Polish Journal of Veterinary Sciences Vol. 16, No. 3 (2013), 477–482

DOI 10.2478/pjvs-2013-0066

Original article

Application of shear wave elastography in the diagnosis of mammary gland neoplasm in dogs

K. Glińska-Suchocka[1], M. Jankowski[1], K. Kubiak[1], J. Spużak[1], S. Dzimira[2], J. Nicpon[1]

[1] Departament of Internal Diseases with Clinic of Horses, Dogs and Cats, Faculty of Veterinary Medicine, Wroclaw University of Environmental and Life Sciences, pl. Grunwaldzki 47, 50-366 Wrocław, Poland
[2]Department of Pathology, Faculty of Veterinary Medicine, Wroclaw University of Environmental and Life Sciences, C.K. Norwida 31, 50-375 Wrocław, Poland

Abstract

The aim of the study was to evaluate the usefulness of elastography in the differential diagnosis of benign and malignant tumours of the mammary gland in dogs. The study was performed to 12 female dogs of different breeds aged 5-12 years in which tumoral lesions of the mammary gland were found in the clinical examination. In all the animals elastographic examination of the lesions was carried out and then the fine-needle aspiration biopsy was performed to determine the nature and degree of malignancy of the lesions. The examinations proved that benign neoplasms of the mammary gland showed low stiffness (average 22.42 kPa, range 19 to 42.4 kPa), whereas malignant neoplasms were characterized by high stiffness (average 235.44 kPa, range 171 to 300 kPa). On the basis of the results obtained we conclude that the elastography of proliferative lesions of the mammary gland is a useful diagnostic method for distinguishing benign neoplastic lesions from malignant neoplasms.

Key words: dog, mammary gland, tumour, shear wave elastography

Introduction

Each body tissue is characterized by its natural flexibility, which can be subject to change as a result of aging, inflammation, fibrosis as well as neoplastic lesions. This feature has already been used in the palpable examination of organs since the time of Hippocrates. Tissue elasticity is defined as the proportion of tension (pressure force) exerted on a tissue to a relative change of its volume (elastic deformation) caused during the pressure (Lyshchik at al. 2005, Asteria at al. 2008). Elasticity can be evaluated by measurement of the pressure force exerted on the tissue and its deformation. The tissue deformation can be easily measured by evaluation of high-frequency echo signals whereas a value of tension cannot be evaluated on the basis of the tissue measurement, therefore a process of exerting force on the tissue must be carried out under strictly controlled conditions (Dobruch-Sobczak and Sudoł-Szopińska 2010, Evans

Correspondence to: K. Glińska-Suchocka, e-mail: kamilaglinska@o2.pl

at al. 2010, Dobruch-Sobczak and Sudoł-Szopińska 2011, Li and Snedeker 2011). The application of elastography in medicine as a method that allows imaging the elastic properties of the soft tissues (the organs) examined, was described for the first time by Ophir et al. from the University of Texas Medical School in Houston in 1991 (Ophir at al. 2000). In 1998, Krouskop et al. determined an extent of deformation of different tissues which occur within the female mammary gland (Ophir at al. 2000). Since then, a number of studies performed in the human medicine have proved usefulness of the above-mentioned technique for distinguishing tumoral lesions not only in the mammary gland but also in the prostatic gland, thyroid, and lymph nodes as well as for evaluation of liver fibrosis and muscle diseases (Stawros at al. 1995, Lyshchik at al. 2005, Itoh at al. 2006, Regner at al. 2006, Asteria at al. 2008, Tanter at al. 2008, Thomas and Fisher 2009, Athanasiou at al. 2010). The rule of the elastograph work consists in application of little pressure on the examined organ by means of an ultrasound probe, which causes deformation of tissues (Li and Snedeker 2011). At present, Shear Wave Elastography (SWE) is the most advanced technique which enables objective measurement of stiffness of a structure examined together with a numerical value of stiffness (expressed in kPa or m/s) with the use of an ultrasound effect of Mach cone (like in jet engines) and Young's modulus (for extensibility and compressibility of centres) (Dobruch-Sobczak and Sudoł-Szopińska 2010, Evans at al. 2010, Dobruch-Sobczak and Sudoł-Szopińska 2011). Nowadays elastography is used in the human medicine mainly in the diagnosis of liver fibrosis and breast tumors and reduced the number of unnecessary biopsies (Itoh at al. 2006, Thomas and Fisher 2009, Athanasiou at al. 2010). However in the available literature there is no information about the application of elastography in the diagnosis of dog diseases.

