

P R A C E O R Y G I N A L N E
położnictwo

Sonoelastography of the uterine cervix as a new diagnostic tool of cervical assessment in pregnant women – preliminary report

Sonoelastografia szyjki macicy jako nowa metoda diagnostyczna w ocenie stanu szyjki u kobiet ciężarnych – doniesienie wstępne

Fuchs Tomasz, Woytoń Robert, Pomorski Michał, Wiatrowski Artur, Slejman Nadim, Tomiałowicz Marek, Florjański Jerzy, Milnerowicz-Nabzdyk Ewa, Zimmer Mariusz

2nd Chair and Department of Gynecology, Obstetrics and Neonatology, Wrocław Medical University, Poland

Abstract

Objectives: The study aimed at determining whether there exists a correlation between the cervical cohesion parameters assessed in the elastography and the length of the cervix.

Material and methods: Assessment of cervical cohesion parameters with the use of real-time sonoelastography was performed on 59 patients between 28 and 39 weeks of gestation.

Results: The analysis showed that there exists a statistically significant ($p=0.033$) correlation between the cervical length and the elasticity of the front cervical labium (strain ratio A). Correlation coefficient (r) stood at (-) 0.28.

Conclusions:

1. There exists a negative correlation between the condition on the front cervical labium in elastographic imaging and the length of the cervical canal in USG imaging.
2. Elastography of the uterine cervix may be helpful in assessing the risk of premature labour or cervical insufficiency.
3. There is a need to perform a study on a larger group of patients in order to determine whether elastography may find its place among routine obstetric diagnostic methods.

Słowa kluczowe: **sonoelastography / elastography / uterine cervix / pregnancy /**

Corresponding author:

Tomasz Fuchs
2nd Chair and Department of Gynecology, Obstetrics and Neonatology, Wrocław Medical University,
Poland, ul. Borowska 213, 50-556 Wrocław,
tel: +48 71 733 14 00, fax: +48 71 733 14 09
e-mail: tfuchs@o2.pl

Otrzymano: **10.06.2012**
Zaakceptowano do druku: **20.12.2012**

Fuchs T, et al. Sonoelastography of the uterine cervix as a new diagnostic tool of cervical assessment in pregnant women – preliminary report.

Streszczenie

Cel pracy: Celem pracy było zbadanie czy istnieje korelacja między spistością szyjki macicy ocenianej metodą elastografii a długością szyjki macicy.

Materiał i metody: Badaniu poddano 59 ciężarnych kobiet pomiędzy 28. i 39. tygodniem ciąży, u których oceniono parametry konsystencji szyjki macicy przy użyciu sonoelastografii w czasie rzeczywistym (real-time sonoelastography).

Wyniki: Analiza wykazała, iż istnieje istotna statystycznie ($p=0.033$) korelacja między długością szyjki macicy a konsystencją przedniej wargi szyjki macicy (strain ratio A). Współczynnik korelacji (r) wyniósł (-) 0.28.

Wnioski:

1. Istnieje ujemna korelacja pomiędzy stanem przedniej wargi szyjki macicy ciężarnej ocenianej w badaniu elastograficznym z długością kanału szyjki macicy w obrazie USG.
2. Badanie elastograficzne szyjki macicy może być pomocne w prognozowaniu ryzyka porodu przedwczesnego oraz niewydolności szyjki macicy.
3. Potrzebne są badania na większej grupie pacjentek aby stwierdzić czy elastografia znajdzie miejsce wśród rutynowych położniczych metod diagnostycznych.

Słowa kluczowe: **sonoelastografia / elastografia / szyjka macicy / ciąża /**

Introduction

The cervix is a vital part of female reproductive organs. Its structure and physiology plays a crucial role in the development of the pregnancy as well as the labour in itself. It is classified as a part of the uterus, yet its histological structure is substantially different from that of the rest of the uterus. Smooth muscles constitute only 8 per cent of the entire volume of the cervix, and the collagen contents is similar to that of skin or fibrous tissue [1]. The changes occurring during cervical dilation are linked to the decrease of its collagen contents and loosening the links among the rest of its fibre [2, 3]. They are triggered by the presence of proteolytic enzymes, such as elastase or collagenase secreted by the neutrophils present in the tissue, eosinophils, and mast cells, and the whole process is similar to what happens during inflammatory reactions [4, 5, 6].

