The role of sonoelastography in planning percutaneous biopsy of soft tissue tumours

Mike Bradley

Department of Radiology, North Bristol NHS Trust, Southmead Hospital, Bristol, UK
Corresponding author: Mike Bradley. Email: Mike.bradley@nbt.nhs.uk

Abstract

The aim of this study was to evaluate whether compression elastography has a useful role in the planning of percutaneous ultrasound-guided biopsies of soft tissue tumours. Consecutive patients were evaluated in the sarcoma clinic after their initial imaging work-up, involving ultrasound and MR. The multi-disciplinary team decided when percutaneous biopsy for histology was required, and this was performed in the multi-disciplinary clinic using ultrasound guidance. An experienced sarcoma radiologist performed the ultrasound with compression elastography in all cases. Grey scale imaging was used to predict the needle track for each biopsy and routinely, two passes were made into each lesion. In this study, the track for the second pass was predicted from the elastogram, aiming for a stiff (blue) area within the lesion. The samples were separately potted in formalin and sent to the sarcoma pathologist. Pathology reports for each sample were assessed to evaluate whether the elastographic blue targets yielded any specific diagnostic quality; 157 biopsies were performed in separate patients, including two passes per patient as per routine protocol; 107 (68.1%) were benign lesions and 50 (31.9%) were malignancies. In the benign group, 16 (14.9%) showed significant blue areas in the lesion. However, nine of these were thought to be artefactual, as they showed grey scale characteristics of complex cysts. Positive histology was recorded in all the blue areas, but in the benign lesions positivity was not seen solely in the blue areas; 14 (28%) in the malignant group showed blue areas in the lesion and five biopsies were positive in blue areas only. Overall, the blue target yielded the only positive tissue in 10% of the malignancies, equating to 3% of the whole study population. The *p* value was 0.008829 for positive histology for malignancy from blue areas only.

Keywords: Compression sonoelastography, soft tissue tumour, sarcoma, percutaneous biopsy, ultrasound

Received: 23 March 2015, Accepted: 19 August 2015

Ultrasound 2015; **23**: 212–215. DOI: 10.1177/1742271X15608214

Introduction

Sonoelastography has been an available adjunct technology on ultrasound machines in recent years. It has been increasingly used to evaluate soft tissue lesions, including lumps and bumps. Ophir et al.¹ used it to apply mechanical compression with an ultrasound probe and described tissue stiffness by comparing the ultrasound frequency signals at compression and relaxation. The strain data are represented as a colour-scale image, which can be superimposed onto the grey scale image. Compression sonoelastography has been performed as an adjunct to grey scale ultrasound imaging for a variety of musculoskeletal conditions.² Stiff areas are typically represented as blue, whereas soft and intermediate areas are shown by the green, yellow and red parts of the colour spectrum. Studies have reported on its use in many tissues, such as breast, thyroid, lymph nodes and liver,^{3–7} but few describe its use for musculoskeletal soft tissue masses.

Although the use of sonoelastography has been described for several different types of musculoskeletal conditions,^{8–10} no publications have described its use to guide percutaneous biopsy. The biopsy result is invaluable to guide the multi-disciplinary team (MDT) to decide upon adjuvant therapy pre-operatively, as well as predict the appropriate surgical clearances.

Studies have looked at sonoelastography for differentiating benign from malignant lesions using qualitative and quantitative analysis of tissue stiffness.

The primary objective of this study was to identify any compression sonoelastography features that could predict a more accurate percutaneous biopsy track, based on the hypothesis that stiff areas within the mass may yield a greater cellular biopsy and thus improve diagnostic material for histological assessment. Traditionally, the lesions are biopsied under ultrasound guidance, aiming for areas of

greater cellular characteristics on the grey scale imaging and avoiding areas of fluid/necrosis within the mass.

Methods

This was a prospective trial with full ethics application and approval; 157 consecutive patients were evaluated in the sarcoma clinic after their initial imaging work-up, involving ultrasound and MR. The MDT decided when percutaneous biopsy for histology was required, and this was performed in the multi-disciplinary clinic using ultrasound guidance. An experienced sarcoma radiologist performed the ultrasound with compression elastography in all cases using a Toshiba Aplio (Toshiba Medical Systems, Crawley, UK) and an 18 MHz ultrasound probe.