The aim of the present study was to evaluate the usefulness of the elastography examination in the differential diagnosis of benign and malignant mammary gland neoplasms.

Materials and Methods

The study was performed in 12 female dogs of different breeds aged 5-12 years in which tumoral lesions of the mammary gland were found in the clinical examination. In all the animals examined, SWE examination of the mammary gland lesions was carried out and then the fine-needle aspiration biopsy was performed in order to diagnose a type of neoplasm and evaluation of the degree malignancy.

Shear wave elastography was performed using the Aixplorer® ultrasound system machine (SuperSonic Imagine, Aix en Provence, France). The probe used for the greyscale and shear wave elastography had a frequency range of 7.5 to 15 MHz, which at -6 dB gives axial resolution of 0.3 to 0.5 mm and lateral resolution of 0.3 to 0.6 mm. Results were displayed on a colour scale according to elasticity expressed in kPa. The examination was performed in the patients with dorsal recumbency. During the examination, pressure on the examined area by means of the probe was not exerted. In each patient, 3 measurements of the tissue elasticity were taken for which an average value was calculated. The fine-needle aspiration biopsy (FNA) of mammary gland tumors was performed using 0.9 -mm -diameter 920G) attached to a to 10 ml syringes. The collected material was applied onto a glass slide and a cytological smear was made. Smears were fixed by Cytofix® preparation, stained by hematoxylin and eosin and then evaluated cytologically.

Results

Based on the cytological examination of the smears following types of mammary gland neoplasms were diagnosed: benign neoplasms – 5 (41.6%) cases (including: fibroadenoma – 3 (60%) cases and adenoma – 2 (40%) cases) and malignant neoplasms – 7 (58.4%) cases of adenocarcinoma (including: solid carcinoma – 4 (57.1%), spindle cell carcinoma – 2 (28.6%),, anaplastic carcinoma – 1 (14.3%) cases).

Table1. Results of the elastographic examination of the mammary gland neoplasms for particular dogs.

No.	Result of cytological examination	Mean value of 3 measurements of tissue stiffness (kPa)
1	fibroadenoma	15.8 ± 2.2
2	fibroadenoma	21.5 ± 3.1
3	fibroadenoma	23.4 ± 4.2
4	adenoma	19.0 ± 2
5	adenoma	32.4 ± 5.6
6	solid carcinoma	285.4 ± 19.5
7	solid carcinoma	211 ± 47.9
8	solid carcinoma	183 ± 34.1
9	solid carcinoma	171 ± 44.2
10	spindle cell carcinoma	300 ± 35.1
11	spindle cell carcinoma	202.3 ± 32.2
12	anaplastic carcinoma	295.4 ± 41

