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Internet-based digital video atlas of sonographic findings for clinical and educational purposes

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Abstract

Introduction: A professional and valid ultrasound examination is dependent upon an extensively experienced examiner. Recognition and classification of rare or minimally distinctive findings are a particular source of uncertainty on the part of the examiner. By creating an online-based video database of sonographic findings, we tried to share our own experience for clinical and educational purposes. **Material and methods:** More than a thousand video clips of documented ultrasound findings were anonymized and cut to a practicable length of between 10 and 25 sec. The findings were critically evaluated and labeled with a primary diagnosis. They were also classified by organ systems and various keywords. **Results:** An online portal that currently contains more than 1,000 video sequences of typical, non-typical, especially vivid or rare ultrasound findings has been created. The portal is free of charge and accessible for any Internet-capable PC. It is also optimized for use on mobile devices (smartphones, iPads, etc.). Search and location of relevant findings is performed using keywords or a diagnosis-based search function. The Internet address is www.sono.gallery. **Conclusions:** The video portal is a fast and universally accessible non-commercial platform. Its moving images can be used as an aid in resolving problematic differential diagnoses of typical, non-typical or especially rare ultrasound findings or in verifying one's own findings.

Introduction

Medical ultrasound (US) takes extensive and structured training to conduct a qualifying examination, for which specialist bodies set strict guidelines.

Apart from proper manual performance, there are further requirements that must be met to ensure an informative US examination. The device should meet the highest possible technical standards, the examiner must be familiar with image optimization (adjustment of frequency, focus, gain, etc.), and many diagnostic questions require a sufficient level of patient compliance. Many questions can only be answered if the examination is afforded sufficient time and diligence.

The US examination technique can be learned in US training courses, which are available in several books, online courses, and in traditional courses as classroom teaching, too. This is a prerequisite for a successful US examination. Learning US technique is also increasingly important in preclinical education[1,2]. For localized questions, it has been demonstrated that web-based training is just as effective as classroom teaching[3,4]. In contrast, *interpretation* of sonographic findings is a permanent challenge.

The clinical evaluation and classification of a sonographic finding are often difficult and, more than any other imaging procedure, dependent on extensive experience on the part of the examiner. This experience is

usually gathered during a lengthy clinical training period. Ideally, an experienced colleague will be available during this clinical training to help interpret unusual findings. Unfortunately, this is often not the case in practice, and not only at universities, because of the lack of time, a high number of students and low practical hands-on time.

An alternative would be to use reference books to clarify differential diagnoses. In practice, the required books are often not found on site, and they are cumbersome to use because even recently published standard works[5] only include small and sometimes outdated pictures.

In the case of CT and MRI, there are increasing databases that facilitate finding out the diagnosis by comparing images and using algorithms and artificial intelligence (AI)[6,7]. US imaging is less standardized and therefore a challenge for AI-based diagnostic tools.

A single image does not reflect the visual impression of a moving US image from a real-time examination.

Many young employees – for the sake of convenience – resort to using general search engines to search the Internet for examples of US images. This makes it impossible to guarantee sufficient quality in the interpretation of findings.

Material and methods

Over more than five years, US clips were digitally recorded and stored by five experienced physicians from three German academic teaching hospitals as part of routine clinical examinations, using high-end US machines of the newest generation. The US clips were critically evaluated by at least two reviewers who had experience analogous to the DEGUM II or III certification (www.degum.de). The result was a selection of more than 1,000 digitally documented US clips with typical, rare or uncommon sonographic findings.

In a subsequent digital post-processing phase, the clips were cut to a practicable length of 10 to 25 s, and a representative standstill image was selected. The pathological findings were highlighted in the images using arrows. All patient-related data were removed. The images were labeled and, if necessary, a pictogram was added.

Finally, each clip was assigned to an organ system (Tab. 1) and tagged with different keywords (Tab. 2). All videos were made freely available by exporting them to an internet-based database.

For our database, we only used clips on which all patient-related data were removed, and conclusions regarding individuals were excluded. The procedure has been reviewed and approved by the responsible ethics committee.