Compression sonography involves the operator 'bouncing' the probe on the skin to compress the lesion with a regular rhythm, avoiding any lateral shift. Machines have differing feedback methods to show the operator is achieving the correct pressure and rhythm. The Toshiba Aplio shows this in the form of a graphical cycloidal waveform to confirm regular rhythm and even pressure during compression and relaxation. The lesion was completely scanned in this way to create the colour maps to reflect any consistently stiff blue areas within the lesion.

Grey scale imaging was used to predict the needle track for each biopsy and routinely two biopsy passes were made in each lesion as per the usual practice. The biopsy is usually taken from a peripheral area to avoid frankly necrotic/cystic areas, as seen on the grey scale ultrasound. However, for this study, the track for the second pass was modified as predicted from the elastogram, aiming for a stiff (blue) area within the lesion. Care was taken to avoid lateral shift artefacts, when the lesion may move out of the field of view due to the mechanical compression.

Significant blue areas were classed as those within the lesion showing a reproducible area of the lesion as stiff tissue. Some lesions showed elastographic artefacts with false blue areas when correlated with the grey scale image; these were not used for biopsy localisation. These included some superficial lesions which showed artefacts from apparent stiffness around boundaries of the lesion (boundary artefacts). Some were clearly complex cystic lesions on the grey scale showing blue or black zones. This is presumed to be artefactual stiffness related to boundary artefacts as well as related to the type of fluid matrix (e.g. myxomas often show stiff areas). These were not included as suitable stiff targets for biopsy.

Strain ratios from regions of interest were calculated in all cases but this did not statistically aid the overall assessment of the tumour and did not help with guiding the biopsy track.

The grey scale and sonoelastography were used to plan the intralesional biopsy path, while the grey scale was used to plan the extra-lesional track to avoid sensitive anatomy (vessels, nerves) and to ensure single compartment invasion within the surgical plane.

All patients gave informed consent prior to the procedure. All biopsies were performed with the same type and gauge of cutting needle (Temno 14G) after instillation of

local anaesthetic (lignocaine 1%). A small number of patients had a delayed biopsy depending on anticoagulant or antiplatelet drugs. The samples were separately potted in formalin and sent to the sarcoma pathologist. They were numbered but blinded to the pathologist, i.e. the pathologist did not know the exact biopsy site for each specimen. Pathology reports for each sample were assessed to evaluate whether the elastographic blue targets yielded any better diagnostic quality. All the samples were assessed for crush artefacts (i.e. histological artefacts created from tissue damage caused by the needle) or any sampling problems from necrotic tissue. All the procedures were well tolerated by the patient and diagnostic samples were obtained from all 157. There were no complications. Outcomes were discussed through the MDT.

Results

One hundred and fifty-seven consecutive patients with a variety of superficial and deep lesions were included in this study. The sizes of the tumours ranged from a maximum diameter of 1.8 cm to over 20 cm.

All patients had a successful ultrasound examination of the mass along with a compression sonoelastography assessment and an ultrasound-guided percutaneous biopsy. All samples were deemed diagnostic for histology with no repeats required in this study group. Elastography was used to determine the consistent stiff areas within the scan field, needing multiple scan fields in the larger lesions.

There was a wide range of benign diagnoses (107), the most common being complex cysts (epidermoid, ganglion, giant cell tumour, myxoma), neurogenic lesions (schwannoma, neurofibroma), endometriosis, and fibromatosis. The majority of the malignant masses were sarcomas, but included two lymphomas, one plasmacytoma, three secondary carcinomas and one neuroendocrine carcinoma. The sarcoma histology matched all surgical specimens for diagnostics and grading. Figure 1 shows a sonoelastogram from one section of the mass from a biopsy proven high-grade liposarcoma.

Compression elastography was accepted in all patients and the results are summarised in Table 1. Most lesions demonstrated a range of colours on the colour maps, but consistent blue areas were limited to 16 in the benign category (14.9% of the group) and 14 in the malignant (28% of the group).

In the benign group, the biopsy was positive in both samples in all cases and so the blue areas did not increase the positive biopsy rate. In the malignant group, 9 of the 14 blue area biopsies were positive in both samples with five diagnostic from the blue area only. These five cases account for 10% of the malignant group and 3.2% for the whole population (p value 0.008829). It is normal practice to make two biopsy passes in different peripheral areas of the mass, but compression elastography may change the biopsy target in a small number of cases (10% of the malignant lesions).