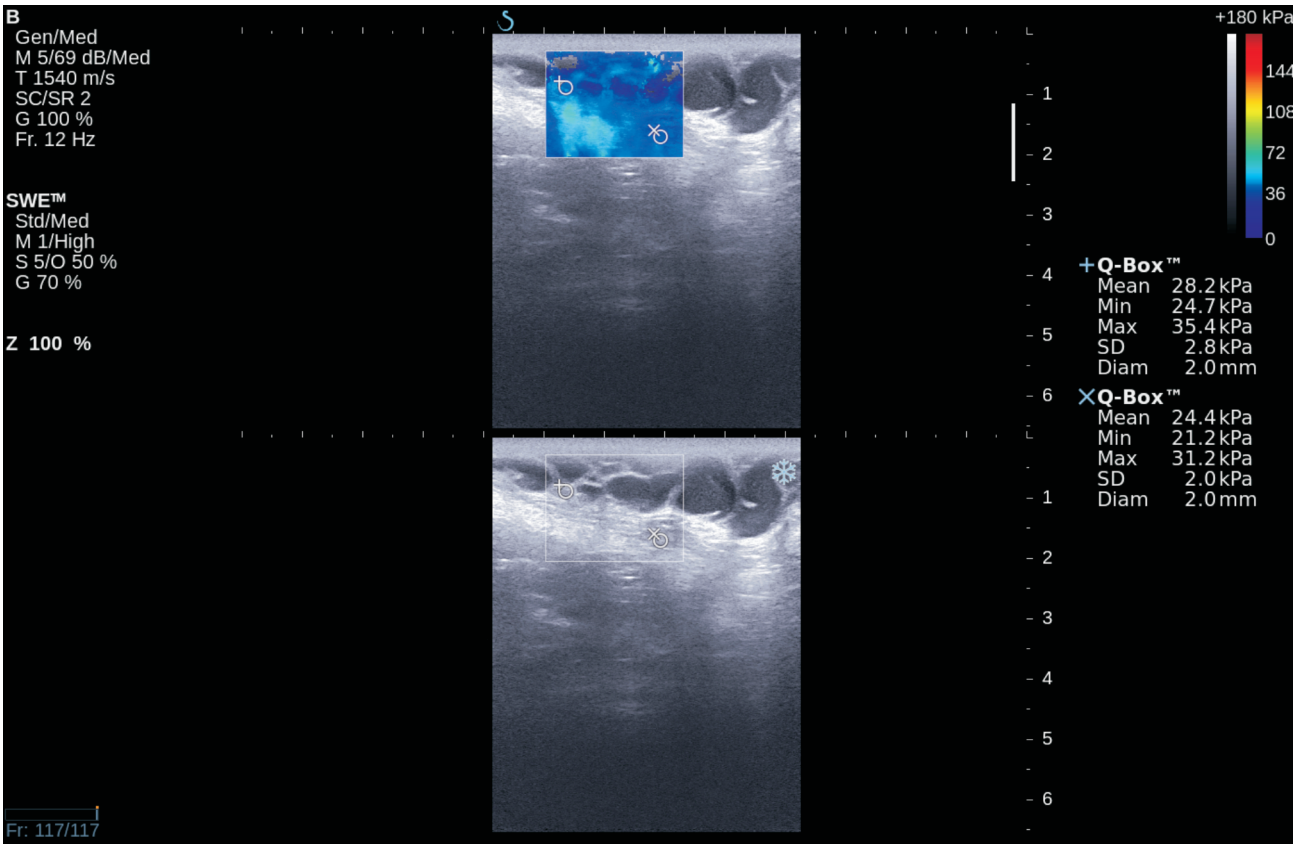

Fig. 1. Ultrasound and elastography images of a benign adenoma showing low stiffness. Mean 28.2 kPa.

