Usefulness of ultrasound elastography in obstetrics and gynaecology

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Summary

Ultrasound elastography involves compression of tissues with subsequent calculations of the strain profile in examined organs – higher in soft tissues and lower in hard tissues. This technique enables to match the elasticity of organs with a range of colours and depicts the strain ratios on a colour map, creating an elastogram that shows the stiffness of the examined areas. The elasticity of individual organs or parts of anatomical structures can be coded with various colours. Ultrasound elastography can be considered a kind of "imaging palpation", particularly concerning lesions of small sizes or organs beyond the classical palpation.

Possible uses of elastography in obstetrics and gynaecology include prediction of preterm delivery and successful labour induction, differential diagnosis of endometrial disorders and intrauterine masses, as well as distinguishing fibroids and the assessment of abdominal wall endometriosis.

Key words:

elastography, preterm delivery, labour induction, endometrial disorders, endometriosis

Ultrasound elastography involves compression of tissues with subsequent calculations of the strain profile in examined organs – higher in soft tissues and lower in hard tissues. This technique enables to match the elasticity of organs with a range of colours and depicts the strain ratios on a colour map, creating an elastogram that shows the stiffness of the examined areas. The elasticity of individual organs or parts of anatomical structures can be coded with various colours. The standard range of colours, starting with red, through yellow and blue, and finally purple, corresponds to the stiffness of a target tissue. Red defines soft tissues while purple hard tissues. The range of colours is selected freely; the order of colours can be reversed or a completely different scale can be applied. Elastograms may be „superimposed" on greyscale ultrasound images, to facilitate precise evaluation of examined organs or lesions, e.g. tumours. Ultrasound elastography can be considered a kind of "imaging palpation", particularly concerning lesions of small sizes or organs beyond the classical palpation. The term "sonoelastography" was first used in literature by Krouskop in 1987 to describe the elasticity of tissues during routine ultrasound examination [1]. In the sixties of the previous century, Ophira et al. published a series of studies regarding elastic properties of tissues [2,3,4,5]. One of the first attempts to apply elastography in practice was made by Lerner, who used vibrations of low frequency supplied from an external source placed closely to the examined organ. Differences in variation amplitudes within hard and soft tissues were mapped using a greyscale. Since then, elastography has been used to evaluate many various tissues, including the liver, breast, thyroid, lymph nodes, blood vessels, the skeleto-muscular system, pancreas, and brain. One of the available elastography techniques is strain elastography, where active or passive (due to respiratory or cardiovascular pulsation) force is used to induce strain in the examined tissues. Possible uses of elastography in obstetrics and gynaecology include prediction of preterm delivery and successful labour induction, differential diagnosis of endometrial disorders and intrauterine masses, as well as distinguishing fibroids and the assessment of abdominal wall endometriosis (AWE) [6].

One of the main areas where elastography may potentially be useful is the assessment of the uterine cervix in pregnancy. Fruscalzo et al. evaluated the use of elastography in cervical quantitative stiffness assessment during pregnancy. Seventy four patients between 12-42 weeks of gestation were included in the study. The results showed that tissue strain correlated with gestational age, cervical length, and parity, proving that elastography may be used for reliable assessment of the uterine cervix in pregnancy [7].

Despite long-standing efforts to reduce it, the percentage of preterm deliveries is still the major cause of morbidity and mortality in newborns. The identification of patients at risk of preterm delivery is one of the main challenges in modern obstetrics. Wozniak et al. in a prospective, observational study involving 333 low-risk, asymptomatic women at 19-22 gestational weeks determine potential significance of elastographic assessment of the internal cervical os for predicting the risk of spontaneous preterm delivery. Ultrasound assessment of the cervix was performed using a transvaginal probe. The stiffness of the internal cervical os was assessed elastographically; moreover, the length of the cervix at gestational week 18-22 and 30 and gestational age on delivery were determined. The number of preterm deliveries (<37 gestational week) was significantly higher in patients with elastographically soft and medium soft (red and yellow) cervices, compared to those with medium hard and hard (blue and purple) cervices. Sensitivity, specificity, positive and negative predictive value (PPV and NPV) of cervical os elastography for warm colours (red, yellow) were 85.7%, 97.6%, 98.3% and 81.1%, respectively. According to the study findings, elastographic assessment of the cervical os between the gestational week 18-22 in low-risk asymptomatic pregnant women enabled identification of patients with increased risk of preterm delivery [8].

