Original Article

DOI: 10.14235/bas.galenos.2023.72623
Bezmialem Science 2023;11(3):295-9

A Prospective Study; Diagnostic Role of Shear-wave Elastography To Differentiate Benign and Non-benign Thyroid Nodules Categorized to According to the ACR 2017 TI-RADS

Prospektif Bir Çalışma; ACR 2017 TI-RADS'a Göre Benign ve Benign Olmayan Tiroid Nodüllerinin Ayırımında Shear-wave Elastografinin Rolü

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ABSTRACT

Objective: The differentiation between benign and non-benign thyroid nodules is a complex problem to solve in clinical practice. We aimed to observe and describe the role of shear-wave elastography (SWE) to distinct benign and non-benign thyroid nodules before a fine-needle aspiration biopsy (FNAB).

Methods: Ninety-seven patients were prospectively included in the study from March 2019 to January 2020. Patients with a history of thyroid infections, surgery or trauma of thyroid tissue, autoimmune diseases associated with thyroid gland, non-diagnostic histopathology (Bethesda I) were excluded from the study. Thyroid imaging reporting and data system (TI-RADS) based on the 2017 American College of Radiology (ACR) was used for the radiological classification of nodules. Patients' age, number of thyroid nodules, SWE value of nodules, and TI-RADS categories were compared to pathological classification.

Results: The mean age of patients was 49.80±11.42 years. Benign thyroid nodules were classified as "Group 1" (G1) (n=79) and non-benign thyroid nodules as "Group 2" (G2) (n=12) according to pathological diagnosis. The median SWE values of patients in G1 and G2 were 9.47 (7.48) and 47.38 (51.46) kPa, respectively. The median SWE values of G2 were statistically significantly higher

ÖZ

Amaç: Benign ve benign olmayan tiroid nodülleri arasındaki ayrım, klinik pratikte çözülmesi gereken karmaşık bir problemdir. Bu çalışma, ince iğne aspirasyon biyopsisi (İİAB) öncesinde benign ve benign olmayan tiroid nodüllerini ayırt etmede shear-wave elastografinin (SWE) rolünü gözlemlemeyi ve tanımlamayı amaçlamaktadır.

Yöntemler: Mart 2019-Ocak 2020 tarihleri arasında tiroid nodülü olan 97 hasta prospektif olarak çalışmaya dahil edildi. Otoimmin tiroid hasalığı, tiroid cerrahisi, travması veya enfeksiyonu, tanısal olmayan histopatolojisi (Bethesda 1) olan hastalar çalışma dışı bırakıldı. Radyolojik sınıflandırma için 2017 American College of Radiology (ACR) tiroid görüntüleme raporlama ve veri sistemi (TI-RADS) kullanıldı. Hastaların yaşı, tiroid nodül sayısı, nodüllerin SWE değeri ve TI-RADS kategorileri patolojik sınıflarına göre karşılaştırıldı.

Bulgular: Hastaların ortalama yaşı 49,80±11,42 yıl idi. Olgular patolojik tanılarına göre "Grup 1" (G1) (n=79) ve "Grup 2" (G2) (n=12) olarak iki gruba ayrıldı. Benign ve benign olmayan grupdaki hastaların medyan SWE değerleri sırasıyla 9,47 (7,48) ve 47,38 (51,46) kPa idi. G2'nin medyan SWE değerleri G1'den yüksekti ve bu fark istatistiksel olarak anlamlı olarak bulundu (p=0,001).

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Cite this article as: Şahin Ediz S, Tarhan M, Kabaalioğlu A. A Prospective Study; Diagnostic Role of Shear-wave Elastography To Differentiate Benign and Non-benign Thyroid Nodules Categorized to According to the ACR 2017 TI-RADS. Bezmialem Science 2023;11(3):295-9

Received: 09.10.2022
Accepted: 31.12.2022

ABSTRACT

than G1 (p=0.001). While nearly 50% of the patients in the G1 were in TI-RADS category 3, the ratio of TI-RADS 5 was over 40% in the G2 and the difference was statistically significant in terms of the TI-RADS category (p=0.001)

Conclusion: In addition to TI-RADS classification based on 2017 ACR, SWE measurements of thyroid nodules may differentiate benign and non-benign thyroid nodules before an FNAB. For this reason, both methods can be combined to increase the diagnosis's specificity, sensitivity, and accuracy.