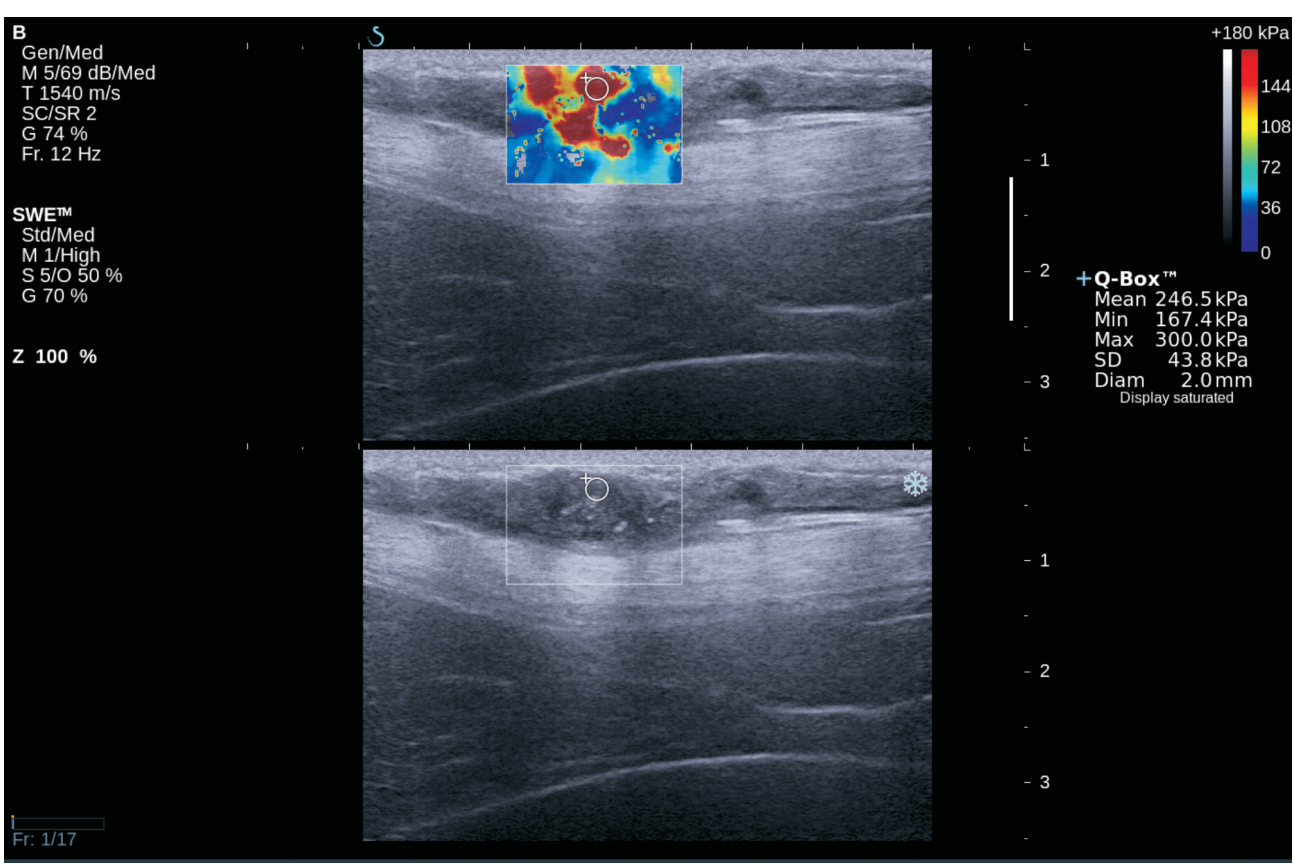

Fig. 2. Ultrasound and elastography images of adenocarcinoma showing high stiffness. Mean 246.6 kPa.

