

# Ultrasound Scanning in Dermatology

Monika-Hildegard Schmid-Wendtner, MD; Walter Burgdorf, MD

**I**n recent years, ultrasound scanning has become an important diagnostic tool in dermatology. It is easy to use, completely safe, and provides important diagnostic information. There are 2 basic types of ultrasonography with dermatologic applications. The best established is 20-MHz scanning, which can be used to measure tumor thickness and/or skin thickness when treating inflammatory diseases such as scleroderma or psoriasis. Real-time sonography with 7.5- to 10-MHz probes has assumed an increasingly important role, since it is used to search for and image lymph nodes and subcutaneous tumors in a variety of clinical settings, including preoperative staging and follow-up of melanoma. Ultrasonography is capable of revealing the 3-dimensional size and outline of subcutaneous lesions, for example, lymph nodes, subcutaneous tumor masses or hematomas, and their relation to adjacent vessels. Moreover, information about the lesion quality (solid, cystic, and combined) and the inner structure (homogeneous, inhomogeneous, hypoechoic, hyperechoic, calcification foci, and necroses) can be obtained. All this information can be combined to help distinguish between benign and malignant lymphadenopathy and to determine the malignant potential of a subcutaneous lesion. In addition to conventional B-mode sonography, newer ultrasound techniques such as native and signal-enhanced color Doppler sonography can be used to assess peripheral lymph nodes.

*Arch Dermatol.* 2005;141:217-224

Ultrasound scanning is of importance in many aspects of clinical medicine, especially in fields such as internal medicine, otorhinolaryngology, and gynecology.<sup>1-3</sup> As a noninvasive diagnostic method, 5- to 10-MHz real-time B-mode sonography has been successfully applied for more than 30 years. During the past 3 decades, diagnostic ultrasound has also entered the arena of clinical dermatology. High-frequency ultrasound systems using at least 20-MHz probes are well established. They provide information about the axial and lateral extension of tumoral and inflammatory processes of the skin and the

subcutaneous fatty tissue and, therefore, are of special interest in preoperative situations and for the monitoring of skin conditions under therapy.<sup>4-7</sup>

*See also pages  
183 and 269*

In contrast to the well-established role of the high-frequency ultrasound systems, the use of ultrasound scanning using 7.5- to 10-MHz probes is not as widespread, although promising results have been reported from specialized diagnostic units, especially for the assessment of peripheral lymph nodes and soft tissue tumors.<sup>8-10</sup> We review technical aspects, examination techniques, and different ultrasound methods such as B-mode sonography, native color Doppler sonography (CDS), and signal-enhanced CDS, with particular emphasis on

**Author Affiliations:** Department of Dermatology and Allergology, Friedrich-Wilhelms University, Bonn, Germany (Dr Schmid-Wendtner); and Department of Dermatology and Allergology, Ludwig-Maximilian University, Munich, Germany (Dr Burgdorf).  
**Financial Disclosure:** None.

the assessment of regional lymph nodes in dermatologic oncology. In addition, further applications for this noninvasive diagnostic method are explored.

## TECHNICAL ASPECTS

Ultrasound is defined as energy above 20 kHz, which represents the upper frequency limit of human hearing. Transducers, which are thin disk-shaped crystals made out of piezoelectric materials, generate acoustic energy when a voltage is applied to them. Acoustic vibrations (frequencies) are generated when those piezoelectric materials expand and contract. Early transducers were made from quartz; newer materials include lithium sulfate, ceramics, and plastic polymers. These newer substances have allowed the development of transducers that produce higher frequencies, which are of special interest for dermatologists because the wavelengths of higher frequencies are smaller and, therefore, allow better resolution of small objects located near the skin surface. With increasing frequency, the depth of penetration of ultrasound waves decreases; for example, ultrasound units using 20 MHz only penetrate 8 mm. Transducers used earlier in general medicine for diagnostic purposes used frequencies between 2 and 5 MHz. At present, the transducers for the diagnosis of regional lymph nodes and soft tissue tumors operate in the 7.5- to 10-MHz range, while the high-frequency transducers used to evaluate cutaneous structures function in the 20- to 50-MHz range.<sup>4</sup>

Diagnostic ultrasound systems are based on pulse-echo systems, similar to the more familiar radar or sonar technology. Acoustic energy is emitted from the transducer. The expansion and contraction of the transducer is transferred as a pulse to the adjacent fluid or tissue and propagates as a wave, which can be reflected or refracted at tissue boundaries. The echo (returning wave) reaches the transducer during breaks of impulse generation. The vibration of the transducer caused by the returning wave generates a voltage difference over the electrodes. These echoes are converted by the transducer into signals that are processed and stored by the computer system.

Resolution of ultrasound systems can refer to either axial or lateral resolution. The axial resolution is the smallest thickness that can be measured and is related to the duration of a pulse. The lateral resolution refers to the width of the smallest structures that can be resolved and is related to the width of the beam at the focus zone. In general, ultrasound systems convert the voltage changes recorded by the transducer and display these signals as images. Two different types of signal processing can be distinguished: A-scans and B-scans. A-scans depict the magnitude of reflection along a single line, resulting in a graph that shows changes in amplitude relative to time. The time of transit of the acoustic wave correlates with distance. Echoes occur at boundaries between tissues where there is a change of acoustic impedance. At present, A-scan ultrasound systems are mainly used in ophthalmology. B-scans combine the information from sequential single A-scans and display each point according to its relative brightness (hence B-scan). Each point on a B-scan is brighter or darker, corresponding to the intensity of echoes from the corresponding anatomic structure. Therefore, B-scans provide im-

ages that resemble anatomic cross sections of scanned tissues.<sup>11,12</sup> B-mode ultrasonography was originally black and white. The introduction of gray-scale images was an improvement because the amplitudes of signals received from reflected ultrasound signals were displayed. Currently, B-mode scans are the mainstay of all ultrasonographic procedures in dermatology using intermediate- or high-frequency ultrasound systems.