Keywords: Thyroid nodule, ultrasonography, shear-wave elastography, TI-RADS

ÖZ

G1'deki hastaların yaklaşık %50'si TI-RADS kategori 3 iken, T1-RADS 5 oranı G2'deki hastaların %40'ının üzerindeydi.

Sonuç: 2017 ACR'ye dayalı TI-RADS sınıflamasına ek olarak, tiroid nodüllerinin shear-wave elastografi ölçümleri İİAB öncesi benign ve benign olmayan tiroid nodüllerinin ayrımında kullanılabilir. Bu nedenle, tanının özgüllüğünü, duyarlılığını ve doğruluğunu artırmak için her iki yöntem birlikte uygulanabilir.

Anahtar Sözcükler: Tiroid nodülü, ultrasonografi, shear-wave elastografi, TI-RADS

Introduction

Thyroid nodules are frequently seen in radiology and endocrinology practice and the incidence of thyroid nodules is increasing, especially in the population who is in the first two decades of life (1). While about 5% of diagnosed thyroid nodules have malign pathology, the majority has benign pathology and it is clinically significant to diagnose malignant nodules.

Although some gray scale ultrasound imaging findings are related to the malignancy of thyroid nodules, the prediction of histopathological diagnosis of thyroid nodules is complicated by using ultrasonography (US) (2).

Ultrasound elastography is a recent and advanced modality that raises the diagnostic performance of US by distinguishing varied tissues elasticity (3). Shear-wave elastography (SWE) is a less operator-dependent imaging technique that directly determines absolute stiffness without a maneuver (4,5). In recent years, elastosonography is widely used for the diagnosis of malignities, fibrosis, or inflammatory (edematous appearance) process in breast, thyroid or prostate tissue and musculoskeletal system. SWE uses shearwaves to quantitatively measure tissue stiffness that allows the differentiation of benign and non-benign thyroid nodules. Further, the best method for this differentiation is fine needle aspiration biopsy (FNAB). Thyroid Imaging Report and Data System (TI-RADS) is a guide for the decision of FNAB. TI-RADS classificaiton system was suggested firstly based on the Breast Imaging Report and Data System model, that was reported by the American College of Radiology (ACR) in 2003 (6). ACR published the revised version of TI-RADS in 2017 based off wide-ranging evidence and clinical confirmation. TI-RADS based on 2017 ACR is a risk grading system to guide decisions concerning FNAB and follow-up of thyroid nodules acording to their gray scale ultrasound features. It identifies the most clinically significant malignancies while decreasing biopsies applied on benign nodules (7). However, FNAB has disadvantages as it is a time-consuming and invasive procedure (8-10).

In this first prospective study, we aim to analyze and investigate the diagnostic efficacy of the TI-RADS based on 2017 ACR classification using the SWE values in detecting benign andnon-benign thyroid nodules before FNAB.

Methods

The local ethics committee of our hospital approved this prospective study (GEAH-KEK-2019/0057). The procedure was explained in detail to each participant prior to measurement and it was performed from March 2019 to January 2020 in our clinic. Informed consent was obtained from each patient before the measurement and FNAB, and the study was conforming to the principles of the Declaration of Helsinki.

Participants with a history of thyroid infections, surgery or trauma of thyroid tissue, autoimmune diseases associated with thyroid gland, non-diagnostic histopathology (Bethesda I) were excluded from the study. Ninety-one thyroid nodules diagnosed in 91 patients were prospectively comprised to the study from March 2019 to January 2020.

We used a Ultrasound 2D SWE system to examine the thyroid nodules, initially the gray scale US, then quantified with SWE software without compression (Esaote QElaXto 2D ultrasound, Genova, Italy). Evaluation of thyroid nodule stiffness was made by using SWE velocity and quantitative measurements were received as kilopascal (kPa). A linear transducer of 6-9 MHz was preferred for the process. The patients laid down with supine position and were told to hold their breath while during the SWE examination and measuring. Quantitative elastographic assessment was performed using a 2x2 mm region of interest (ROI). We placed the ROI within the biopsy considered nodule. Course calcified and cystic areas were excluded from the ROI area. The preset of grayscale ultrasound was set to a depth of 0-2.5 cm. Five ROI areas were randomly selected for each area for quantitative measurement. We obtained the mean value of the 5 ROI areas to use in the statistical analysis as shown in Figure 1.