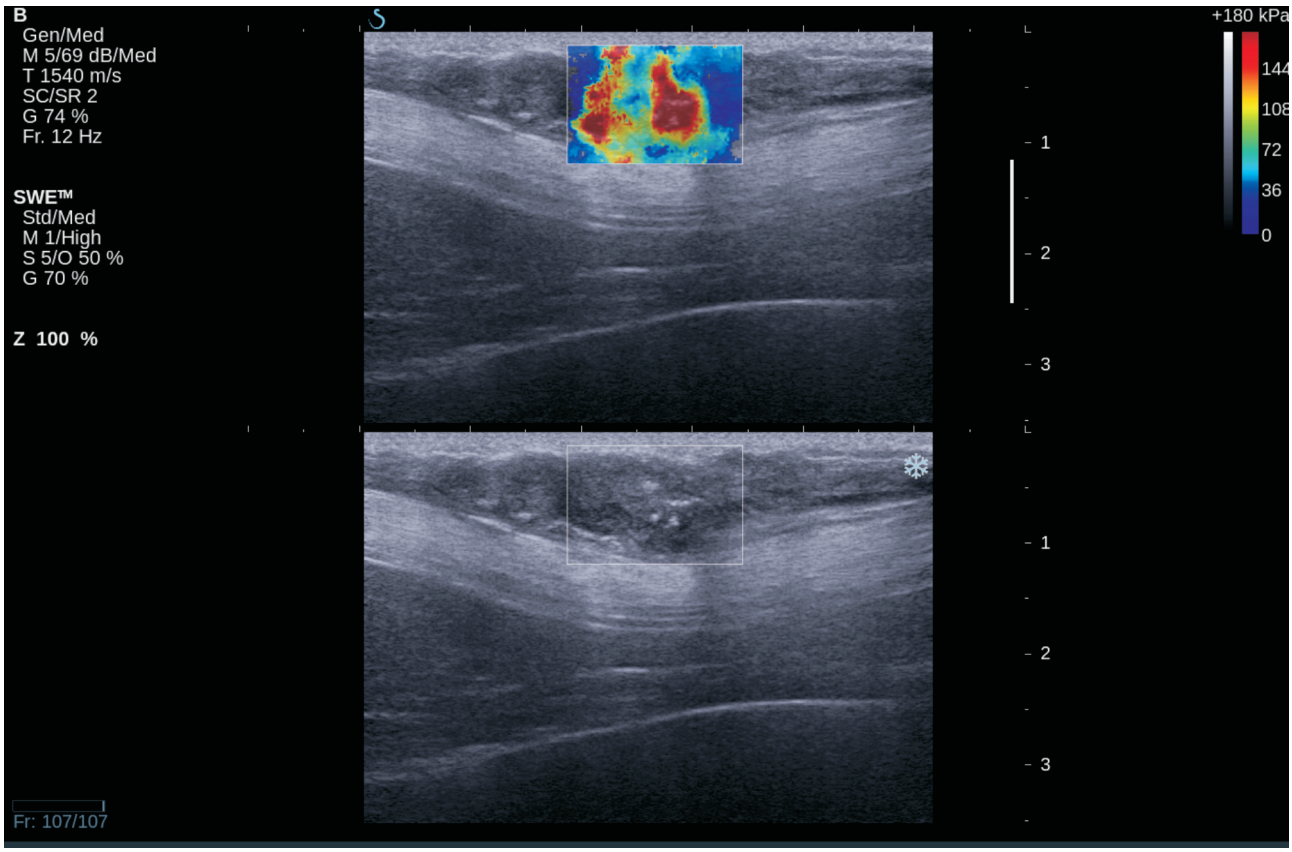

Fig. 3. Ultrasound and elastography images of adenocarcinoma. Ultrasound and elastography images of adenocarcinoma showing typical peri-tumoural stiffness.