## EQUIPMENT AND EXAMINATION TECHNIQUES

For high-frequency ultrasound examinations (20-50 MHz), there are 2 different ultrasound systems available: the Dermascan C (Cortex Technology, Hadsund, Denmark) and the DUB 20 (Taberna pro medicum, Lüneburg, Germany). For examinations in the range of 7.5 to 10 MHz, there are various ultrasound systems available, such as the SSA-340 A (Toshiba Medical Systems, Neuss, Germany) or the Siemens Sonoline Elegra (Siemens, Erlangen, Germany). Other producers of comparable systems are Esaote Biomedica, Genoa, Italy, and Acuson, Mountain View, Calif.

When evaluating skin or tumor thickness with the 20-MHz unit, the individual lesion or area of interest is simply scanned. Usually, a water bath is used between the transducer and the area to be examined to prevent total reflection of ultrasound waves at the epidermis. The physician should avoid compressing superficial tumors because this may result in a false thinning. There is one disadvantage of 20-MHz sonography that should be kept in mind: in tumors with an underlying inflammatory infiltrate, as is often seen in melanoma, the measured tumor thickness may be too thick, since the tumor and the inflammatory reaction cannot be reliably separated. The mirror image or contralateral unaffected skin can be used as a control for skin thickness in inflammatory skin diseases.

When searching for regional lymph nodes with the 7.5- to 10-MHz unit, a protocol must be carefully followed. In patients with melanoma, ultrasound scanning should be performed every 3 to 12 months according to the thickness of the primary melanoma.<sup>8-10,13</sup> After examination of the scar region, the transducer should be moved along the lymphatic vessels toward the regional lymph nodes. On the arms and legs, this area corresponds to the axillae or inguinal region, whereas on the trunk about one third of cutaneous melanomas have 2 or more different lymphatic draining areas. The number and size of suspicious lymph nodes or subcutaneous lesions should always be described and documented in 2 planes (transverse and longitudinal).<sup>8</sup> Sonography should be used prior to initial melanoma surgery. If the regional lymph nodes clearly show changes of metastases, a sentinel lymph node operation is probably not appropriate. In such cases, a total lymph node dissection of the region should be performed on the basis of the sonographic findings.

## APPLICATIONS

### 20-MHz Sonography

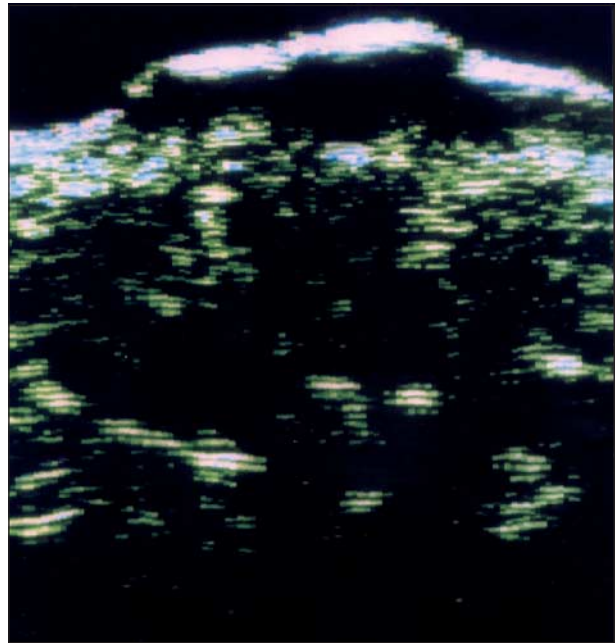
High-frequency sonography using a 20-MHz transducer renders important preoperative information about the tumor

size and especially about the tumor thickness in different skin tumors including cutaneous melanoma (**Figure 1**), basal cell carcinoma, and squamous cell carcinoma. These tumors are mainly visualized as hypoechoic structures within the hyperechoic dermis. In melanoma, however, the preoperative tumor thickness is sometimes overestimated, since an underlying inflammatory infiltrate, which also is visualized as a hypoechoic area, cannot be discriminated from the melanoma. Basal cell carcinomas can also show a mixed echogenicity. When the tumors extend beyond the dermis-subcutis border, the demarcation may become difficult because apart from connective tissue septae, the subcutaneous fatty tissue is also hypoechoic.<sup>6</sup> In addition, the deep tumor borders of basal cell carcinomas cannot be visualized by 20 MHz. In these cases, examination with 13- to 15-MHz probes may be helpful. A problem in squamous cell carcinoma may be the hyperkeratotic epidermis, sometimes leading to total reflection of ultrasound waves. In these cases, measurement of tumor thickness is not possible.