Classification of thyroid nodules and biopsy indications were made according to ACR 2017 TI-RADS. Then, we performed FNAB to thyroid nodules under ultrasound guidance after SWE measurements by two radiologists who had three years of experience in FNAB. 1% lidocaine was used for skin local

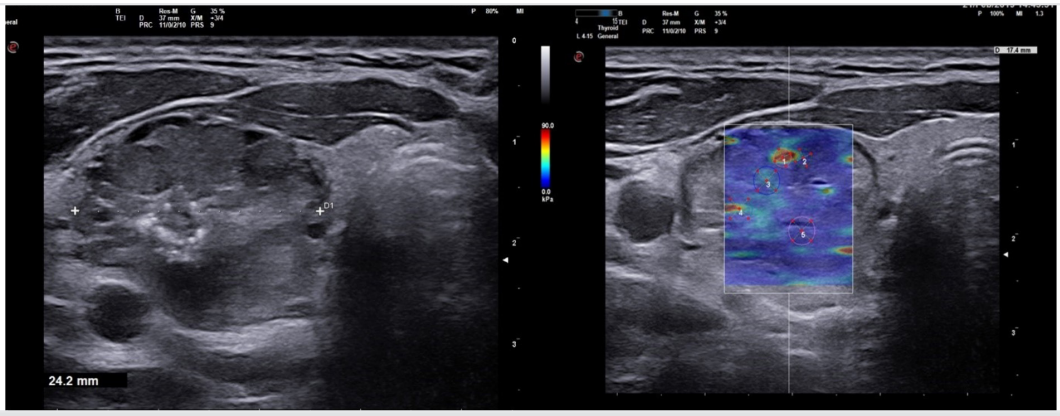

Figure 1. Grey-scale ultrasound (left) and color SWE (right) images showing the SWE measurement technique of thyroid nodule in our study

SWE: Shear-wave elastography

anaesthesia then 22- gauge PTC needle was used for biopsy under ultrasound guidance. Three aspirations and smears were made for each nodule. A pathologist classified the FNA thyroid cytopathology according to the Bethesda System as follows; Bethesda I (non-diagnostic or unsatisfactory), Bethesda II (benign), Bethesda III (AUS/FLUS, atypia of undetermined significance/follicular lesion of undetermined significance), Bethesda IV (FN/SFN, follicular neoplasm/suspicious for follicular neoplasm), Bethesda V (suspicious for malignancy), and Bethesda VI (malignant)(11).

Benign (Bethesda II) thyroid nodules were defined as "Group 1" (G1) (n=79) and non-benign (Bethesda II-III-IV-V-VI) thyroid nodules as "Group 2" (G2) (n=12) according to pathological diagnosis. Both groups were evaluated in terms of age, the number of thyroid nodules, SWE values, and TI-RADS categories.

Statistical Analysis

We used SPSS version 22.0 software in the data analysis of the study (IBM SPSS, USA). The normality of distributions was assessed by using the Shapiro-Wilk test. We used the descriptive statistics analysis such as mean, Standard deviation, frequency or median and interquartile range. Student-t test was performed to compare normally distributed parameters and Mann-Whitney U test was performed as a non parametric test when the parameters did not have normal distribution. Values were assessed within 95% confidence range at $p<0.05$ significance level.