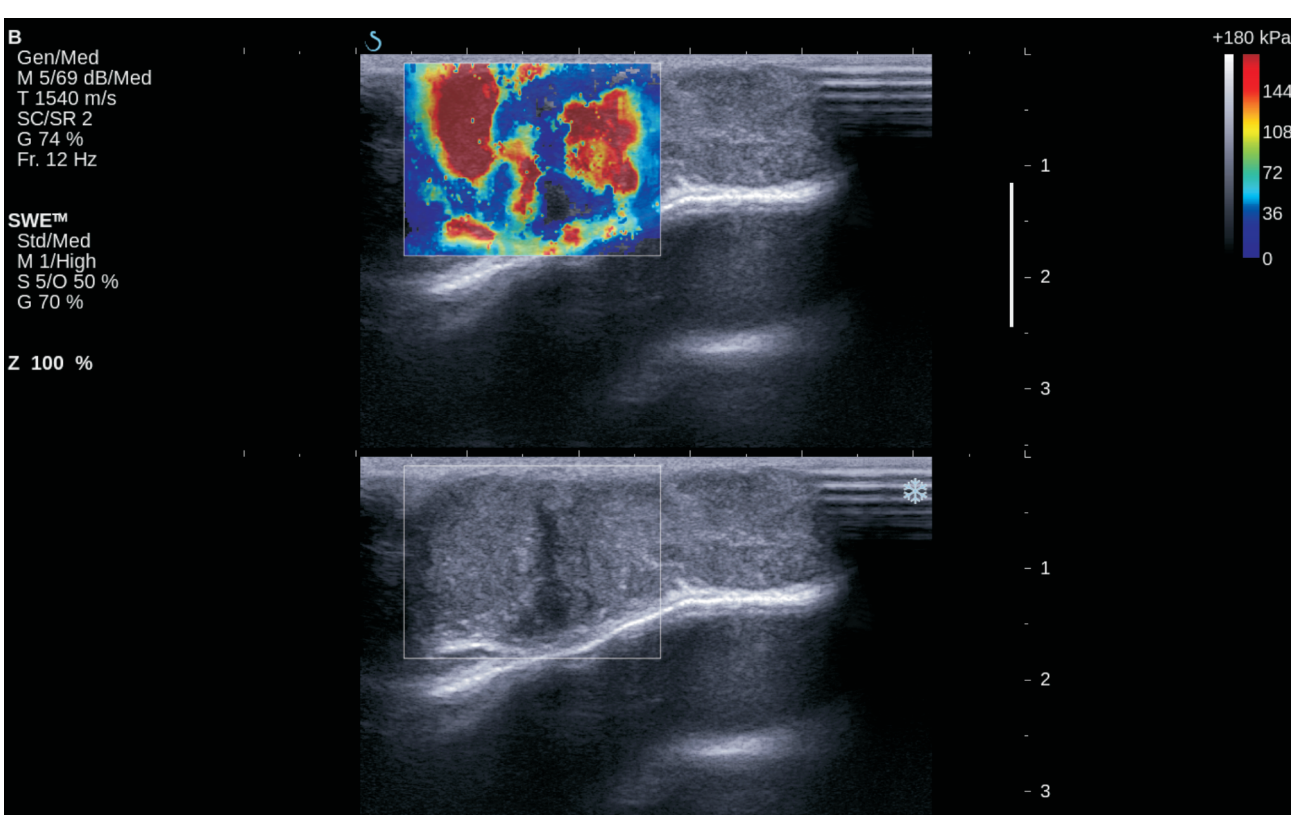

Fig. 4. Ultrasound and elastography images of adenocarcinoma.

In the elastographic examination of the dogs suffering from benign neoplasms of mammary gland tumors (Fig. 1), low stiffness of tissues was proved, for which an average value of 3 measurements amounted from 19.0 ± 2 kPa to 32.4 ± 5.6 kPa (the average value – 22.42 kPa). In these dogs, no significant differences in elasticity of both adenofibroma and adenoma were found. However, in the case of the elastographic examination of the dogs with malignant neoplasms of the mammary gland, high stiffness of tissues was proved for which an average value of 3 measurements amounted from 171 ± 44.2 kPa to 300 ± 35.1 kPa (the average value – 235.44 kPa) (Fig. 2, 3, 4). The results of the elastographic examination of the mammary gland neoplasms for particular dogs have been presented in Table 1.

Discussion

Mammary gland tumors (MGTs) are the most frequently diagnosed neoplasms in female dogs and constitutes approximately 42% of all neoplasms and 82% of the reproductive system neoplasms (Moulton 1990). They occur most often in bitches aged 10-11 years. In young animals, benign neoplasms of the mammary gland occur frequently. The benign neoplasms constitute 50-60% of all MGTs, and most of them are fibroadenomas. The remaining 40-50% represent malignant neoplasms out of which approximately 50% may metastasize. Among benign neoplasms of the mammary gland adenomas or benign mesenchymal tumors are most often found. The most frequently diagnosed malignant neoplasms in bithces are adenocarcinomas, others, such as sarcoma represent only 5% but they have a higher risk of metastasis than carcinomas (Moulton 1990). Nowadays the fine-needle aspiration biopsy is a method of choice that enables collection of the material from tumors for the cytological examination which makes it possible to distinguish benign from malignant MGTs (Stavros at al. 1995).

