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Application of three-dimensional ultrasonography (3D ultrasound) to pretreatment evaluation of plastic induration of the penis (Peyronie's disease)

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Abstract

Aim: Peyronie's disease (PD) or plastic induration of the penis, require complete evaluation of plaques in order to decide the best therapeutic option for patient. The purpose of this study is to compare the findings of three-dimensional ultrasound (3D US) and two-dimensional ultrasound (2D US) in patients with PD. **Materials and methods:** Twenty patients with PD aged 30 to 72 years were included in study. The examination was performed with a 12 MHz linear probe, using 2D US and 3D US. Localization and size of plaques were determined and time needed for imagine acquisition was determined in every case. **Results:** 3D ultrasound permits the visualization of the entire plaque in the coronal plane of plaque with its precise measurements. No statistical difference in plaque dimensions and its surface area assessment using 3D US and 2D US was found (127.72 mm² *vs.* 128.74 mm², p>0.05). The possibility to perform detailed analysis of the acquired images using generated digital cube reduced the average duration of the acquisition to 69.8 seconds (median 64 seconds) for 3D US *vs.* 151.25 seconds (median 145.5 seconds) for 2D US (p<0.05). A supplementary plaque was detected using 3D US. **Conclusions:** 3D US seems to be a valuable complement of 2D US for patients with PD. The acquisition time is significantly reduced using 3D US comparing to 2D US and thus it is more comfortable for the patient.

Keywords: Peyronie's disease; two-dimensional ultrasound; three-dimensional ultrasound

Introduction

Plastic induration of the penis (*induratio penis plastica*) was described for the first time by de La Peyronie in 1743. This condition is characterized by the occurrence of cicatrical and fibrous sclerotic areas within the tunica albuginea, septum or tissues of the cavernous body resulting in a painful bend during erection, which impedes sexual intercourse [1-3]. The induration develops slowly into the form of plaque or hard "string" palpable in the dorsal part of the penis and near the urethra. The epidemiological data on Peyronie's disease (PD) are inconsistent. PD affects males of all ages, from teenagers to elders. It was established that tunical mechanical stress and microvascular trauma were major contributory factors to the pathophysiology of PD. The role of genetics as a causative factor for PD is still unknown [4].

Evaluation of the plaque localization and size determines the therapeutic strategy and provides a basis for determining progress in the course of medical treatment. Imaging techniques used to evaluate the size of the plaque were X-ray examinations, ultrasound (US) and magnetic

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resonance imaging (MRI) [5-7]. The US examination is most cost-effective and most accessible of the mentioned methods and thus seems to be an excellent diagnostic modality [8]. It provides the opportunity to assess disease progress and response to treatment during follow up in an outpatient clinic [9]. In addition, current US devices permitted three-dimensional ultrasound (3D US) images.

According to our knowledge, no data regarding 3D US in PD have been published. For this reason, the purpose of the study was to compare 3D US and 2D US findings in PD.

Materials and method

Patients

Twenty patients with PD were included in this prospective study. The study was conducted between 2007-2018 in the Department of General and Oncological Urology, Collegium Medicum in Bydgoszcz, Nicolaus Copernicus University in Toruń. The average patient age was 55.4 years (30-72, mediana 56.5 years). The diagnosis criteria for inclusion was a palpable plaque in the tunica albuginea and acute symptoms of active disease, e.g. pain. The angle of curvature in patients ranged from 15° to 35°. The exclusion criteria was prior treatment for PD. The study was approved by the local Ethics Committee. All patients gave their signature on the written informed consent before joining the study.

Ultrasound examination

All US examinations were performed by one experienced urologist using B&K Medical Pro Focus 2202 device with 12 MHz linear probe. The first step of evaluation included a regular grey-scale US scan of the penis in order to visualize PD plaque. Both axial and sagittal scans were obtained with dimension assessment. In the second step the 3D ultrasound images were obtained. The probe was set transversely to the longer axis of the penis and it was moved one time at the dorsal surface from the root of the penis toward the glans with the 3D option on (fig 1). During the probe movement, the device acquired single US images (fig 2) which were encoded as voxels or "volume units" and processed into a 3D shape (cube) (fig 3). After the examination, the obtained cube was processed using computer software. The cavernous and spongy bodies were evaluated, the plaque was identified, located and measured (length, width and thickness). By rotating the cube in any direction, non-standard cross-section views may be acquired. Thus, it was possible to obtain a coronal view, apart from traditional axial and sagittal views (fig 4). A detailed analysis of the images including measurements of the plaque, evaluation of its location and number of plaques were conducted on the obtained 3D cube. All patients were included in the conservative treatment. The time necessary for 3D US acquisition and 2D US examination were measured in every case.