Results

The general data of the participants are summarized in Table 1. The mean age of all patients with SD was 49.80±11.42 years. Compared to the patients in G1, the mean age of patients in G2 was statistically lower (p=0.02). However, no statistically significant difference was found in the number of thyroid nodules between the groups (p>0.05). The median SWE values of patients in G1 and G2 were 9.47 (7.48) kPa and 47.38 (51.46) kPa, respectively. The median SWE values of G2 were statistically significantly higher than G1 (p=0.001). While nearly 50% of the patients in the G1 were in TI-RADS category 3, the rate of TI-RADS 5 was over 40% in the G2 and the difference was statistically significant in terms of the TI-RADS category (p=0.001)

Discussion

The differentiation of benign and non-benign thyroid nodules is a complex problem to solve in medical practice. Recently, elastography has been investigated in the distinction of benign and non-benign thyroid nodules, and different studies have reported that SWE is helpful for the distinction of benign and non-benign thyroid nodules (12-24). However, some studies did not support this positive contribution (25-29). Thyroid nodules were not classified according to the ACRTI-RADS based on 2017 in all studies mentioned above. According to the results of a study in the literature evaluating thyroid nodules based on the last reported TI-RADS grading system in ACR 2017 and investigating the effect of SWE on thyroid nodules before biopsy; it is recommended that SWE must be used especially unclear fine-needle aspiration cytology (Bethesda III, IV, and V) (30). Zhang et al. (30) suggested that using of the SWE and TI-RADS based on 2017 ACR together might contribute to diagnostic accuracy and sensitivity and help determine benign and malignant thyroid nodules with uncertain fine-needle aspiration cytology. In another study, Xu et al. (31) suggested a similar idea that the combination of the SWE and 2017 ACR TI-RADS could increase the precision of the diagnosis. Bora Makal and Aslan (32) concluded that SWE was more successful than the 2017 version of ACR TI-RADS categorization in the distinction of benign and non-benign thyroid nodules. However, one of the limitations of the studies is retrospective planning. In a prospective study, "modified TI-RADS" [the combination of ACR TI-RADS, SWE and CEUS (contrast-enhanced ultrasound)] was recommended to provide a decrease in the number of biopsiesapplied on benign nodules (33). In our study, it was found that the non-benign nodules had higher SWE values, thus SWE had a diagnostic effect to differentiate between benign and non-benign thyroid nodules prior to FNAB. We suggest ACR TI-RADS + SWE or "modified

Table 1. The detailed SWE findings of both groups are described

	G1 (n=79)	G2 (n=12)	p
Age $_{\text{mean ± SD}}$	50.72±10.14	54.62±17.10	[1]0.02
Number of thyroid nodule$_{\text{median(IQR)}}$	1 (0.001)	1 (0.001)	[2]0.297
SWE$^{\text{mean}}_{\text{median (IQR)}}$	9.47 (7.98)	47.38 (51.46)	[2]0.0001
TI-RADS 3 $_{\text{(number)}}$	54	3	[3]0.0001
TI-RADS 4 $_{\text{(number)}}$	25	4	
TI-RADS 5 $_{\text{(number)}}$	0	5	

[1]Student's t-test, [2]Mann-Whitney U test, [3]Pearson chi-square, SD: Standard deviation

TI-RADS" in the distinction of benign and non-benign thyroid nodules. Although elastosonography is exciting, it has some limitations, such as lack of standardization (34). Therefore, the presence of interventional radiologists with sufficient experience on the subject is significant.

Study Limitations

Our study has some limitations. First of all, measurement on SWE is an operator-dependent imaging tecnique. Also, we have a small sample size; but the design of our prospective study enhances the reliability of our outcomes.

Conclusion

Measurements with SWE on thyroid nodules that we suggested as a non-invasive and an easily approachable tecnique with the use of the ACR TI-RADS (2017 version) might be advantageous to differentiate benign and non-benign thyroid nodules prior to FNAB.

Ethics

Ethics Committee Approval: The local ethics committee of our hospital approved this prospective study (GEAH-KEK-2019/0057).

Informed Consent: Informed consent was obtained from each patient before the measurement and FNAB, and the study was conforming to the principles of the Declaration of Helsinki.

Peer-review: Externally peer reviewed.