The changes occurring within the cervix at term lead to labour, yet should they occur earlier they may induce a premature labour or a miscarriage, caused by cervical insufficiency [7].

Although, over the years, medical sciences witnessed many advances, the two disease entities continue to challenge perinatal medicine.

Medicine is still in search for new diagnostic tools allowing to decrease the percentage of late miscarriages and premature labours. The etiology and pathogenesis of these pregnancy complications remain unknown, which makes the planning of an efficient prevention and monitoring even more challenging [8]. At the moment, assessment of the cervix is carried out with standard methods, such as gynecological examination, digital palpation of the cervix (Bishop's score), accompanied by biophysical and biochemical methods [9, 10, 11, 12].

We should bear in mind that the abovementioned standard methods, though subjective to a certain extent, have priority and it does not seem plausible that they should be completely replaced by the most up-to-date diagnostic tools, but rather supplemented by them, which would undoubtedly add up to their objectivity.

Ultrasonography was the first biophysical method used in this respect, first abdominal with full bladder, and later transvaginal. It allowed to measure the length of the cervical canal, assess the dilation of the internal ostium (its type) and the width of the cervix [13].

While studying the etiology of miscarriages, the infectious factor was also taken account of. It plays a crucial role in etiopathogenesis of premature labours [14]. In cases of both infections and cervical insufficiency, the cervix changes in structure. While performing a digital palpation of the cervix due to its insufficiency or during progressive premature labour, one may find that its consistency has changed. The assessment of the cervical length alone is not sufficient as the patients with short cervix may not necessarily be at risk of a premature labour or a miscarriage [15, 16, 17, 18].

Thus it seems only logical that a new diagnostic method allowing for an objective assessment of the cervical structure be sought [19].

Sonoelastography is a new diagnostic tool allowing for real-time assessment of the stiffness of tissues [20]. Currently, research is carried out regarding its use in early detection of prostate and breast cancer [21, 22, 23, 24, 25].

Researchers take advantage of the fact that neoplasms occurring in those organs are stiffer than the surrounding tissue. Assessment of liver fibrosis or uterine myomas is based on the same premise [26, 27, 28, 29].

Using transvaginal probes of ultrasound devices featuring sonoelastography allows to perform direct assessment of the stiffness of the cervix, which may prove useful in risk assessment relating to cervical insufficiency and imminent premature labour.

The study aimed at determining whether there exists a correlation between the cervical cohesion parameters assessed in the elastography and the length of the cervix.

Materials and methods

The study was performed on 59 patients between 28 and 39 weeks of gestation, hospitalized in the Department of Gynecology, Obstetrics and Neonatology, Wrocław Medical University, Poland.

The examinations were performed with the use of Hitachi EUB 7500 (Tokio, Japan), featuring 3.5 Mhz abdominal probe, 7.5 Mhz transvaginal probe and real-time sonoelastography. Apart from the standard obstetrical exams assessing fetal biometry, the amount of amniotic fluid and the cervical length, the sonographical scanning of the cervical stiffness was also performed.

After a full-length cervical image in sagittal cross-section had been generated and the measures of cervical length were taken, the sonoelastography mode was turned on, with the Region of Interest (ROI) set on the anterior (Strain Ratio A) and the posterior cervical labium (Strain Ratio B) (Figure 1, Figure 2).

The Hitachi 7500 ultrasound device uses the method designed by Shiin et al. allowing for real-time assessment of the tissue elasticity. Next, the cervical image was displayed in a stiffness score, according to which the red areas consist of the softest tissues, then through orange, yellow and green the score moves towards blue areas, consisting of the stiffest tissues.

The most appropriate moment for taking measurements was when the signal quality displayed on the screen stood at 3 or higher. Elastographic signals are registered in real-time and put on a B-mode ultrasound image as a transparent colour map of the examined tissue.

There are several ways to classify the changes in stiffness observed during elastography. However, this concerns the changes within the breast gland at risk of malignant lesions. The created systems describe such lesions' behavioral patterns in elastography and their degree of heterogeneity displayed in the elastographic image (Tsukuba elasticity score, Italian elasticity classification system). There are also systems providing quantitative description of proportions of tissues of different elasticity ratio within such organs as liver, prostate, thyroid or lymphatic nodes.

