same side of the neck because of flow characteristics. It is hoped that the authors and other investigators will apply color flow Doppler sonography in those patients who have ectopic locations in their parathyroid glands and those who have multiple adenomas and to gain some data on location after failed neck exploration. Although the need for localization preoperatively in initial neck exploration is not considered essential, surgeons feel comfort and reassurance in knowing preoperatively the exact side and location of the suspected adenoma. I am sure cost is important in all diagnostic studies. Of all the modalities available, the color Doppler ultrasound would appear to be the diagnostic modality that would minimally increase cost for maximum reward.


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