Preface to the Second English and Third German Edition

The longer and the more intensively one has been working with medical imaging, the more questions of a broader, more general kind one is confronted with: How well does the image represent the truth? Can our interpretation of the imaging findings explain the patient's disease? Which imaging appearances mean that the patient requires treatment, and if so, which treatment? When does imaging (including incidental findings) lead to unnecessary interventions – due to users not being aware of the intrinsic problems of a diagnostic method or failing to take its inherent limitations into account? These issues are relevant for all diagnostic modalities, including the traditional gold standard of angiography and more recent developments such as magnetic resonance and computed tomography angiography. Applied to diagnostic ultrasonography, the more specific question that arises is how we misinterpret echo patterns or ultrasound features and consequently make erroneous treatment decisions. These problems become particularly manifest when dealing with the morphology of internal carotid artery plaque, where the sonographic appearance of the plaque may be used as a criterion for making treatment recommendations. In the name of scientific rigor investigators sometimes end up focusing too heavily on a single aspect of a complex problem, in turn giving rise to specific assumptions and hypotheses that affect the study design and ultimately lead to wrong, contradictory, and biased results, as well as to the wrong therapeutic conclusions. Despite these cautionary remarks, however, there is good scientific evidence that vascular duplex ultrasonography – as long as both the morphologic appearance and hemodynamic findings are taken into account and as long as the examiner remains critically aware of the methodological basis – comes very close to depicting the true clinical situation in patients with vascular disease. Although somewhat neglected by some "schools of ultrasound," where color flow images (which are more angiography-like) are preferred, spectral Doppler analysis can provide some very valuable information. In particular it can depict the hemodynamic situation (in both normal and diseased vessels) with excellent sensitivity, making it highly useful in the diagnostic assessment of vascular disease and in solving problems of differential diagnosis.

In terms of method and didactic approach this second English edition continues in the tradition of the earlier German editions and of the first English edition and emphasizes the therapeutic relevance of the diagnostic measures being taken. For details on this approach please refer to the earlier prefaces. Staying in the same pedagogical vein but seeking to advance this method further, this extensively revised edition incorporates even more diagrams and tables. The hope is that this will help make examination protocols and complex diagnostic procedures even easier to visualize and understand. This new edition presents the most recent scientific insights as well as new developments in ultrasound technology, which are discussed with regard to their role in providing therapeutically relevant diagnostic information for treating patients with vascular disease. On points where there is no clear consensus regarding the diagnostic status of certain ultrasound features and findings, these controversies are discussed. The atlas sections of the individual chapters have also been expanded to include even more examples of ultrasound findings obtained in the routine clinical setting, along with examples of less common vascular diseases. A focus here is on showing the reader how to interpret Doppler waveforms and how to use the hemodynamic

information to help make a diagnosis. As a little cultural aside, color flow ultrasound can also be counted on to produce images with highly artistic color compositions. My 4-year-old son's comment, upon seeing the proofs of the book, was, "Your new art book is really beautiful."

The author would like to thank Ms Zorn, Ms Rieker, Ms Mehlbeer, and Ms Lietz for secretarial assistance. My thanks are also due to Ms Mütschele for her support in preparing the diagrams and figures. Thank you also to Ms Herwig for the translation and excellent support through all stages of preparing this English edition. Further, I would like to thank the staff of Springer-Verlag for their excellent support in preparing this new edition, particularly Ms Heilmann and Mr Bachem. Most of all, however, I would like to thank my family for their patience and understanding and for the humor that is necessary and makes it easier to pull off a project like this.