There are very few data referring to elastographic assessment of the uterine cervix during gestation. In one of a rather limited number of studies on the subject, Thomas and Fisher outline the fact that a larger number of soft tissue fragments within the cervix occur in cervical insufficiency, however, they failed to provide any scope of norms or other parameters objectifying the results of their study. In order to objectify the prospective study, it was assumed that during cervical elastography, an operator shall mark the Region of Interest and, looking at the cervical image in sagittal cross-section, shall mark a circular area of 1 cm diameter on the anterior (Strain Ratio A) and the posterior cervical labium (Strain Ratio B), which shall allow to obtain a ratio of the two parameters, coming from the quotient: Strain Ratio B/Strain Ratio A. Next, the existence of any correlations between the resulting values and the cervical length was determined.

Statistical analysis

The results of the preformed examinations were statistically analysed. The chosen pairs of parameters were used in correlation analysis to calculate Pearson's correlation coefficient.

$P \leq 0.05$ was deemed as statistically significant; the statistical analysis was carried out in EPIINFO Ver. 3.4.3. (as of 11/8/2007) statistical software.



Figure 1. Assessment of cervical length.



Figure 2. The sonoelastography mode with the Region of Interest (ROI) set on the anterior (Strain Ratio A) and the posterior cervical labium (Strain Ratio B).

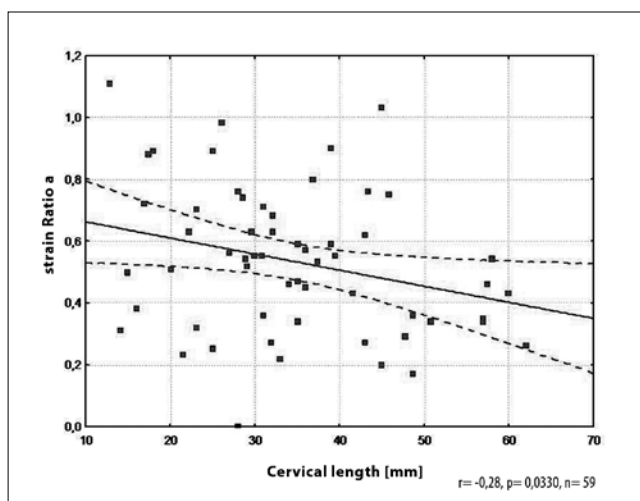


Figure 3. Regression curve of the values of correlation coefficients between the length of cervical cana and the values of strain ratio A.

Results

The analysis showed that there exists a statistically significant ($p=0.033$) correlation between the cervical length and the elasticity of the anterior cervical labium (strain ratio A). Correlation coefficient (r) stood at (-) 0.28. (Table I).

Regression curve of the values of correlation coefficients between the length of cervical canal and the values of strain ratio A is presented in figure 3.

Table I. Values of correlation coefficients between the length of cervical canal and the values of strain ratio A and strain ratio B.

		strain ratio A	strain ratio B	B/A
Length of cervical canal	r	-0.28	-0.09	0.04
	p	0.0330	0.522	0.757

p - p value
 r - correlation coefficient

Discussion

The existence of a correlation between the cervical length and the strain ratio of the anterior cervical labium (Strain Ratio A) indicated that the changes in the cervical texture and structure occur with the changes of the cervical length.

The key question here is whether elastography provides a possibility to perform an assessment of the cervix when it has not started to shorten, yet the changes in its structure are already occurring.

The study by Rechberger showed that the collagenolytic activity within the cervix increases in physiological pregnancies during labour as well as during pregnancies complicated by the cervical insufficiency [30]. More to the point, such activity increases even more in pregnancies complicated by cervical insufficiency during the second trimester in comparison to the collagenolytic activity in physiological pregnancies approaching to labour. In addition, in both cases the collagen content in the cervical tissue is reduced, all of which leads to lowering sufficiency of the cervix, proved in biomechanical exams.

Cervical diagnostics during pregnancy is one of the most fundamental methods of risk assessment of preterm delivery. Simultaneously, cervical assessment at or after term constitutes a vital prognostic assessing the chances for developing an effective contraction and labour activity [31].

While the Bishop's score is useful in relation to full-term pregnancies, ultrasound assessment of the cervix is the basic diagnostic tool in cervical insufficiency or premature labour risk-assessment.

Meta-analysis carried out by Honest revealed that ultrasound assessment of cervical maturity, as well as the assessment of the state of dilation, constitute a sufficient method of premature labour risk assessment [32].