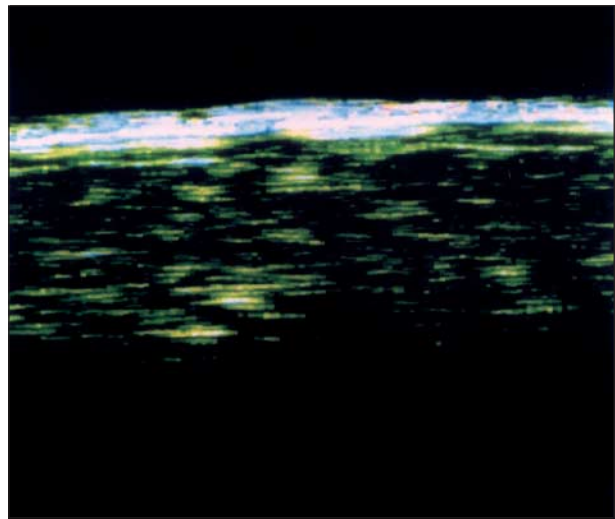
High-frequency ultrasound systems are also suited to follow inflammatory skin diseases over time, for example, dermatitis, hypersensitivity reactions, and psoriasis. During the acute inflammatory process, the sonograms usually show an irregular, superficial, hypoechoic band within the dermis. Over time there is a gradual increase in echogenicity.<sup>15</sup> Another well-established indication for high-frequency ultrasound is the monitoring in the course of scleroderma (**Figure 2**). Intraindividual comparison of sclerotic skin with corresponding areas of healthy skin show a thickening of the dermis, which decreases, for example, under photochemotherapy.<sup>16</sup> Additional applications include assessment of steroid atrophy, wound healing, scars, and testing of topical pharmaceutical agents.<sup>7</sup> In more experimental settings, 20-MHz sonography can be used to assess the degree of inflammatory disorders, dermal edema, or photo damage of the skin and to monitor treatment responses in these conditions.<sup>4</sup>

### 7.5- to 10-MHz Sonography

The dermatologic applications of B-scan ultrasound with 7.5- to 10.0-MHz transducers include the identification and description of suspicious palpable structures within the subcutis (solid, cystic, and complex) as well as the assessment of peripheral lymph nodes. Owing to their different echo patterns, discrimination between inflamed lymph nodes and those containing metastases is possible in many cases. Moreover, 7.5- to 10-MHz sonography is used to explore the deeper aspects of larger tumors, assessing their relationship to nerves and vessels to provide crucial preoperative information. Thus this form of sonography plays an important role not only in the preoperative situation (primary staging) but also in the follow-up of patients with malignant skin tumors mainly including melanomas, sarcomas, malignant epithelial tumors, and malignant lymphomas.<sup>17</sup> In addition, ultrasound scanning can be used for the monitoring of subcutaneous as well as lymph node metastases, for example, during chemotherapy. While real-time sonography offers many clues helping to distinguish between benign and malignant changes in lymph nodes, it cannot replace the histopathologic examination. In other words, a melanoma metastasis cannot



**Figure 1.** B-scan ultrasound image of melanoma (20 MHz). Below the hyperechoic and homogeneous entry echo there is a well-demarcated hypoechoic area resembling the tumor. Reprinted from Korting et al,<sup>14(p277)</sup> with permission from Georg Thieme Verlag, Stuttgart, Germany.



**Figure 2.** B-scan ultrasound image of localized scleroderma: inflammatory stage (20 MHz). Below an enlarged homogeneous hyperechoic entry echo there is an enlarged homogeneous dermis with decreased echodensity. Reprinted from Korting et al,<sup>14(p47)</sup> with permission from Georg Thieme Verlag, Stuttgart, Germany.

be separated from that of another tumor. The quality of information depends heavily on the examiner's skill and experience, as well as on specific clinical setting and what question is being asked.

### ASSESSMENT OF LYMPH NODES BY 7.5- TO 10-MHZ SONOGRAPHY

In B-mode sonography, normal unaffected lymph nodes of healthy individuals cannot be separated from surrounding tissue because their acoustic impedance is identical. When the lymph nodes are abnormal, B-mode

sonography is a highly sensitive diagnostic method. Assessment of reactive and malignant lymph nodes is based on size (largest and smallest diameter), shape, border, and echodensity of the lymph node center and the lymph node margin. Lesions suggestive of metastases can be identified mainly according to the criteria of Vassallo et al,<sup>11</sup> which and Solbiati et al,<sup>18</sup> which are listed in **Table 1**. Reactive lymph nodes in both infectious and noninfectious inflammatory diseases such as psoriasis present as oval or spherical masses with hypodense margins and hyperechoic centers (**Figure 3**). Their size ranges between 5 and 30 mm. In the early stage of inflammation, reactive lymph nodes can present as round, totally hypoechoic masses, resembling

the alterations in malignant lymph nodes. In these cases, sonographic follow-up examinations may help to differentiate between malignant and benign lymph node changes. In addition, ultrasound-guided fine-needle aspiration cytology may be of special value in this setting. Although older studies did not prove an increased efficacy of fine-needle aspiration cytology, newer prospective evaluations including more than 800 patients with melanoma suggest that the technique is indeed useful.<sup>19</sup>