Tab. 1. *Assignment of videos to different organ systems (in alphabetical order)*

Biliary
Intestine
Kidney
Liver
Lymph
Pancreas
Spleen
Thorax
Thyroid
Unassigned
Vascular

Tab. 2. *Assignment of different key words to each video (in alphabetical order)*

Beginner
Benign
CEUS*
Duplex
EUS**
Excellent
Expert
Inflammatory
Intervention
Malignant
Normal
Pronounced
Typical
Unspecific
* Contrast-enhanced ultrasound, ** Endoscopic ultrasound
CEUS – contrast-enhanced ultrasound; EUS – endoscopic ultrasound

Results

A website has been created with the Internet address www.sono.gallery with 1,220 US clips available (as of January 2020).

When creating the website, a great deal of emphasis was placed on clarity and ease of use. There is no login procedure. There are no pop-up windows, and the site is operated without advertising. To simplify navigation, there are no submenus.

On the home page, the videos are displayed as tiles with the standstill images as thumbnails (Fig. 1). When clicked, the video plays at an optimized resolution of at least 360 dpi. The website logo – a stylized bat – functions as a "Home" button, which is always displayed at the top of the page. A diagnosis can be entered in a search field to narrow down the videos displayed, resulting in a list of all videos associated with this diagnosis. Another way to navigate is by selecting organ systems and tags (Tab. 1 and Tab. 2).

The website has been optimized for different playback formats. This way, video clips can be viewed on conventional

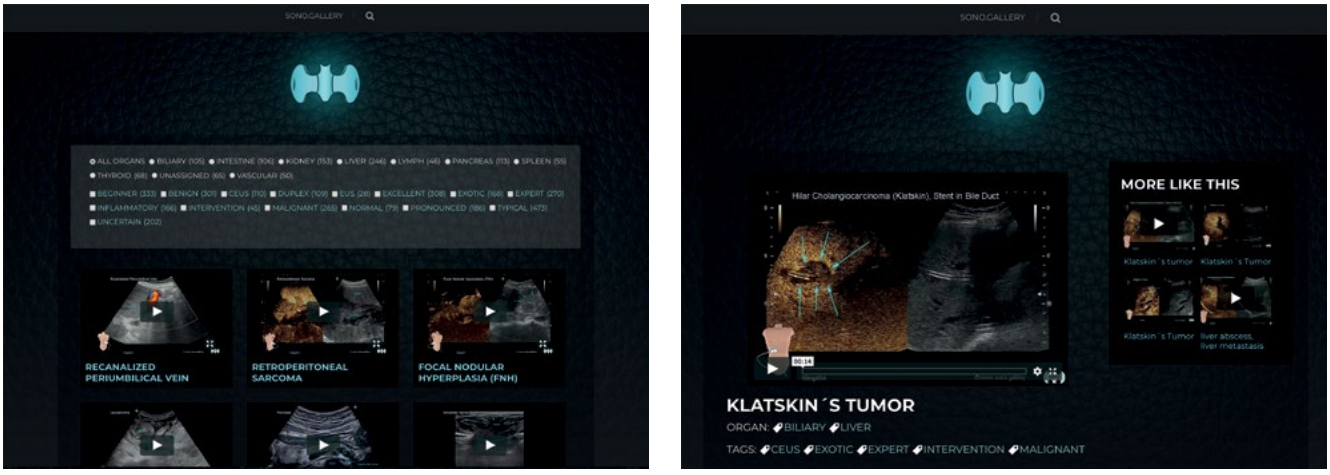

Fig. 1. *Design of the website with standstill images as thumbnails*

desktop computers as well as on portable computers and mobile phones.

The website is designed for a continuous expansion of the database. To this end, physicians who perform US examinations are invited to send their sonographic findings per mail to submit@sono.gallery. The findings should meet the above criteria and be video-recorded on a high-end device. After a pre-selection, the videos will undergo a review process and digital processing as described above. Also, the sender will be identified (name and city) with the phrase "by courtesy of..." on the standstill image of the video clip.

Video clips on the website are displayed in the order of submission, with the most recently added videos shown first.