However, a lack of standardization makes the ultrasound assessment of the cervix problematic. Currently, there are recommendations regarding the methods of carrying out such assess-

ment transvaginally, yet some exams are taken abdominally or via perineum, which only adds up to information buzz concerning the efficiency of the mentioned techniques [33, 34, 35].

After initial good reports, the attempts to use 3D cervical assessment in premature labour diagnostics failed [36]. The next marker used in the diagnostics of premature labour is ultrasonographic assessment of the internal cervical ostium performed by pressing abdominal wall above the pubic symphysis. The exam is deemed positive when it gives a dilation of the internal cervical ostium over 5mm [37].

Although the attempts were made to standardize the methods of transvaginal ultrasound exams, the risk assessments differ between the particular studies on the subject. In the study of Heath et al. the cervical length under 20 mm in the second trimester suggests an 8-times higher likelihood of preterm delivery prior to 32 weeks of gestation, yet according to Hassan et al. that risk rises 18 times [38, 39].

Moreover, introduction of additional assessment parameters like dilation of the internal cervical ostium in ultrasound imaging failed to bring in expected results regarding increased sensitivity or specificity of ultrasonography in prognosis of premature labour [37, 40, 41]. Grey-range histogram assessment of the cervix obtained during classic ultrasound performed with transvaginal probe so far has not been found clinically useful [42].

Taking into consideration the medical history of pregnant women, they constitute a rather heterogeneous group as far as the risk of premature labour goes. Thus different results of the studies dealing with the usability of cervical measurements for early labour and cervical insufficiency risk assessment [43, 44, 45].

In the light of the above, it seems only fair that there is a lot of hope to do with elastography as a far more objective tool of cervical assessment, analyzing not only its length but also its biomechanical features.

Yamaguchi et al.'s and Thomas et al.'s findings showed that elastography can be used in cervical imaging and gave a boost to further clinical trials of the method [46, 47, 48].

The works of Świątkowska-Freud et al. and Preis et al. revealed that there exists a possibility of using elastography as an alternative to digital palpation assessment of the uterine cervix prior to labour induction in which case elastography aims at objectifying the palpation exam [49, 50].

The results of our study, indicating that there is a (negative) correlation between the condition of the front cervical labium in elastographic imaging and the length of the cervix, raise hopes that further studies of the issue shall be successful, which may result by rendering elastography a standard obstetric tool for performing risk assessment regarding premature labour or cervical insufficiency.

Conclusions

There exists a negative correlation between the condition on the front cervical labium in elastographic imaging and the length of the cervical canal in USG imaging.

Elastography of the uterine cervix may be helpful in assessing the risk of premature labour or cervical insufficiency.

There is a need to perform a study on a larger group of patients in order to determine whether elastography may find its place among routine obstetric diagnostic methods.

Fuchs T, et al. Sonoelastography of the uterine cervix as a new diagnostic tool of cervical assessment in pregnant women – preliminary report.