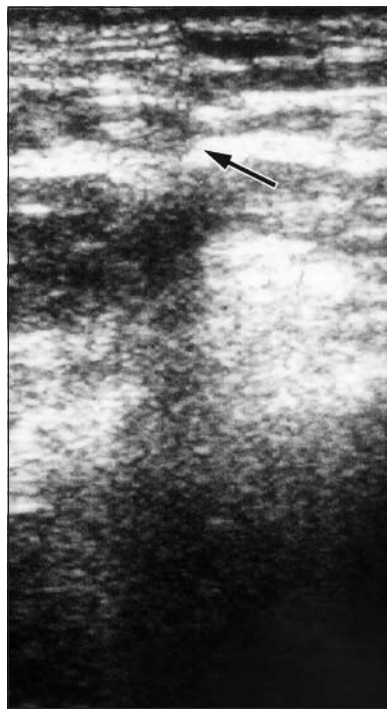
Larger lymph node metastases (diameter  $\geq 1$  cm) typically present as well-marked, hypoechoic masses with spherical or irregular shapes (**Figure 4**).<sup>8-10</sup> This sonomorphologic pattern can be found in metastases of most solid neoplasms and is not tumor specific. When evaluating questionable hypoechoic structures, which may represent metastases in patients who have undergone lymph node dissection, several differential diagnostic possibilities have to be kept in mind. These include postoperative seromas, hematomas, and accumulations of lymph, as well as abscesses. Additional important differential diagnostic possibilities for hypoechoic masses are listed in **Table 2**. Small hypoechoic metastases (diameter  $< 3$  mm), often located at the hypoechoic margins of reactive lymph nodes, may be difficult to find by B-mode ultrasound examination alone. In such cases, further diagnostic steps including the evaluation of vascular patterns in suspect peripheral lymph nodes by native or signal-enhanced CDS can be helpful.<sup>20,21</sup>

Involvement of the peripheral lymph nodes in malignant lymphomas does not have a uniform sonographic picture. In many patients, hypoechoic enlarged masses

**Table 1. Morphologic Criteria for the Evaluation of Suspicious Peripheral Lymph Nodes by B-Mode Sonography\***

Morphologic Criteria	Reactive Lymphadenopathy	Lymph Node With Metastasis
Shape	Longitudinal or oval	Round
Border	Both sharp and blurred	Mostly sharp
Center	Hyperechoic	Hypoechoic or echolucent
Peripheral rim	Usually small and hypoechoic	Usually absent
Solbiati index (longitudinal-transverse-diameter ratio)	$\geq 2$	$< 2$

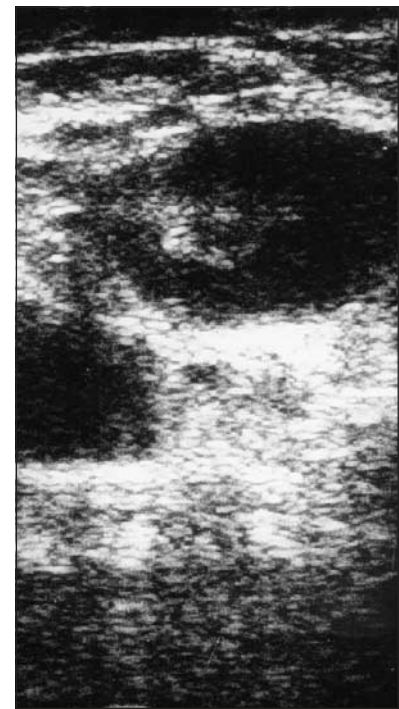
\*Modified according to Vassallo et al<sup>11</sup> and Solbiati et al.<sup>18</sup>



**Figure 3.** Image from a B-scan ultrasound examination of a postinflammatory lymph node (8 MHz): small longitudinal structure with hyperechoic center and hypoechoic margin (arrow). This small cervical node can be easily overlooked.



**Figure 4.** Image from a B-scan ultrasound examination of a metastasis (8 MHz): round structure with homogeneous low echodensity.



**Figure 5.** Image from a B-scan ultrasound examination of a non-Hodgkin lymphoma (8 MHz): oval structure with medallionlike echo pattern (hyperechoic center and a hypoechoic margin).

**Table 2. Differential Diagnoses of Hypoechoic Structures in B-Mode Sonography**

Differential Diagnoses of Hypoechoic Structures	Sonomorphologic Pattern
Metastasis	Round hypoechoic structure, sometimes dorsal echo enhancement
Vessel	Round echolucent structure, flattened under pressure, dorsal echo enhancement
Seroma	Echolucent structure with sharp border, dorsal echo enhancement
Hematoma	Irregular hypoechoic structure, gradual increase in echogenicity over time
Cyst/abscess	Round echolucent structure, dorsal echo enhancement

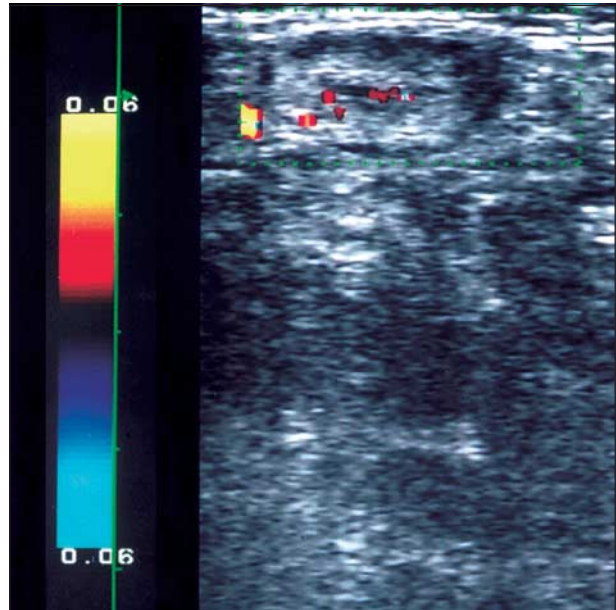
**Table 3. Differential Diagnoses of Hyperechoic Structures in B-Mode Sonography**