Discussion

It is often difficult to differentiate between benign and malignant soft tissue tumours using conventional grey

Figure 1 An example of a large blue area within this biopsy proven high-grade liposarcoma. The blue area yielded positive histology

Table 1 The frequency of blue areas within the tumours for both the benign and malignant lesions. 10% of the malignant lesions, i.e. 3% for the whole study population of 157, show biopsy positive in blue areas only

	Benign	Malignant
Total number	107	50
Blue areas	16 (14.9%)	14 (28%)
Grey scale ultrasound	9 complex cysts	7 solid
Biopsy positive for both targets	16 (100%)	Solid but some with necrotic zones
Biopsy positive for blue only	0 (0%)	9 (64%)
		5 (36%)

scale ultrasound. Ultrasound is useful for detecting soft tissue lesions and describing their morphology. In this study, the aim was to demonstrate whether targeting the biopsy track to a blue stiff area within the lesion, as demonstrated during compression sonoelastography, yielded additional value for determining positive histology in benign and malignant lesions.

In the past few years, sonoelastography has been adopted to assess the consistency of the lesion in terms of its elasticity or ‘stiffness’ in many differing soft tissues. Previous studies have shown that sonoelastography can be considered a useful tool in the differentiation of malignant from benign lesions in the breast, prostate, parotid gland and testicles, but is also valuable in the assessment of liver fibrosis.^{4–7} Colour Doppler helps to show angiogenesis within a lesion, which may be a differentiating factor between benign and malignant masses.¹¹ The addition of compression sonoelastography could improve objectivity.

Maccauro et al.¹² describe malignant tumours to be generally stiffer than benign masses, appearing as blue areas on sonoelastography. However, this was a small study population and in the author’s experience, many benign lesions may contain blue intralesional areas, e.g. fibromatosis is stiff and may be largely blue or black on the elastogram. Complex cysts containing ‘stiff’ fluid may also appear blue on sonoelastography and some benign superficial lesions may show boundary artefacts falsely, creating blue areas.

Chong et al.¹³ showed more blue areas in thyroid malignant lesions (65.8%) than benign lesions (24.6%). They demonstrated a higher frequency of blue areas than this study (malignant/benign – 28%/14.9%, respectively). This may be related to the widely varying tumour sizes in this study as well as the varying depth of lesions with differing surrounding soft tissues. Different equipment manufacturers may also be a factor as there is no industry standard algorithm.

Only Lalitha et al.,⁹ in their pictorial description on the musculoskeletal applications of sonoelastography, reference some experience in specific soft tissue lesions; they reported that haemangiomas and neurofibromas demonstrated red to green colour on sonoelastography. They suggested a soft to firm consistency without hard (blue) areas as the most representative sonoelastography appearance of benign lesions.

The ‘blue halo sign’, described by Itoh et al.¹⁴ and Scaperrotta et al.,¹⁵ where the malignant lesions are surrounded by a blue halo representing a desmoplastic reaction was described as a feature of malignancy. This study found this difficult to interpret when the lesion was superficial with a soft centre, such as a lipoma; this feature was not used to guide the biopsy.

The quantitative results of soft tissue elasticity with sonoelastography could give a better evaluation of tissue mechanical properties than qualitative sonoelastography.¹² The strain may depend on the lesion location, and the mechanical properties of the surrounding tissues, e.g. superficial soft tissue lesions can move laterally under the compression applied. The analysis of tissue stiffness could help differentiate the spatial distribution and extent of tissue stiffness in heterogeneous lesions.¹²

In this study, as the tumours are larger and deeper with greater heterogeneity, the strain ratio measurements were widely variable. Breast tumours are typically much smaller and strain ratios are calculated by using normal surrounding tissue as a reference. The strain ratio assessment was limited in this study as it was calculated using areas of interest solely within the tumour, reflecting heterogeneity of the mass.

The study design was limited by using only one observer and so inter-observer error was not assessed. Shear wave technology has the prospect of reducing inter-observer errors.