Göppingen Wilhelm Schäberle
November 2010

Preface to the First English Edition

Vascular ultrasonography becomes increasingly valuable the more the diagnostic query to be answered is based on the clinical findings and the more the examination is performed with regard to its therapeutic consequences. As with other specialties that make use of ultrasound findings, the diagnostic yield of vascular ultrasound relies crucially on the close integration of the examination into the routine of the clinician or physician treating the patient. That is why in the German-speaking countries, vascular ultrasound is chiefly performed by angiologists and vascular surgeons. Duplex ultrasound can indeed be regarded as an integral component of the angiologic examination or an extension of the clinical examination by fairly simple technical means. Thus the sonographic findings do not simply supplement other imaging modalities but, together with the clinical findings, provide the basis for deciding whether medical therapy, a radiologic intervention,or surgical reconstruction is the most suitable therapy for an individual patient. This means that in a patient with atherosclerotic occlusive disease of the leg arteries, the patient's clinical presentation determines whether or not surgical repair is necessary, while the duplex sonographic findings serve to plan the kind of repair required and to confirm the localization and extent of the vascular pathology suspected on clinical grounds. Up to this point, no invasive diagnostic tests are needed. Angiography continues to have a role in planning the details of the surgical procedure, i.e., identification of a suitable recipient vessel for a bypass graft. Some surgical procedures such as thromboendarterectomy of the carotid arteries or femoral bifurcation can be performed without prior angiography, which does not provide any additional information that would affect the surgical strategy. Duplex sonography has evolved into the gold standard for answering most queries pertaining to venous conditions (therapeutic decision-making in thrombosis, planning of the surgical intervention for varicosis, chronic venous insufficiency).

Special emphasis is placed on the therapy-oriented presentation of indications for vascular ultrasonography, including the sonographic differentiation of rare vascular pathology and the role of the ultrasound examination in conjunction with the patient's clinical findings. The abundant images provided are intended to facilitate morphologic and hemodynamic vascular evaluation and put the reader in a position to become more confident in identifying rare conditions as well, which often have a characteristic appearance and are thus recognizable at a glance. The high acceptance of the diagnostic concept advocated here as reflected in the success of the first two editions of the book in the German-speaking countries led to the decision to have an English edition. I would like to thank Springer-Verlag, in particular Dr. Heilmann, for making this English edition possible.

Göppingen
August 2005

Wilhelm Schäberle

Preface to the Second German Edition

Vascular duplex sonography is the continuation of the clinical examination of vascular disease by fairly simple technical means. A sonographic examination relies on interaction with the patient and is guided by the clinical findings, therapeutic relevance, and treatment options available. It is highly examiner-dependent and does not easily lend itself to full documentation of the results, which are thus difficult to communicate and verify. For these reasons, sonographers require thorough training, both to avoid inaccurate findings with disastrous consequences for patients and in order not to discredit the method.

The format of the first edition with a text section and an atlas for each vascular territory has been retained as has the subdivision of the individual chapters into sections on sonoanatomy, examination technique, normal findings, abnormal ultrasound findings, and diagnostic role of the sonographic findings. Given the special focus of this textbook on clinically and therapeutically relevant aspects of vascular ultrasonography, each of the main chapters (peripheral arteries and veins, extracranial arteries supplying the brain, hemodialysis shunts, and abdominal and retroperitoneal vessels) has been supplemented with a section on the clinical significance of ultrasound examinations in the respective vascular territory. This addition was considered necessary in order to do justice to the expanding and changing role of diagnostic ultrasound since the first German edition six years ago. While until only a few years ago vascular ultrasound was used for orientation or served as a supplementary diagnostic test only, it has since evolved into a key modality in this field. It has since even become a kind of gold standard in the diagnostic evaluation of veins, in particular in patients with thrombosis and varicosis. In this setting, venography has lost its significance and its use is now restricted to exceptional cases where it serves to obtain supplementary information to answer specific questions.

In patients with arterial disease, duplex ultrasound is an integral part of the step-by-step diagnostic workup. The sonographic findings provide the key to adequate therapeutic management (medical therapy, radiologic intervention, or vascular surgical repair). Together with the patient's clinical status, duplex sonography is thus decisive for establishing the indication for medical therapy or invasive vascular reconstruction. Duplex sonography has replaced angiography in the localization of a vascular obstruction and the evaluation of its significance. The invasive radiologic modality is used only to identify a suitable recipient segment in patients scheduled for a bypass procedure or in combination with a catheter-based intervention (PTA and stenting). The morphologic information provided on the vessel lumen and wall as well as on perivascular structures makes nonatherosclerotic vascular disorders a domain of ultrasound.