Clinical Finding	Sonographic Pattern
Lymphoma after chemotherapy or radiation	Round or oval structure, gradual increase in echodensity during therapy
Lipoma	Homogeneous hyperechoic structure, sometimes without sharp border
Fibroma	Irregular hyperechoic structure, sometimes without sharp border
Scar	Hyperechoic structure, "infiltration" of surrounding tissue
Calcification	Echo-rich structure, dorsal echo extinction

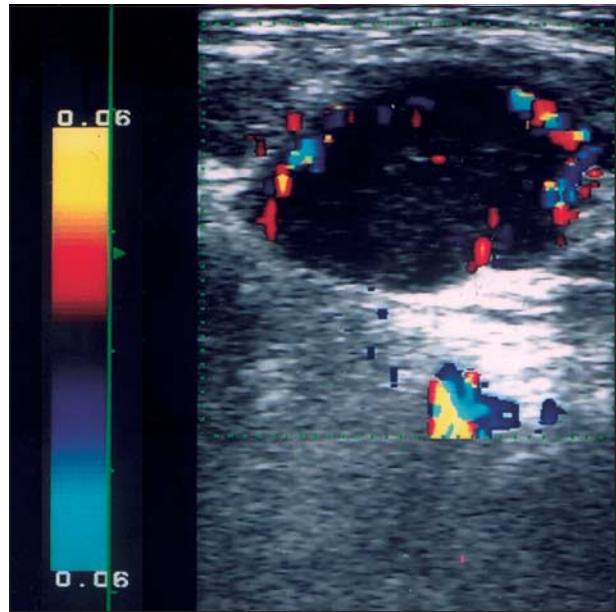
can be demonstrated by B-mode sonography. Other patients present with lymph nodes with medallionlike echo pattern with a hyperechoic center and a hypoechoic margin (Figure 5), resembling the pattern described for inflammatory lymph nodes. These sonomorphologic patterns do not help to distinguish between different types of lymphomas.<sup>22</sup> The involved lymph nodes usually gradually increase in echogenicity when a lymphoma is treated with chemotherapy or radiotherapy.<sup>22</sup> Table 3 gives an overview of the differential diagnostic considerations for hyperechoic structures.

### NATIVE AND SIGNAL-ENHANCED CDS

Color Doppler sonography extends the range of ultrasound diagnosis by allowing assessment of the vascularity of superficial lymph nodes. It combines gray-scale ultrasound and the pulsed Doppler technique. In real-time B-mode scanning, flowing blood is displayed in color superimposed on the gray-scale image. Color code reflects the frequency shift that is dependent on flow velocity and the angle of the sound beam in relation to the blood flow.<sup>20</sup> For visualization of the vascularization in small lymph node vessels, ultrasound equipment with "slow-flow modus" is necessary. According to early angiographic studies, alterations in the vascular pattern in lymph nodes involved with metasta-

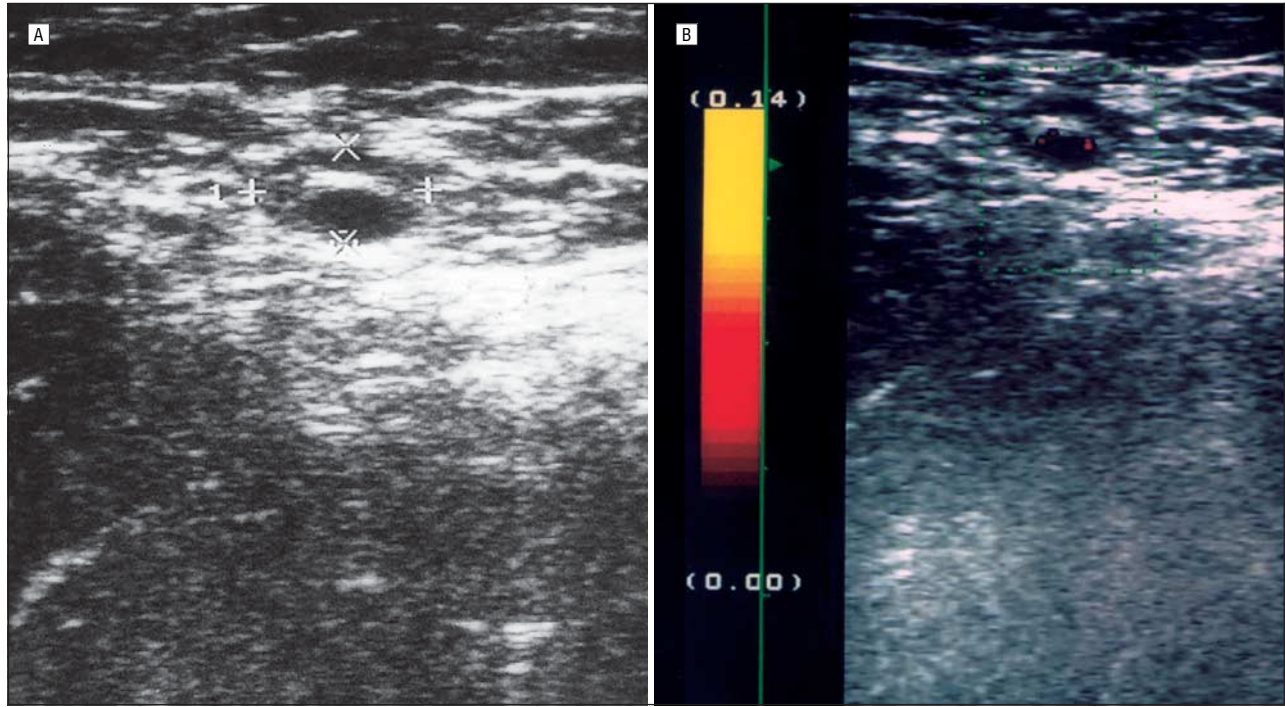


**Figure 6.** Native color Doppler sonography of a reactive lymph node (8 MHz): oval structure with hyperechoic center and small hypoechoic margin; central hilus vessel visible.