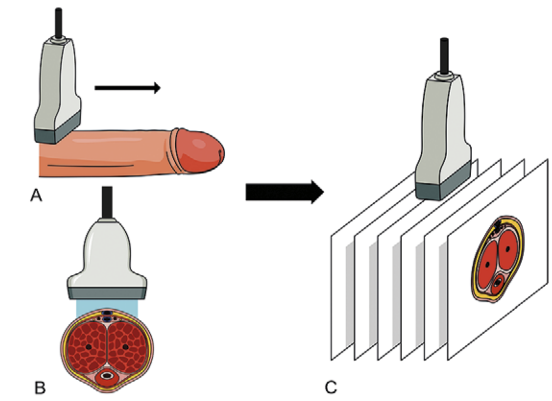

Fig 1. 3D ultrasound acquisition process. (A, B) The probe was set transversely to the longer axis of the penis and it was moved once at the dorsal surface from the root of the penis toward the glans with the 3D option on. (C) During the probe movement the device acquires single ultrasound images and converts them into a three-dimensional shape (cube)

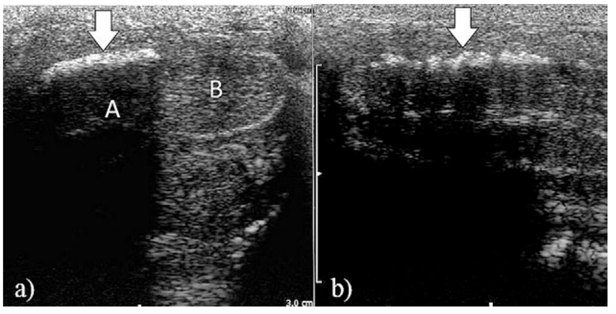

Fig 2. 2D ultrasound a) axial (transverse) cross-section of the penis. Visualization of cavernous bodies (A, B) and hyperechogenic plaque (arrow) above the right cavernous body; b) sagittal (longitudinal) cross-section of the penis with hyperechogenic plaque (arrow).

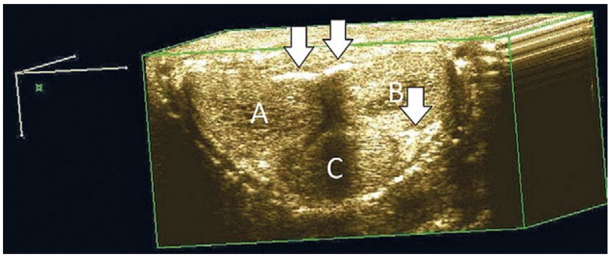

Fig 3. 3D ultrasound: visualization of the cube consisting of voxels acquired after 2D image processing. This cube may be rotated in any direction, the walls may be relocated and 3D images may be generated. It depicts transverse cross-section of the penis with hyperechogenic plaque within the tunica albigunea (front wall of the cube). Cavernous bodies (A,B) and hyperechogenic plaque (arrow)