Tremendous progress in the development of non-invasive imaging techniques has been observed in recent years. Sonoelastography is a technique that enables both visualization of irregular lesions within tissues and determination of their character (Regner at al. 2006). In many cases, it makes it possible to qualify patients for further cytological diagnostics, which, as a consequence, contributes to the increase in detectability of malignant neoplastic lesions (Bercoff at al. 2004, Asteria at al. 2008, Athanasiou at al. 2010, Li and Snedeker 2011).

Most of malignant neoplastic lesions which occur in the mammary gland cause abnormal hyperplasia of the stromal fibrous tissue (the so-called desmoplasia), thanks to which it is possible to assess their 'hardness' in the elastographic examination (those lesions are not subject to deformation) (Li and Snedeker 2011). The fatty tissue and glandular tissue are subject to the greatest deformation (they have the lowest value of Young's modulus), however, the malignant neoplastic lesions are not subject to deformation (they have high values of Young's modulus) (Dobruch-Sobczak and Sudoł-Szopińska 2010, Evans at al. 2010, Dobruch-Sobczak and Sudoł-Szopińska 2011).

Elastography is widely applied in the human medicine for typing the thyroid gland tumors for the cytological diagnosis, the prostate tumors for the histopathological examination, and is also performed to evaluate an extent of a fibrosis degree of the organ in liver diseases (Bercoff at al 2004, Lyshchik at al 2005, Asteria at al. 2008, Li and Snedeker 2011). There are many published results of the studies on sonoelastographic differentiation of focal lesions of the female mammary gland, in which usefulness of this diagnostic method has been proved (Stavros at al. 1995, Itoh at al. 2006, Regner at al 2006, Tanter at al 2008, Thomas and Fisher 2009, Athanasiou at al. 2010).

The first paper on shear wave elastography of the breast in the human medicine presented the results of the study obtained from 15 patients (Tanter at al. 2008). In the study, significant differences in elasticity of the particular tissues which build the female mammary gland were found. Elasticity of the fatty tissue amounted to 3 kPa, the glandular tissue – 45 kPa, benign neoplastic tumors < 80 kPa, and malignant neoplastic lesions > 100 kPa. On the basis of another study conducted on a group of 52 women, it was shown that the electrographic examination of the tumoral lesions of the gland is characterized by high sensitivity (97%), and specificity of the study amounts to approximately 78% (Evans at al. 2010). In this study, benign neoplastic lesions showed low elasticity whereas malignant neoplastic lesions – high elasticity. The similar results were obtained in the present study in which an average value for tissue elasticity for benign neoplastic lesions amounted to 22.42 kPa and was very close to the results of the study on elasticity of benign tumors of the female mammary gland (average 28 kPa) carried out by Evans et al (2010). On the other hand, an average value for tissue elasticity for malignant neoplastic lesions amounted to 235.44 kPa and was considerably higher than that obtained in a study on elasticity of tissue regarding malignant lesions of the female mammary gland (average 140 kPa). Unfortunately, the authors of this study do not specify a type of malignant neoplasm. Such a difference in an average value for elasticity of malignant neoplastic lesions of the mammary gland can depend

on a type of neoplasm or its size. In the present study, malignant neoplastic lesions of the mammary gland had a size over 20 mm. It was proved by the study carried out by Evans et al. (2010) in which malignant neoplastic lesions ≥ 15 mm were characterized by considerably higher elasticity (average 167 kPa) compared to the lesions with a size lower than 15 mm (109 kPa).

In the present study, fibroadenoma, adenoma, and adenocarcinoma neoplasms were detected on the basis of the cytological material.

Most malignant neoplastic changes are characterized by lower elasticity, hence they do not undergo deformation. Yet, it should be remembered that in the case of the *tumor mixtus* tumours containing the cartilaginous and bone tissue of both malignant and benign nature, their tissue may be characterized by higher stiffness, which could lead to false positive results. However, in the case of neoplastic tumours growing so fast that fibrous tissue hypertrophy does not take place and they are accompanied merely by an inflammatory reaction, there is a probability of obtaining false negative results. In such cases the role of elastography is limited (Dobruch-Sobczak and Sudoł-Szopińska 2011).