**Figure 7.** Native color Doppler sonography of a metastasis (8 MHz): round hypoechoic structure; mainly peripheral vascular pattern.

ses may be caused by quantitative or qualitative perfusion changes owing to necrosis or arteriovenous shunts. Different intranodal vascular patterns can be detected for reactive and malignant lymphadenopathy using native CDS.<sup>20</sup> Patterns for reactive lymph nodes include hilar or longitudinal vessels (Figure 6) or branching of longitudinal vessels.<sup>23</sup> Patterns for metastases include accessory peripheral vessels (Figure 7), displacement of intranodal vessels, asymmetric avascular areas, or aberrant course of central vessels ("chaotic" intranodal flow).<sup>20</sup> In addition to qualitative variables, recording of Doppler spectra and measurement of peak velocities have been recommended.<sup>24</sup> The resistive index, representing the peripheral vascular obstruction,



**Figure 8.** A, B-scan ultrasound examination of an uncertain diagnosis (8 MHz): oval structure with hyperechoic center and asymmetric hypoechoic margin. B, Native color Doppler sonography (8 MHz): tiny areas of perfusion (red dots) in the asymmetric hypoechoic area in the lymph node margin. Diagnosis: small metastatic infiltration in the lymph node margin; differential diagnosis: reactive lymph node. The histologic examination confirmed the diagnosis of metastasis.

and the pulsatility index, representing the peripheral vascular resistance, can be determined by an integrated function of the ultrasound device.<sup>24</sup> To obtain more objective criteria, different groups have tried to establish quantitative thresholds for defining vascularity of malignant and benign lymph nodes. The most often used classification is that of Tschammler and colleagues,<sup>25</sup> who found lymph nodes with a pulsatility index of 1.8 or more and a resistive index of 0.9 or more to be suggestive of malignancy. In our own patients with melanoma, the pulsatility index and resistive index values were disappointing in their ability to separate malignant from benign lymph nodes<sup>21</sup>; Moehrle and coworkers<sup>26</sup> have reported the same problem.

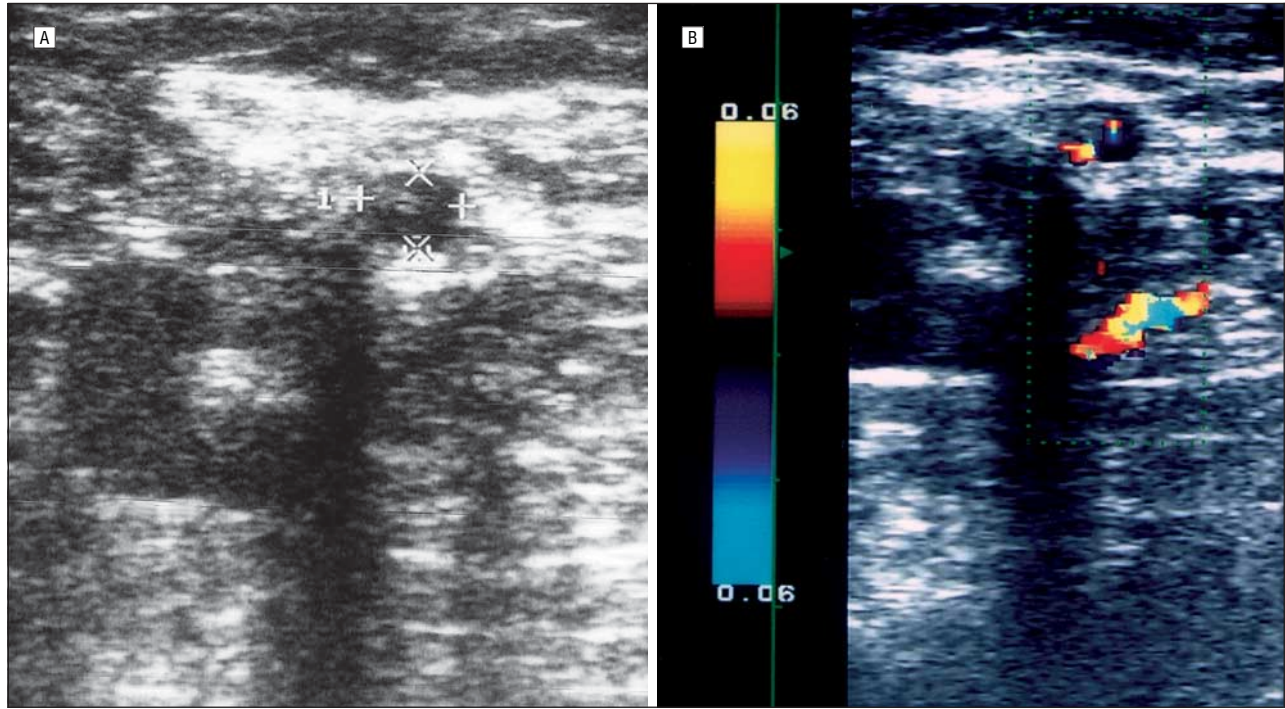
These qualitative vascular patterns are difficult to detect in very small lymph node metastases, for example, those located in the margin of a reactive lymph node (**Figure 8**). In such clinical situations, administration of ultrasound contrast enhancers should be considered. Contrast enhancers were originally developed to facilitate the examination of vessels such as the transcranial arteries, renal arteries, or portal vein. Before intravenous administration, the D-galactose-based contrast enhancer Levovist (Schering, Berlin, Germany) is shaken, leading to a fragmentation of the microparticles with binding on small air bubbles. This induces an increase in scattering, resulting in a signal enhancement, which can be used for diagnosis of blood flow even in very small vessels (0.1-0.3 mm in diameter).<sup>27</sup> Intravenous administration of Levovist improved visualization of vessel topography in lymph nodes of patients with squamous cell carcinomas of the head and neck and in lymph nodes of patients with malignant lymphomas.<sup>28,29</sup> Levovist has been tried in a