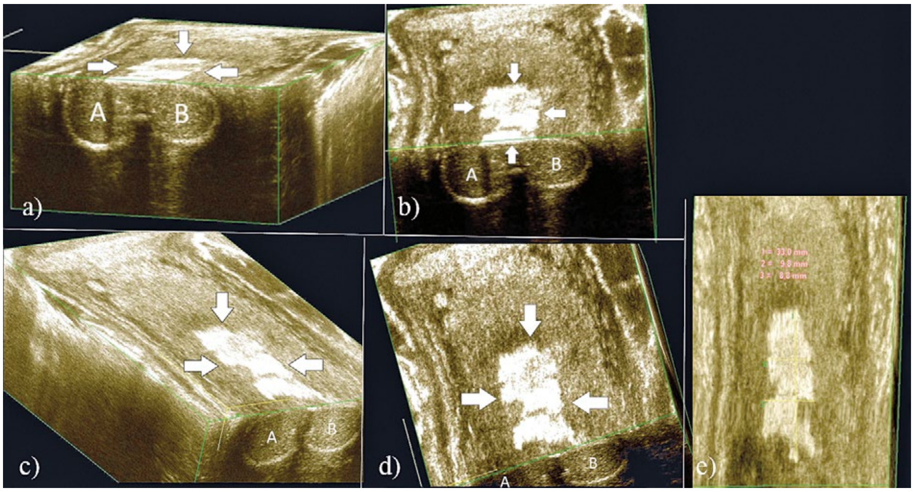

Fig 4. 3D ultrasound. The cube made of voxels provides three-dimensional ultrasound image. In successive illustrations (a to e) the cube is being rotated. The superior wall of the cube is relocated in order to visualize the whole plaque in coronal cross-section. Visualization of the whole plaque allows the specialist to estimate the extent of lesion, which in turn facilitates the planning of the surgical procedure. Cavernous bodies (A, B) and hyperechogenic plaque (arrows).

Statistical analysis

Nonparametric data are presented by mean or median and range The Mann–Whitney U test was used to compare 2D US and 3D US examinations. A p value <0.05 was chosen for statistical significance.

Results

No statistical difference in plaque dimensions and its surface area assessment using 3D US and 2D US was found (127.72 mm² *vs*. 128.74 mm², p>0.05) (fig 5). The possibility to perform detailed analysis of the acquired images using generated digital cube reduced the average duration of the acquisition to 69.8 seconds (median 64 seconds) for 3D US *vs*. 151.25 seconds (median 145.5 seconds) for 2D US (p<0.05). One new plaque was identified during 3D image processing which was not recognized earlier using 2D US (fig 6). Seventeen patients had a single plaque and three patients had two plaques. Eighteen plaques were located in the dorsal part of the cavernous body, three in the lateral part of the cavernous body and two in the ventral part of the penis, near the spongy body of the urethra. Two examinations had to be repeated due to an error during the acquisition (the first

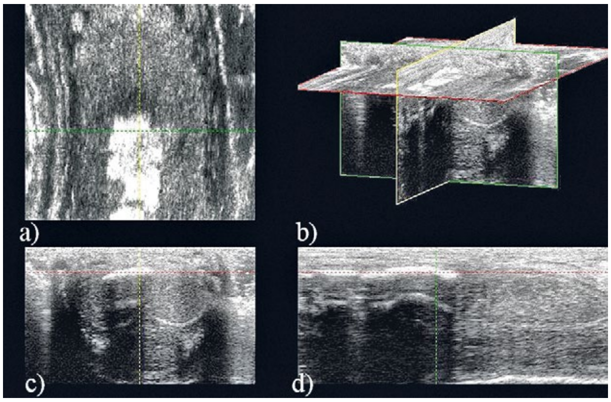

Fig 5. 3D ultrasound: a) coronal cross-section that depicts the entire plaque; b) visualization of the cube of voxels with cross-section planes which may be relocated. This is the active part of the image where the user may select cross-section plane illustrated in a, b, c; c) axial cross section with axial view of the plaque; d) sagittal cross-section, depicts the cavernous bodies and the plaque above them.

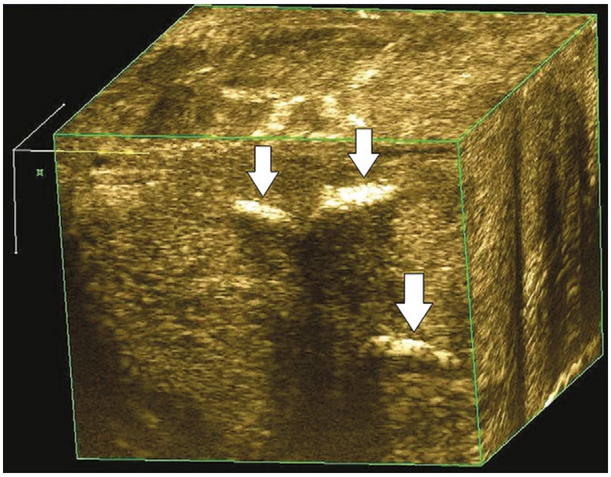

Fig 6. 3D ultrasound cube, transverse cross-section of the penis. Depicts one plaque in dorsal part of the cavernous bodies. Another smaller plaque overlooked during prior 2D examination is visible in the ventral part of the left cavernous body.

examination was repeated due to the patient's sneezing and the second due to the inappropriate movement of the probe by the physician). Both errors were noted directly on acquisition; therefore, the procedure was repeated immediately, without the need to recall the patient.

Discussion

Visualization of the plaques permits the estimate of the extent of the lesion, and the measurement of its size and impact on penis behavior during erection. This information is crucial for interventional treatment modalities and planning the procedure itself.