Wozniak et al. in another study assessed the value of elastographic evaluation of the internal cervical os for predicting preterm deliveries in patients with short cervices observed between the gestational week 18-22. This prospective, observational study included 109 patients with the cervix length ≤ 25 mm at gestational week 18-22. The number of preterm deliveries was significantly higher in the group of pregnant women with elastographically soft internal cervical os, compared to those with medium hard and hard ones. Sensitivity, specificity, NPV and PPV for predicting preterm delivery for internal os evaluated as soft and medium soft were found to be 82.2%, 75.0%, 84.0% and 72.5%, respectively. The cut-off point for elastography suggests that both soft and medium soft (red and yellow) internal cervical os can be accepted as factors predisposing to preterm delivery. Elastographic assessment of the internal cervical os at gestational week 18-22 may be useful for predicting preterm deliveries in patients with ultrasound-determined short cervices [9]. Both papers discussed above indicate that the usefulness of clinical ultrasound assessment of the cervix can be increased. Ultrasound assessment of the elasticity of the internal cervical os enables to predict preterm deliveries in asymptomatic pregnant women. In patients with ultrasound-detected short cervices, this method allows to distinguish the group with a real high risk of premature delivery in contrast to patients where preterm delivery is less likely, despite short cervices.

Another study showing how semiquantitative elastography can be used to assess the changes in cervical stiffness during pregnancy, was performed in a group of 262 women. It was based on 1557 strain estimations between 8-40 weeks of gestation. As a result it revealed that nulliparous women in comparison with parous ones had lower mean strain rates – 5% to 14%. Moreover cervical tissue strain was associated with cervical length more than with gestational age and was by 13% greater in the group of women with the cervical length of between 25 and 30 mm in comparison to those with a cervical length of > 30 mm. Additionally comparing the cervical tissue strain estimates obtained in the entire cervix with those obtained in the endocervical canal the difference was 33% [10].

Improper selection of pregnant women for labour induction can increase the risk of Caesarean section, postpartum complications and negatively affect the condition of newborns. The possible role of elastography in predicting the success of labour induction patients for labour induction has been investigated. It has been found, that softening of tissue in the region of the internal os before induction of labour can be assessed with the use of the uterine cervix elastography. The study was performed in a group of 29 patients before induction of labour. Elastography assessment of the uterine cervix tissue surrounding the internal os was quantified using an elastography index (EI). The results were evaluated with the use of a colour map from purple to red where the hardest tissues displayed as purple and assigned a score of 0 points and progressively softer tissues displayed as blue (1 point), green (2 points), yellow (3 points) and red (4 points). In the group of patients with successful induction of labour mean EI of the internal os was 1.23, while in the group with failed induction of labour it was 0.39. The study showed that the evaluation of cervical consistency with the use of elastography has significant predictive value according to the success of induction of labour [11].

Another study included 39 pregnant women at term with unsatisfactory assessment of the cervix according to the Bishop score (< 6), qualified for induction of labour using a Foley catheter. Before the induction of labour, the following variables were analysed: Bishop score, cervical length (ultrasound-measured), elasticity of internal cervical os, external cervical os and cervical canal using ultrasound elastography (elastography index – EI). Moreover, the correlation between cervix assessment before induction of labour and the outcome of Foley catheter labour induction (successful induction, time to delivery and the route of delivery) was investigated. The EI for the internal cervical os and cervical canal was found to be significantly lower (softer) in patients with successful labour induction and vaginal delivery. However, no statistically significant differences were observed between the EI's of the external cervical os, Bishop score and cervix length versus the effect of labour induction using the Foley catheter. A positive correlation was observed between the time to vaginal delivery and the EI of the internal cervical os and cervical canal, as well as the length of the cervix. These findings imply that elastography of the cervix enables to predict the effect of Foley catheter labour induction [12].