Ultrasonography is the method of first choice in evaluating carotid artery stenoses for stroke prevention by identifying those patients who would benefit from surgical repair on the basis of hemodynamic parameters but also taking into account morphologic information. Ultrasound can retain its central role in therapeutic decision-making only if its advantages are fully exploited, which means that the examination should be performed by the angiologist or vascular surgeon who is also treating the patient. This is why this second edition is again intended mainly for angiologists and vascular surgeons.

The revised edition also describes recent developments such as the use of ultrasound contrast media, or echo enhancers, in angiology and the B-flow mode although their role in the routine clinical setting is small from the angiologist's and vascular surgeon's perspective. The use of ultrasound contrast media in differentiating liver tumors is not dealt with in detail since it is mainly of interest to gastroenterologists and visceral surgeons and would therefore go beyond the scope of this textbook.

As in the first edition, great care was taken in selecting illustrative ultrasound scans of high quality for the atlas, following the motto "an ultrasound image must speak for itself ". The sonomorphologic context is important for didactic purposes; that is why the pathology of interest is not shown in a magnified view (zoom) but presented in the constellation in which it appears in the course of a routine examination. In those settings where the sonication conditions are poor but an ultrasound examination nevertheless appears to be indicated from a clinical perspective as in postoperative patients, the examples shown were not selected specifically but are such as illustrate this fact. Angiograms, and in individual cases graphic representations, are intended to clarify the situation.

The abundant images contained in the atlas sections reflect the intention not only to present abnormal finding as such but to illustrate more clearly situations that are relevant from a therapeutic perspective and to also show the development of vascular pathology. Adhering to the ultrasound convention of depicting cranial on the left side of the image and caudal on the right, the blood flow direction is color coded in accordance with the defaults settings of the ultrasound equipment. This means, for instance, that the internal carotid artery is coded in blue, indicating arterial blood flow away from the transducer. Following this convention, it is thus not necessary to first have to look for the color key, and orientation is facilitated when complex vascular territories such as the abdominal and retroperitoneal vessels are examined.

The detailed introduction to the fundamental physical principles of diagnostic ultrasound and basic hemodynamics under normal and abnormal conditions as well as the detailed description of vascular anatomy, examination protocols, and of the interpretation of the findings aim at providing the beginner with an introduction to vascular ultrasound. It is hoped that the richly illustrated atlas sections will facilitate the first steps for the beginner. For experienced sonographers, the detailed illustrations also of rare vascular pathology are expected to broaden their knowledge and help them diagnose rare disorders with greater confidence. To this end the role of ultrasound examinations is compared with that of other diagnostic modalities and tips and tricks are described that facilitate the examination and provide a basis for tackling more difficult diagnostic tasks. That is why all diseases in which ultrasonography is indicated and that are of relevance for angiologists and vascular surgeons are represented by images in the atlas. Rare vascular conditions can often be identified sonographically at a glance. Where appropriate, additional angiograms illustrate the role of the respective modality in comparison, and occasionally the situation is further clarified by an intraoperative photograph.

The constant support I received from Professor R. Eisele is gratefully acknowledged. My special thanks are due to the co-workers of Springer-Verlag for their excellent cooperation in preparing the second edition and to Ms. R. Mütschele for her assistance in preparing the graphics.

Göppingen
February 2004

Wilhelm Schäberle

Preface to the First German Edition

Conventional and color duplex ultrasonography has evolved into an indispensable tool for the diagnostic evaluation of vascular pathology. As a noninvasive test that can be repeated any time, sonography is increasingly replacing conventional diagnostic modalities that cause more discomfort to the patient. The combination of gray-scale sonographic information for evaluating topographic relationships and morphologic features of vessels with the qualitative and quantitative data obtained with the Doppler technique enables fine diagnostic differentiation of vascular disorders. In particular, the hemodynamic Doppler information is a useful supplement to the findings obtained with radiologic modalities. Being noninvasive and easy to perform any time, duplex sonography precedes more invasive, stressful, and expensive diagnostic tests in the step-by-step diagnostic workup of patients with vascular disease. It provides crucial information for optimal therapy and will replace invasive modalities such as angiography and venography as examiners gain skills and experience and ultrasound equipment becomes more sophisticated.