Discussion

There are several established methods for learning US methodology. In addition to traditional classroom teaching in standardized courses, there are various textbooks, some of which are also freely available online. Finally, there are online tutorials, which mostly provide different kinds of video-based instruction in US examination[1,2,7–10]. Some of them have been validated in comparative studies[4,11], but there is no generally accepted standardized training tutorial for web-based US training[12,13].

When it comes to aids for interpreting sonographic findings, there are significantly fewer computer-assisted tools available[12,14].

Internet-based e-learning modules are described in various disciplines, e.g. rheumatology[15], echocardiography[16,17] or breast US[18], but all these modules are either not freely available or not placed online, or they are not in English. The EFSUMB and WFUMB websites offer comprehensive online textbooks with both systematic examination instructions and a variety of US findings. The collection is partly freely available, and US pictures are shown predominantly as standstill images and not in a video format[1,19,20].

Traditionally, differential diagnoses are clarified using books. Some of these books are quite extensive[5], but the image quality is sometimes poor and the pictures are seemingly decades old. Alternatively, there are US atlases on the Internet, some of which are also extensive[21], but the quality of their content is not always checked.

Both printed books and the available online libraries provide predominantly standstill images, which do not sufficiently reflect the sonographic reality. There are many examples in which a moving image offers advantages (e.g. a cyst vs vascular graft, intestinal motility, lung US, duplex US, CEUS, and many more). Furthermore, moving images make it possible to develop a three-dimensional idea of imaged findings and can record different findings that are not located within a single plane.

The data speed available on the Internet in most regions today offers the possibility of providing high-quality US videos in place of standstill images. In the website presented here, older videos have a resolution of 600 × 800 pixels, while the newer ones: 800 × 1,200 pixels. This resolution corresponds to the quality supported by the video export function of most modern US devices. The online database presented here is permanently up-to-date, extremely extensive and can be expanded. The videos can be watched at any time and almost everywhere, as often as desired. These are clear advantages compared e.g. to classroom teaching.

Clarity plays an important role in the acceptance of a new online service. Branched submenus were deliberately left out. Search terms can even be entered on the start page. Alternatively, one can narrow the video search according to tags and organ systems. Clicking the home button, which is prominently displayed on all pages, allows one to perform another search.

Because of this clarity, the website is also suitable and optimized for smaller devices, such as tablets or mobile phones. This should appeal to younger doctors in particular, and it becomes usable even in ward rounds or during outpatient visits.

The website presented here also has limitations. It does not replace a textbook with systematic differential-diagnostic considerations. This was not the goal when creating the website. The principles of great clarity and easy navigation also mean that detailed differential-diagnostic treatises cannot be integrated into the website.

Compared to a standstill image, a video has the advantage that different findings can be displayed, even if they do not lie in one plane. In the present collection, the findings were only labeled on the standstill image. It would require a much greater technical effort to add arrows and labels to moving images, and so this has not been done.

Many findings have been taken from a clinical context. It would often be clearer and more desirable to display the entire case including histopathological findings, medical history, follow-up time, etc., especially for rare findings or when depicting interventions. However, this would disproportionately increase the cost and scope of the website and was not the goal of creating a collection of findings, such as that of the website described here.

Excellent grayscale screen resolution is especially necessary when displaying sonographic findings from the fields of gastroenterology and hepatology. In our experience, most modern tablets and mobile phones have sufficient screen quality for good sonographic display, whereas many desktop computers in hospitals do not, since they are optimized for text display and frequently do not have a robust graphics card.

Operating an ad-free website results in constraints due to the limited budget. For example, search engine optimization (SEO) of sono.gallery could be improved.

On the other hand, the simple structure and the lack of advertising are precisely the qualities intended to make the website attractive to the user, thus encouraging wider acceptance and use. Despite the low operating budget, it is planned to continually expand the video collection and, soon, offer it as a standalone application in popular web stores to improve exposure to younger doctors in particular.

Conclusions

The video portal www.sono.gallery is a freely accessible platform for sonographic findings. It is permanently up-to-date and available nearly everywhere and at any time. By consistently using videos, it is superior to standstill images. The videos can be played as often as required and are therefore an efficient tools both in US teaching and for differential diagnosis during clinical routine.

Conflict of interest

Authors do not report any financial or personal connections with other persons or organizations, which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

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