The usefulness of elastography is not only valuable in obstetrics, but may also play a significant role in gynaecological conditions. Abdominal wall endometriosis most frequently develops in a C-section scar, yet the cases of AWE foci in a scar after hysterectomy or laparoscopy have also been described. Moreover, the literature includes cases of AWE unrelated to surgery. Typical symptoms of AWE are a palpable lesion located near a surgical scar and cyclic perimenstrual pain. The diagnosis is usually confirmed with histopathology. AWE is commonly located in the subcutaneous tissue but it can also spread to the rectus abdominal muscle and/or infiltrate its fascia, which hinders the surgical treatment and requires the use of a mesh. Therefore, accurate thorough assessment of lesions before surgery is essential. B-mode ultrasound is most commonly applied in the diagnostic process, yet AWE lesions are usually poorly defined, indistinct, their borders commonly ragged, thus accurate assessment of lesion location using this method is generally difficult. Wozniak et al. assessed 33 patients qualified for surgical excision of symptomatic AWE located within the abdominal layers. The assessment was performed using B-mode ultrasound with the alpha blend elastography option (the B-mode image and elastography simultaneously superimposed) The criteria of B-mode ultrasound assessment of AWE location were as follows: superficial (only in the subcutaneous tissue; the subcutaneous tissue visible between the fascia and lesion, the fascia intact); intermediate (in the subcutaneous tissue or rectus abdominal muscle: no subcutaneous tissue or muscle between the lesion and the fascia; the lesion infiltrates the fascia) or deep (located in the rectus abdominal muscle: the muscular tissue visible between the lesion and fascia; the fascia intact). After B-mode assessment the lesions were also assessed by alpha-blend elastography, with the following criteria: superficial (hard lesion located in soft subcutaneous tissue; soft subcutaneous tissue between the fascia and the lesion; no hard areas on the fascia); intermediate (hard lesion in the soft subcutaneous tissue or soft rectus abdominis muscle; no soft subcutaneous or muscle tissue between the lesion and the fascia; hard areas on the fascia); or deep (hard lesion located in the soft rectus abdominis muscle; soft muscle tissue between the fascia and the lesion; no hard areas on the fascia. All locations of AWE were verified surgically, and the operator was blinded to ultrasound findings. Furthermore, the effects of patient's obesity on the accuracy of B-mode ultrasound and elastographic examinations were analysed. Preoperative B-mode ultrasound assessment was positively verified intraoperatively in 33.3% of cases, whereas the addition of an elastographic option improved the accuracy of AWE location to 87.9%. Moreover, inclusion of the elastographic option to the preoperative diagnostic ultrasound procedures for AWE locations in overweight and obese patients significantly improved the diagnostic accuracy of the examinations. The results showed that elastography markedly improved the accuracy of ultrasound examinations for evaluation of the depth of AWE infiltration into the abdominal layers, thus can beneficially supplement ultrasonography [13].

According to novel studies, elastography might be a useful tool for differentiating intrauterine masses such as polyps and fibroids, which are common in the female population and are the most frequent causes of abnormal bleeding from the uterus. Moreover, intrauterine masses may lead to infertility. The incidence of these lesions in the reproductive period increases with age and usually decreases after menopause. The major tool of imaging diagnosis is ultrasonography, yet its accuracy is still considered non-optimal. Wozniak demonstrated that the stiffness of submucosal fibroids assessed by elastography was comparable to elasticity of the uterine muscle and higher than elasticity of the surrounding endometrial tissues. Similarly, in case of endometrial polyps the stiffness of the lesions was similar to the endometrium and softer than the myometrium [14]. Moreover, in a recent prospective monocentric single-operator study, strain elastography was conducted in forty seven patients before hysteroscopy. The diagnostic accuracy rates for B-mode sonography, power Doppler imaging, and strain elastography in distinguishing endometrial polyps and submucosal fibroids were 70.2%, 65.9%, and 89.4%, respectively. The proportion of correct findings was significantly higher for strain elastography than for B-mode sonography (P = .0265) and power Doppler imaging

(P = .0153) [6]. Elastography was demonstrated to enable accurate assessment of stiffness of focal intrauterine pathologies. This imaging modality may be useful in differentiating endometrial polyps and submucosal fibroids.

The results of the studies discussed above have practical potential and evidence that the use of diagnostic procedures based on ultrasound elastography in obstetrics and gynaecology is clinically grounded and may possibly improve treatment outcomes in the future. It should be stressed, however, that the analysed studies only highlight the potential of the method discussed; further multicentre studies on larger clinical material should enable complete assessment of clinical usefulness of elastography in obstetrics and gynaecology.

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