On the basis of the present results, it can be stated that sonoelastography is a safe and very useful method that enables differentiation of benign and malignant neoplastic lesions of the mammary gland in biches. Due to the fact that the elastographic evaluation of tumoral lesions of the mammary gland in female dogs enables determination of a further diagnostic procedure, it can constitute a form of screening examination in the future, on the basis of which an animal will be qualified for further diagnostic examination (e.g. biopsy) or appropriate treatment.

References

Asteria C, Giovanardi A, Pizzocaro A, Cozzaglio L, Morabito A, Somalvico F, Zoppo A (**2008**) US – elastography in the differential diagnosis of benign and malignant thyroid nodules. Thyroid 18: 523-531.

Athanasiou A, Tardivon A, Tanter M, Sigal-Zafrani B, Bercoff J, Deffieux T, Gennisson JL, Fink M, Neuenschwander S (**2010**) Breast lesions: quantitative elastography with supersonic shear imaging – preliminary results. Radiology 256: 297-303.

Bercoff J, Tanter M, Fink M (**2004**) Supersonic shear imaging: a new technique for soft tissue elasticity mapping. IEEE Trans Ultrason Ferroelectr Freq Control 51: 396-409.

Dobruch-Sobczak K, Sudoł-Szopińska I (**2010**) Real time elastography – the role in differential diagnosis of focal breast lesions. Acta Bio-Optica et Informatica Medica 16: 352-354.

Dobruch-Sobczak K, Sudoł-Szopińska I (**2011**) The usefulness of sonoelastography in the differential diagnosis of solid breast lesions. Ultrasonografia 11: 8-16.

Evans A, Whelehan P, Thomson K, McLean D, Brauer K, Purdie C, Jordan L, Baker L, Thompson A (**2010**) Quantitative shear wave ultrasound elastography: initial experience in solid breast masses. Breast Cancer Res 12: R104.

Itoh A, Ueno E, Tohno E, Kamma H, Takahashi H, Shiina T, Yamakawa M, Matsumura T (**2006**) Breast disease: Clinical application of US elastography for diagnosis. Radiology 239: 341-350.

Li Y, Snedeker JG (**2011**) Elastography: modality-specific approaches, clinical applications, and research horizons. Skeletal Radiol 40: 389-397.

Lyshchik A, Higashi T, Asato R, Tanaka S, Ito J, Mai JJ, Pellot-Baracat C, Insana MF, Brill AB, Saga T, Hiraoka M, Togashi K (**2005**) Thyroid gland tumor diagnosis at US elastography. Radiology 237: 202-211.

Moulton JE (**1990**) Tumors of the mammary gland. In Moulton JE (ed) Tumours in Domestic Animals 3rd ed., Berkeley, University of California Press, pp 518-552.

Ophir J, Garra B, Kallel F, Konofagou E, Krouskop T, Righetti R, Varghese T (**2000**) Elastographic imaging. Ultrasound Med Biol 26: 23-39.

Regner DM, Hesley GK, Hangiandreou NJ, Morton MJ, Nordland MR, Meixner DD, Hall TJ, Farrell MA, Mandrekar JN, Harmsen WS, Charboneau JW (**2006**) Breast lesions: evaluation with US strain imaging – clinical experience of multiple observers. Radiology 238: 425-437.

Stavros AT, Thickman D, Rapp CL, Dennis MA, Parker SH, Sisney GA (**1995**) Solid breast nodules: use of sonography to distinguish between benign and malignant lesions. Radiology 196: 123-134.

Tanter M, Bercoff J, Athanasiou A, Deffieux T, Gennisson J-L, Montaldo G, Muller M, Tardivon A, Fink M (**2008**) Quantitative assessment of breast lesion viscoelasticity: initial clinical results using supersonic shear imaging. Ultrasound Med Biol 34: 1373-1386.

Thomas A, Fisher T (**2009**) Elastografia bezpieczna metoda różnicowania zmian chorobowych piersi za pomocą ultradźwięków? Acta Bio-Optica et Informatica Medica 15: 168-169.