The significance duplex ultrasonography has gained in the hands of angiologists and vascular surgeons is also reflected in the further education programs for these specialties. This book therefore aims at providing a detailed description of the diagnostic information that can be obtained by (color) duplex sonography in those vascular territories that are relevant to angiologists and vascular surgeons. Each of the main chapters introduces beginners to the relevant vascular anatomy and scanning technique while at the same time offering detailed discussions of the parameters involved and a thorough review of the pertinent scientific literature to help experienced sonographers become more confident in establishing their diagnoses.

The first chapter presents the basic hemodynamic concepts that are relevant to vascular sonography and the fundamental physical and technical principles of vascular ultrasonography. This introductory chapter is intended to help readers grasp the potential and limitations of the method.

The situation in Germany is different from that in many other countries in that duplex sonography is performed primarily by angiologists, internists, and increasingly by vascular surgeons rather than by radiologists. On the basis of a patient's clinical findings, it is thus possible to specifically address therapeutically relevant questions in performing the sonographic examination. Besides general assessment of the vascular status, ultrasound can thus serve to acquire additional diagnostic information important for therapeutic decision-making in general and for planning the surgical procedure in particular. Duplex sonography in the hands of the clinician who is also treating the patient is seen as the continuation of the clinical examination by technical means. That is why the emphasis in this book is on the clinical and therapeutic role of ultrasound findings, and the individual chapters are organized according to such pragmatic aspects.

Each of the six main chapters deals with a specific vascular territory and consists of a text section as well as an atlas section with ample illustrations and detailed descriptions of normal findings, variants, and abnormal findings.Whenever considered appropriate for better illustration of complex pathology, the sonographic images have been supplemented with angiograms or CT scans. The comparison also illustrates the advantages and disadvantages of the respective

radiologic modalities. As many rare vascular disorders are diagnosed at a glance by an experienced sonographer, their appearance is shown in numerous figures. Series of ultrasound scans document the course of the examination and complex hemodynamic changes in vascular disorders as well as their clinical significance and changes under therapy. The legends provide detailed descriptions allowing the reader to use the atlas sections independently for reference when looking for information on specific vascular conditions.

Different ultrasound modes are described in detail and their respective merits and shortcomings are discussed for the benefit of readers using different equipment. Gray-scale sonography alone (compression ultrasound) is quite sufficient for the diagnostic assessment of thrombosis while conventional duplex ultrasonography is a valid modality for diagnosing therapeutically relevant abnormal changes of the femoropopliteal territory. In most instances, color flow images are shown together with the Doppler waveform but occasionally "only" the conventional duplex scan is presented to illustrate the fact that many abnormalities can be identified by conventional duplex ultrasound alone. Despite the additional diagnostic information obtained with the color-coded technique, quantitative evaluation relies on the Doppler frequency spectrum. The color duplex mode can facilitate the examination procedure (identification of small vessels, recanalization, differential diagnosis) but the sonographer needs some basic knowledge of the conventional Doppler technique for the proper interpretation of color flow images.

My special thanks are due to Professor R. Eisele for promoting the use of diagnostic ultrasound in the department of vascular surgery at our hospital and for his valuable advice. I thank Ms. G. Rieker and Ms. E. Stieger and Mrs. B. Sihler for typing the manuscript and Ms. R. Uhlig for the photographic work in preparing the figures.

Finally I would like to express my thanks to the publishers, Springer-Verlag, and in particular to Ms. Zeck and Dr. Heilmann, for their excellent cooperation and constructive support.

Göppingen Wilhelm Schäberle
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