References

- Schwalm H, Dubrauský V. The structure of the musculature of the human uterus-uscles and connective tissue. *Am J Obstet Gynecol.* 1966, 94, 391-404.
- Ruoslahti E. Structure and biology of proteoglycans. *Annu Rev Cell Biol.* 1988, 4, 229-255.
- Uldbjerg N, Ekman G, Malmström A, [et al.]. Ripening of the human uterine cervix related to changes in collagen, glycosaminoglycans, and collagenolytic activity. *Am J Obstet Gynecol.* 1983, 147, 662-666.
- Spanggaard H, Knudsen U, Uldbjerg N, [et al.]. Mast cells in cervical ripening—an immunohistochemical and biomechanical study in rats. *Eur J Obstet Gynecol Reprod Biol.* 1997, 73, 91-97.
- Osmers R, Rath W, Adelman-Grill B, [et al.]. Origin of cervical collagenase during parturition. *Am J Obstet Gynecol.* 1992, 166, 1455-1460.
- Junqueira L, Zugaib M, Montes G, [et al.]. Morphologic and histochemical evidence for the occurrence of collagenolysis and for the role of neutrophilic polymorphonuclear leukocytes during cervical dilation. *Am J Obstet Gynecol.* 1980, 138, 273-281.
- Johnstone J. Cervical incompetence and habitual abortion. *J Obstet Gynaecol Br Emp.* 1958, 65, 208-213.
- Woodring T, Klauser C, Cromartie D, [et al.]. When is a cerclage indicated for cervical insufficiency? A literature review. *J Miss State Med Assoc.* 2006, 47, 264-266.
- Brik M, Antonio P, Perales-Puchalt A, [et al.]. Cervical interleukin-6 as a predictive test for preterm delivery in symptomatic women: preliminary results. *Eur J Obstet Gynecol Reprod Biol.* 2011, 155, 14-18.
- Adhikari K, Bagga R, Suri V, Takhtani M. Cervical length compared to Bishop's score for prediction of pre-term birth in women with pre-term labour. *J Obstet Gynaecol.* 2011, 31, 213-216.
- Bernstine R, Lee S, Crawford W, Shimek M. Sonographic evaluation of the incompetent cervix. *J Clin Ultrasound.* 1981, 9, 417-420.
- Bauer M, Mazza E, Jabareen M, [et al.]. Assessment of the in vivo biomechanical properties of the human uterine cervix in pregnancy using the aspiration test: a feasibility study. *Eur J Obstet Gynecol Reprod Biol.* 2009, 144, Suppl 1, S77-S81.
- Balde M, Stolz W, Unteregger B, Bastert G. Transvaginal echography. An application in the diagnosis of cervical incompetence. *J Gynecol Obstet Biol Reprod (Paris).* 1988, 17, 629-633.
- Bobrzynska M, Reron A. The influence of antibiotic treatment on tocolysis in threatened advanced pregnancy. *Neuro Endocrinol Lett.* 2004, 25, 373-380.
- Floyd W. Cervical dilatation in the mid-trimester of pregnancy. *Obstet Gynecol.* 1961, 18, 380-381.
- Panikh M, Mehta A. Internal cervical os during the second half of pregnancy. *J Obstet Gynaecol Br Emp.* 1961, 68, 818-821.
- Visintine J, Berghella V, Henning D, Baxter J. Cervical length for prediction of preterm birth in women with multiple prior induced abortions. *Ultrasound Obstet Gynecol.* 2008, 31, 198-200.
- Szychowski J, Owen J, Hankins G, [et al.]. Vaginal Ultrasound Cerclage Trial Consortium. Timing of mid-trimester cervical length shortening in high-risk women. *Ultrasound Obstet Gynecol.* 2009, 33, 70-75.
- House M, Socrate S. The cervix as a biomechanical structure. *Ultrasound Obstet Gynecol.* 2006, 28, 745-749.
- Shiina T, Yamakawa M, Nitta N, Ueno E. Real – time tissue elasticity imaging using the combined autocorrelation method. *Medix Supplement. Hitachi Medical Corporation.* 2007, 4-7.
- Chang J, Moon W, Cho N, Kim S. Breast mass evaluation: factors influencing the quality of US elastography. *Radiology.* 2011, 259, 59-64.
- Barr R. Real-time ultrasound elasticity of the breast: initial clinical results. *Ultrasound Q.* 2010, 26, 61-66.
- Itoh A. Review of the techniques and diagnostic criteria of breast ultrasound elastography. *Medix Supplement. Hitachi Medical Corporation.* 2007, 8-11.
- Rizzatto G. Real – time elastography of the breast in clinical practice- the italian experience. *Medix Supplement. Hitachi Medical Corporation.* 2007, 12-15.
- Fleury E, Rinaldi J, Plato S, [et al.]. Appearance of breast masses on sonoelastography with special focus on the diagnosis of fibroadenomas. *Eur Radiol.* 2009, 19, 1337-1346.
- Hirooka M, Koizumi Y, Hiasa Y, [et al.]. Hepatic elasticity in patients with ascites: evaluation with real-time tissue elastography. *Am J Roentgenol.* 2011, 196, 766-771.