The first imaging method of PD was an X-ray examination. For the penis examination a mammography-like technique is used [10]. The effect depends on the amount of calcification in the lesion, only the calcified lesions being visible. Moreover, lesions located proximally to the root of the penis in some cases may be not visualized due to impaired imaging by overlapping surrounding tissues. The disadvantage of this method is the need to expose the body to radiation in the vicinity of the testicles.

MRI, a non-radiant imaging technique, is an accurate method for PD lesions assessment, especially for planning the surgery procedure, but is expensive and devices are still not widely available [11,12]. MRI should be considered especially in cases with suspicion of malignant disease and prior penile surgery [13,14]. Calcified plaques are better visualized with the use of US. Moreover, color Doppler US was proved to be superior to MRI in evaluating vascular causes of erectile dysfunction [15].

US examination is a largely available and repeatable imaging technique, reasonably cost and without radiation exposure, being the method of choice in the initial urological evaluation. Pioneering reports describing the application of US in PD assessment were published in 1980 [16-18]. The major advantages as painless, free of risk, easy to perform examination, yielding precise morphologic images ideal for documentation and assessment of the anatomic alterations, as well as the follow up, were underlined [19]. Kumar et al showed that US was more accurate than the clinical examination in the assessment of the extent lesions. In 30% of patients included in his study, US demonstrated that fibrotic plaques were in fact more extensive than primarily described after palpation [20].

In the last 40 years, the image quality was improved due to development of higher frequency probes and US devices equipped with additional properties as color Doppler, power Doppler and elastography [21-24]. The most commonly used method was 2D examination visualizing the axial and sagittal view of the plaque. US provides identification of small and non-palpable lesions and enables to assess the extent of fibrosis. All patients with erectile dysfunction and penile rigidity, length loss, chronic pain with erection should be suspected of PD manifested with nonpalpable isolated septal scars [25]. Chung et al showed, with 1120 patients, a strong correlation between the plaque size and the development of erectile dysfunction. Moreover, authors concluded that large plaque size is a strong predictor of surgical intervention [26]. The association of vascular abnormalities with PD has been proven. Kadioğlu et al indicated that penile vascular abnormalities could be observed in 76.5% of PD cases with a tendency to increase to 87.5% among patients with erectile dysfunction [27].

Devices with 3D software option allowed to visualize the coronal view of the penis. This was a breakthrough, which facilitated visualization of the whole plaque in its actual size, shape and location. To our knowledge, it is the first study that has used 3D US in the assessment of plaques in PD. In addition, the US examination of penis is quite an intimate procedure, so it is crucial to limit the examination time to minimum. Our study showed that 3D US examination lasts for the patient only as long as the data acquisition requires. All measurements, evaluation of the quantity and size of plaques may be performed after the image acquisition, similarly to computed tomography and MRI, without the patient's participation. Furthermore, 3D US seems to be a great tool for the evaluation of treatment outcomes. It allows to assess the effect of treatment on the plaque size, echogenicity and plaque shape. Imaging of the entire plaque gives a unique opportunity to compare images during treatment. 3D ultrasound examination in those cases ceases to be a subjective assessment, but becomes an objective examination that can be fully appraised in the future by another physician during follow up, which is difficult in 2D ultrasound.

The limitations of the US technique are related to the individual skills of the examiner, which affect the length and quality of the 2D US and 3D US examinations. Each case can vary in severity and may require a different examination time. Assessing the quality of examinations, the attention should be paid to the appropriate speed for the movement of the ultrasound probe along the examined tissue maintaining a constant direction and angle of displacement. Even slight irregularities during the acquisition process disturb the final image (cube) and make impossible to assess the correct dimensions of plaque in the coronal view. In our study, all examinations were performed by one experienced 3D ultrasound urologist.

The limitations of the study are the lack of inter- and intraobserver comparisons. Also, US results were not compared with other imaging technique, e.g. MRI. The lack of follow-up makes it impossible to assess the value of 3D US in treatment results assessment.

In our opinion a prospective study comparing the histological, MRI and US with elastography and Doppler findings should be performed to improve the knowledge regarding the pathology of PD.

Conclusions

3D US seems to be a valuable complement of 2D US for patients suffering from PD. The final evaluation of disease using 3D US is performed after the acquisition of images and does not require patient participation. It reduces significantly the acquisition time and thus it is more comfortable for the patient.

Conflict of interest: none

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