pilot study in patients with melanoma to improve visualization of the vascularization pattern in lymphadenopathy, for which it provided additional discriminatory information.<sup>21</sup> Although signal-enhanced CDS is not recommended as a routine diagnostic method, it may be helpful in small lymph nodes with uncertain results by B-scan examination and native CDS, especially to help prevent unnecessary surgery for small reactive lymph nodes (**Figure 9**).

Recently, signal enhancers of the second generation were introduced for the diagnosis of lymph nodes, for example, in patients with head and neck tumors.<sup>30</sup> The advantage of those new signal enhancers is a prolonged period of contrast enhancement leading to an improved contrasting compared with signal enhancers of the first generation (Levovist). One example of a second-generation signal enhancer is SonoVue (Bracco, Princeton, NY), which contains phospholipids and sulfur hexafluoride. SonoVue was introduced in 2001 and is of interest, for example, in the diagnosis of neoplasms of the liver and the kidney. Its value for the assessment of lymph nodes in patients with melanoma will need to be examined in future studies.

## CONCLUSIONS

High-frequency ultrasound using 20-MHz transducers is well established for noninvasive imaging of the borders of skin tumors, the assessment of inflammatory skin diseases, and the measurement of skin thickness. Nevertheless, in case of important inflammatory peritumoral infiltration with the same echo structure as the tumor, the thickness measurement exceeds the histologic tumor thickness. On the other hand, in presence



**Figure 9.** A, B-scan ultrasound examination of an uncertain diagnosis (8 MHz): round mainly hypoechoic structure with small hyperechoic area. B, Signal-enhanced color Doppler sonography (8 MHz): hilus vessel detectable. Diagnosis: reactive lymph node.

of ulcerated lesions, an underestimation may occur. According to both the literature and our own experience, ultrasound scanning with 7.5- to 10-MHz transducers demonstrates a very good sensitivity (up to 99.2%) and an excellent specificity (up to 99.7%) in the diagnosis of metastatic changes in peripheral lymph nodes as well as in assessing soft tissue tumors.<sup>8-10</sup> B-mode sonography is a noninvasive, inexpensive, and reproducible technique. In Germany, the practice of dermatologic oncology without the regular use of ultrasound examinations is almost unimaginable today. In patients with cutaneous melanoma at greater risk for the development of regional lymph node metastases (tumor thickness  $\geq 1.5$  mm), ultrasound examinations are highly recommended both at the first examination and during follow-up, particularly within the first 5 years.<sup>13</sup> In addition, sonographic monitoring of the response of malignant tumors to therapy allows an objective verification and quick adjustment of the treatment plan if necessary. The criteria for the discrimination between benign and malignant lymphadenopathy are not absolute, since B-mode sonography can miss micrometastases. Therefore, native CDS should be used in addition to assess pattern of intranodal blood flow, which may help to increase the diagnostic accuracy. Signal-enhanced CDS for improved visualization of characteristic vascularization pattern should be considered as a supplementary but valuable diagnostic tool in complex cases of lymphadenopathy.

Accepted for Publication: March 29, 2004.

Correspondence: Walter Burgdorf, MD, Traubinger Str 45 A, D-82327 Tutzing, Germany (wburgdorf@gmx.de).