Authorship Contributions

Surgical and Medical Practices: S.Ş.E., M.T., Concept: S.Ş.E., A.K., Design: S.Ş.E., M.T., A.K., Data Collection or Processing: S.Ş.E., M.T., Analysis or Interpretation: S.Ş.E., M.T., Literature Search: S.Ş.E., A.K., Writing: S.Ş.E., A.K.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Niedziela M. Thyroid nodules. Best Pract Res Clin Endocrinol Metab 2014;28:245-77.
2. Lim DJ, Luo S, Kim MH, Ko SH, Kim Y. Interobserver agreement and intraobserver reproducibility in thyroid ultrasound elastography. AJR Am J Roentgenol 2012;198:896-901.
3. Kyriakidou G, Friedrich-Rust M, Bon D, Sircar I, Schrecker C, Bogdanou D, et al. Comparison of strain elastography, point shear wave elastography using acoustic radiation force impulse imaging and 2D-shear wave elastography for the differentiation of thyroid nodules. PLoS One 2018;13:e0204095.
4. Yang YP, Xu XH, Guo LH, He YP, Wang D, Liu BJ, et al. Qualitative and quantitative analysis with a novel shear wave speed imaging for differential diagnosis of breast lesions. Sci Rep 2017;7:40964.
5. Alfuraih AM, O'Connor P, Hensor E, Tan AL, Emery P, Wakefield RJ. The effect of unit, depth, and probe load on the reliability of muscle shear wave elastography: Variables affecting reliability of SWE. J Clin Ultrasound 2018;46:108-15.
6. Horvath E, Majlis S, Rossi R, Franco C, Niedmann JP, Castro A, et al. An ultrasonogram reporting system for thyroid nodules stratifying cancer risk for clinical management. J Clin Endocrinol Metab 2009;94:1748-51.
7. T Tessler FN, Middleton WD, Grant EG, Hoang JK, Berland LL, Teefey SA, et al. ACR Thyroid Imaging, Reporting and Data System (TI-RADS): White Paper of the ACR TI-RADS Committee. J Am Coll Radiol 2017;14:587-95.
8. Kagoya R, Monobe H, Tojima H. Utility of elastography for differential diagnosis of benign and malignant thyroid nodules. Otolaryngol Head Neck Surg 2010;143:230-4.
9. Vorländer C, Wolff J, Saalabian S, Lienenlüke RH, Wahl RA. Real-time ultrasound elastography--a noninvasive diagnostic procedure for evaluating dominant thyroid nodules. Langenbecks Arch Surg 2010;395:865-71.
10. Hoang JK, Lee WK, Lee M, Johnson D, Farrell S. US Features of thyroid malignancy: pearls and pitfalls. Radiographics 2007;27:847-65.
11. Cibas ES, Ali SZ. The 2017 Bethesda System for Reporting Thyroid Cytopathology. Thyroid 2017;27:1341-6.
12. He YP, Xu HX, Li XL, Li DD, Bo XW, Zhao CK, et al. Comparison of Virtual Touch Tissue Imaging & Quantification (VTIQ) and Toshiba shear wave elastography (T-SWE) in diagnosis of thyroid nodules: Initial experience. Clin Hemorheol Microcirc 2017;66:15-26.
13. Hu X, Liu Y, Qian L. Diagnostic potential of real-time elastography (RTE) and shear wave elastography (SWE) to differentiate benign and malignant thyroid nodules: A systematic review and meta-analysis. Medicine (Baltimore) 2017;96:e8282.