- Kapoor A, Kapoor A, Mahajan G, [et al.]. Real-time elastography in differentiating metastatic from nonmetastatic liver nodules. *Ultrasound Med Biol.* 2011, 37, 207-213.
- Morikawa H, Fukuda K, Kobayashi S, [et al.]. Real-time tissue elastography as a tool for the noninvasive assessment of liver stiffness in patients with chronic hepatitis C. *J Gastroenterol.* 2011, 46, 350-358.
- Ami O, Lamazou F, Mabile M, [et al.]. Real-time transvaginal elastosonography of uterine fibroids. *Ultrasound Obstet Gynecol.* 2009, 34, 486-488.
- Rechberger T, Uldbjerg N, Oxlund H. Connective tissue changes in the cervix during normal pregnancy and pregnancy complicated by cervical incompetence. *Obstet Gynecol.* 1988, 71, 563-567.
- Gabriel R, Darnaud T, Chalot F, [et al.]. Transvaginal sonography of the uterine cervix prior to labor induction. *Ultrasound Obstet Gynecol.* 2002, 19, 254-257.
- Honest H, Bachmann L, Coomarasamy A, [et al.]. Accuracy of cervical transvaginal sonography in predicting preterm birth: a systematic review. *Ultrasound Obstet Gynecol.* 2003, 22, 305-322.
- Cicero S, Skentou C, Souka A, [et al.]. Cervical length at 22-24 weeks of gestation: comparison of transvaginal and transperineal-translabial ultrasonography. *Ultrasound Obstet Gynecol.* 2001, 17, 335-340.
- To M, Skentou C, Chan C, [et al.]. Cervical assessment at the routine 23-week scan: standardizing techniques. *Ultrasound Obstet Gynecol.* 2001, 17, 217-219.
- Carr D, Smith K, Parsons L, [et al.]. Ultrasonography for cervical length measurement: agreement between transvaginal and translabial techniques. *Obstet Gynecol.* 2000, 96, 554-558.
- Bega G, Lev-Toaff A, Kuhlman K, [et al.]. Three-dimensional multiplanar transvaginal ultrasound of the cervix in pregnancy. *Ultrasound Obstet Gynecol.* 2000, 16, 351-358.
- Hoesli I, Terzanli S, Holzgreve W. Cervical length assessment by ultrasound as a predictor of preterm labour—is there a role for routine screening? *BJOG.* 2003, 110, Suppl 20, 61-65.
- Heath V, Southall T, Souka A, [et al.]. Cervical length at 23 weeks of gestation: prediction of spontaneous preterm delivery. *Ultrasound Obstet Gynecol.* 1998, 12, 312-317.
- Hassan S, Romero R, Berry S, [et al.]. Patients with an ultrasonographic cervical length < or =15 mm have nearly a 50% risk of early spontaneous preterm delivery. *Am J Obstet Gynecol.* 2000, 182, 1458-1467.
- Valentin L. Ultrasound examination of the cervix to predict preterm delivery: we still know too little to use it in clinical practice. *Ultrasound Obstet Gynecol.* 2003, 21, 106-110.
- Berghella V. Novel developments on cervical length screening and progesterone for preventing preterm birth. *BJOG.* 2009, 116, 182-187.
- Furtado M, Pires C, Araujo Júnior E, [et al.]. Transvaginal grey scale histogram of the cervix at 20-25 weeks of pregnancy. *Aust N Z J Obstet Gynaecol.* 2010, 50, 444-449.
- Rozenberg P, Gillet A, Ville Y. Transvaginal sonographic examination of the cervix in asymptomatic pregnant women: review of the literature. *Ultrasound Obstet Gynecol.* 2002, 19, 302-311.
- Crane J, Hutchens D. Use of transvaginal ultrasonography to predict preterm birth in women with a history of preterm birth. *Ultrasound Obstet Gynecol.* 2008, 32, 640-645.
- Sotiropoulos A, Papatheodorou S, Kavvadias A, [et al.]. Transvaginal cervical length measurement for prediction of preterm birth in women with threatened preterm labor: a meta-analysis. *Ultrasound Obstet Gynecol.* 2010, 35, 54-64.
- Yamaguchi S, Kamei Y, Kozuma S, Taketani Y. Tissue elastography imaging of the uterine cervix during pregnancy. *J Med Ultrasonics.* 2007, 34, 209-210.
- Thomas A. Imaging of the cervix using sonoelastography. *Ultrasound Obstet Gynecol.* 2006, 28, 356-357.
- Thomas A, Fischer T. Cervical elastography. *Medix Supplement. Hitachi Medical Corporation.* 2007, 58-62.
- Swiatkowska-Freund M, Preis K. Elastography of the uterine cervix: implications for success of induction of labor. *Ultrasound Obstet Gynecol.* 2011, 38, 52-56.
- Preis K, Swiatkowska-Freund M, Pankrac Z. Elastography in the examination of the uterine cervix before labor induction. *Ginekol Pol.* 2010, 81, 757-761.