## REFERENCES

1. Makela PJ, Leminen A, Kaariainen M, et al. Pretreatment sonographic evaluation of inguinal lymph nodes in patients with vulvar malignancy. *J Ultrasound Med.* 1993;12:255-258.
2. Kauczor HU, Voges EM, Wieland-Schneider C, et al. Value of routine abdominal and lymph node sonography in the follow-up of breast cancer patients. *Eur J Radiol.* 1994;18:104-108.
3. Steinkamp HJ, Cornehl M, Hosten N, et al. Cervical lymphadenopathy: ratio of long- to short-axis diameter as a predictor of malignancy. *Br J Radiol.* 1995; 68:266-270.
4. Cammarota T, Pinto F, Magliaro A, et al. Current uses of diagnostic high-frequency ultrasound in dermatology. *Eur J Radiol.* 1998;27(suppl 2):S215-S223.
5. Hoffmann K, Happe M, Schuller S, et al. Ranking of 20 MHz sonography of malignant melanoma and pigmented lesions in routine diagnosis. *Ultraschall Med.* 1999;20:104-109.
6. Hoffmann K, el Gammal S, Winkler K, et al. Skin tumors in high-frequency ultrasound. In: Altmeyer P, el Gammal S, Hoffmann K, eds. *Ultrasound in Dermatology.* New York, NY: Springer; 1992:181-201.
7. Gottlöber P, Steinert M, Bähren W, et al. Interferon-gamma in patients with cutaneous radiation syndrome after radiation therapy. *Int J Radiat Oncol Biol Phys.* 2001;50:159-166.
8. Blum A, Schlagenhauß B, Stroebel W, et al. Ultrasound examination of regional lymph nodes significantly improves early detection of locoregional metastases during the follow-up of patients with cutaneous melanoma. *Cancer.* 2000;88: 2534-2539.
9. Voit C, Mayer T, Kron M, et al. Efficacy of ultrasound B-scan compared with physical examination in follow-up of melanoma patients. *Cancer.* 2001;91:2409-2416.
10. Schmid-Wendtner MH, Paerschke G, Baumert J, et al. Value of ultrasonography compared with physical examination for the detection of locoregional metastases in patients with cutaneous melanoma. *Melanoma Res.* 2003;13:183-188.
11. Vassallo P, Wernecke K, Roos N, et al. Differentiation of benign from malignant superficial lymphadenopathy: the role of high-resolution ultrasound. *Radiology.* 1992;183:215-220.
12. Tikjoh G, Kassiv V, Sondergaard J. Ultrasonic B-scanning of the human skin. *Acta Derm Venereol.* 1984;64:67-90.
13. Garbe C, Paul A, Kohler-Späth H, et al. Prospective evaluation of a follow-up schedule in 2,008 patients with cutaneous melanoma: recommendations for an improved follow-up strategy. *J Clin Oncol.* 2003;21:520-529.

14. Korting HC, Gottlöber P, Schmid-Wendtner M-H, Peter RU, eds. *Ultraschall in der Dermatologie—Ein Atlas*. Berlin, Germany: Blackwell; 1999.
15. Fornage BD, McGavran MH, Duvic M, et al. Imaging of the skin with 20 MHz ultrasound. *Radiology*. 1993;189:69-76.
16. Hoffmann K, Gerbaulet U, El Gammal S, et al. 20 MHz B-mode ultrasound in monitoring the course of localized scleroderma (morphea). *Acta Derm Venereol Suppl (Stockh)*. 1991;164:3-16.
17. Tregnaghi A, De Candia A, Calderone M, et al. Ultrasonographic evaluation of superficial lymph node metastases in melanoma. *Eur J Radiol*. 1997;24:216-221.
18. Solbiati L, Rizzato G, Belotti E. High-resolution sonography of cervical lymph nodes in head and neck cancer: criteria for differentiation of reactive versus malignant lymph nodes. In: *Proceedings of the 74th Meeting of the Radiologic Society of North America*. Chicago, Ill: Radiologic Society of North America; 1988. Abstract 113ff.
19. Voit C, Mayer T, Proebstle T, et al. Ultrasound-guided fine needle aspiration cytology in the early detection of melanoma metastases. *Cancer*. 2000;90:186-193.
20. Tschammler A, Wirkner H, Ott G, et al. Vascular patterns in reactive and malignant lymphadenopathy. *Eur Radiol*. 1996;6:473-480.
21. Schmid-Wendtner MH, Partsch K, Korting HC, et al. Improved differentiation of benign and malignant lymphadenopathy in patients with cutaneous melanoma by contrast-enhanced color Doppler sonography. *Arch Dermatol*. 2002;138:491-497.
22. Riedl B, Hiller D, Stosiek N. B-scan ultrasound of regional lymph nodes in different dermatological diseases. In: Altmeyer P, el Gammal S, Hoffmann K, eds. *Ultrasound in Dermatology*. New York, NY: Springer; 1992:87-92.
23. Ohnsorge I, König H, Schill S, et al. Color-coded duplex sonography of pathological enlarged lymph nodes [abstract]. *Radiology*. 1991;181(suppl):S117.
24. Gosling RG, King DH. Arterial assessment by Doppler shift ultrasound. *Proc R Soc Med*. 1974;67:447-449.
25. Tschammler A, Knitter J, Wittenberg G, et al. Quantifizierung der Lymphknotenperfusion mittels farbkodierter Duplexsonographie. *Rofo Fortschr Geb Rontgenstr Neuen Bildgeb Verfahr*. 1995;163:203-209.
26. Moehrle M, Blum A, Rassner G, Juenger M. Lymph node metastases of cutaneous melanoma: diagnosis by B-scan and color Doppler sonography. *J Am Acad Dermatol*. 1999;41:703-709.
27. Schürmann R, Schlieff R. Saccharide based contrast agents: characteristics and diagnostic potential. *Radiol Med (Torino)*. 1994;87(suppl 1):15-53.
28. Mäurer J, Willam C, Schroeder R, et al. Evaluation of metastases and reactive lymph nodes in Doppler sonography using an ultrasound contrast enhancer. *Invest Radiol*. 1997;32:441-446.
29. Ludwig A, Mortiz JD, Kirchhoff L, et al. New perspectives in head and neck sonography by signal-enhanced color Doppler sonography. *Mund Kiefer Gesichtschir*. 1998;2(suppl 1):S163-S167.
30. Stetter S, Jecker P, Stenzel M, et al. Der Einsatz eines neuen Signalverstärkers in der Kopf-Hals-Sonographie [abstract]. *Ultraschall Med*. 2002;23(suppl 1):43.

#### ARCHIVES Feature

Free color publication if color illustrations enhance the didactic value of the article.