Operator feedback on the Toshiba Aplio is via a graphical waveform showing the operator’s even rhythm and pressure in both compression and relaxation phases, but shear wave technology may improve operator variability and reduce some of the artefacts created by the compression

technique (e.g. lateral shift artefact). Shear wave technology was not available at the time of this study.

This was an observational study suggesting that compression sonoelastography may offer some benefit when deciding where to position the biopsy needle within the mass. It demonstrated that 10% of the malignant lesions were biopsy positive in blue areas only ($p=0.008829$). This equates to 3% for the whole study population of 157. Previously, these patients would have had to undergo a second biopsy without this additional confirmation of 'stiff' areas provided from sonoelastography.

Conclusion

Compression sonography is operator dependent and is limited by artifacts which may reduce inter-observer reliability. This study demonstrated stiff areas in both benign and malignant tumours and so blue areas do not always indicate malignancy. The use of compression sonoelastography to guide needle biopsy has been shown to be of some benefit in providing more accurate histology with reduced repeat procedures. A further study is planned using shear wave technology to assess any statistical benefits with inter-observer analysis.

DECLARATIONS

Declaration of Conflicting Interests: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding: This work was supported by a NHS pump priming grant.

Ethical approval: Full ethical approval was obtained from the North Bristol NHS Trust.

Guarantor: MB

Contributorship: MB conceived and carried out the study, analysed the data and prepared and revised the manuscript.

ACKNOWLEDGEMENT

The author would like to acknowledge the help of Mr Paul Wilson, lead sarcoma surgeon, North Bristol.

REFERENCES

1. Ophir J, Céspedes I, Ponnekanti H, et al. Elastography: a quantitative method for imaging the elasticity of biological tissues. *Ultrason Imaging* 1991;**13**:111–34
2. Pedersen M, Fredberg U, Langberg H. Sonoelastography as a diagnostic tool in the assessment of musculoskeletal alterations: a systematic review. *Ultraschall Med* 2012;**33**:441–46
3. Nazarian LN. Science to practice: can sonoelastography enable reliable differentiation between benign and metastatic cervical lymph nodes? *Radiology* 2007;**243**:1–2
4. Garra BS, Céspedes EI, Ophir J, et al. Elastography of breast lesions: initial clinical results. *Radiology* 1997;**202**:79–86
5. Lyshchik A, Higashi T, Asato R, et al. Thyroid gland tumor diagnosis at US elastography. *Radiology* 2005;**237**:202–11
6. Bhatia KS, Tong CS, Cho CC, et al. Shear wave elastography of thyroid nodules in routine clinical practice: preliminary observations and utility for detecting malignancy. *Eur Radiol* 2012;**22**:2397–06
7. Motosugi U, Ichikawa T, Koshiishi T, et al. Liver stiffness measured by magnetic resonance elastography as a risk factor for hepatocellular carcinoma: a preliminary case-control study. *Eur Radiol* 2013;**23**:156–62
8. Botar Jid C, Vasilescu D, Damian L, et al. Musculoskeletal sonoelastography. Pictorial essay. *Med Ultrason* 2012;**14**:239–45
9. Lalitha P, Reddy MC, Reddy KJ. Musculoskeletal applications of elastography: a pictorial essay of our initial experience. *Korean J Radiol* 2011;**12**:365–75
10. Drakonaki EE, Allen GM, Wilson DJ. Ultrasound elastography for musculoskeletal applications. *Br J Radiol* 2012;**85**:1435–5
11. Lee WJ, Chu JS, Huang CS, et al. Breast cancer vascularity: color Doppler sonography and histopathology study. *Breast Cancer Res Treat* 1996;**37**:291–98
12. Maccauro G, Bonomo L, Leone A, et al. Sonoelastography for qualitative and quantitative evaluation of superficial soft tissue lesions: a feasibility study. *Eur Radiol* 2014;**24**:566–73
13. Chong Y, Shin JH, Ko ES, et al. Ultrasonographic elastography of thyroid nodules: Is adding strain ratio to colour mapping better? *Clinical Radiol* 2013;**68**:1241–6
14. Itoh A, Ueno E, Tohno E, et al. Breast disease: clinical application of US elastography for diagnosis. *Radiology* 2006;**239**:341–50
15. Scaperrotta G, Ferranti C, Costa C, et al. Role of sonoelastography in non-palpable breast lesions. *Eur Radiol* 2008;**18**:2381–9