14. Tian W, Hao S, Gao B, Jiang Y, Zhang X, Zhang S, et al. Comparing the Diagnostic Accuracy of RTE and SWE in Differentiating Malignant Thyroid Nodules from Benign Ones: a Meta-Analysis. Cell Physiol Biochem 2016;39:2451-63.
15. Lin P, Chen M, Liu B, Wang S, Li X. Diagnostic performance of shear wave elastography in the identification of malignant thyroid nodules: a meta-analysis. Eur Radiol 2014;24:2729-38.
16. Ma BY, Parajuly SS, Ying SX, Lan PY. Application of shear wave elastography in fine needle aspiration biopsy for thyroid nodule. J Pak Med Assoc 2014;64:954-7.
17. Chen M, Zhang KQ, Xu YF, Zhang SM, Cao Y, Sun WQ. Shear wave elastography and contrast-enhanced ultrasonography in the diagnosis of thyroid malignant nodules. Mol Clin Oncol 2016;5:724-30.
18. Liu Z, Jing H, Han X, Shao H, Sun YX, Wang QC, et al. Shear wave elastography combined with the thyroid imaging reporting and data system for malignancy risk stratification in thyroid nodules. Oncotarget 2017;8:43406-16.
19. Park AY, Son EJ, Han K, Youk JH, Kim JA, Park CS. Shear wave elastography of thyroid nodules for the prediction of malignancy in a large scale study. Eur J Radiol 2015;84:407-12.
20. Duan SB, Yu J, Li X, Han ZY, Zhai HY, Liang P. Diagnostic value of two-dimensional shear wave elastography in papillary thyroid microcarcinoma. Onco Targets Ther 2016;9:1311-7.
21. He YP, Xu HX, Wang D, Li XL, Ren WW, Zhao CK, et al. First experience of comparisons between two different shear wave speed imaging systems in differentiating malignant from benign thyroid nodules. Clin Hemorheol Microcirc 2017;65:349-61.
22. Kim H, Kim JA, Son EJ, Youk JH. Quantitative assessment of shear-wave ultrasound elastography in thyroid nodules: diagnostic performance for predicting malignancy. Eur Radiol 2013;23:2532-7.
23. Bhatia KS, Lam AC, Pang SW, Wang D, Ahuja AT. Feasibility Study of Texture Analysis Using Ultrasound Shear Wave Elastography to Predict Malignancy in Thyroid Nodules. Ultrasound Med Biol 2016;42:1671-80.
24. Tian W, Hao S, Gao B, Jiang Y, Zhang S, Guo L, et al. Comparison of Diagnostic Accuracy of Real-Time Elastography and Shear Wave Elastography in Differentiation Malignant From Benign Thyroid Nodules. Medicine (Baltimore) 2015;94:e2312.
25. Bhatia KS, Tong CS, Cho CC, Yuen EH, Lee YY, Ahuja AT. Shear wave elastography of thyroid nodules in routine clinical practice: preliminary observations and utility for detecting malignancy. Eur Radiol. Shear wave elastography of thyroid nodules in routine clinical practice: preliminary observations and utility for detecting malignancy. Eur Radiol 2012;22:2397-406.
26. Bardet S, Ciappuccini R, Pellot-Barakat C, Monpeyssen H, Michels JJ, Tissier F, et al. Shear Wave Elastography in Thyroid Nodules with Indeterminate Cytology: Results of a Prospective Bicentric Study. Thyroid 2017;27:1441-9.
27. Dobruch-Sobczak K, Zalewska EB, Gumińska A, Słapa RZ, Mlosek K, Wareluk P, et al. Diagnostic Performance of Shear Wave Elastography Parameters Alone and in Combination with Conventional B-Mode Ultrasound Parameters for the Characterization of Thyroid Nodules: A Prospective, Dual-Center Study. Ultrasound Med Biol 2016;42:2803-11.
28. Liu B, Liang J, Zheng Y, Xie X, Huang G, Zhou L, et al. Two-dimensional shear wave elastography as promising diagnostic tool for predicting malignant thyroid nodules: a prospective single-centre experience. Eur Radiol 2015;25:624-34.
29. Wang F, Chang C, Gao Y, Chen YL, Chen M, Feng LQ. Does Shear Wave Elastography Provide Additional Value in the Evaluation of Thyroid Nodules That Are Suspicious for Malignancy? J Ultrasound Med 2016;35:2397-404.
30. Zhang WB, Li JJ, Chen XY, He BL, Shen RH, Liu H, et al. SWE combined with ACR TI-RADS categories for malignancy risk stratification of thyroid nodules with indeterminate FNA cytology. Clin Hemorheol Microcirc 2020;76:381-90.
31. Xu X, He XL, Guo LL. [The diagnostic value of the maximum value of Young's modulus of shear-wave elastography and ACR TI-RADS for thyroid nodules]. Lin Chuang Er Bi Yan Hou Tou Jing Wai Ke Za Zhi 2019;33:764-7.
32. Bora Makal G, Aslan A. The Diagnostic Value of the American College of Radiology Thyroid Imaging Reporting and Data System Classification and Shear-Wave Elastography for the Differentiation of Thyroid Nodules. Ultrasound Med Biol 2021;47:1227-34.
33. J Jin ZQ, Yu HZ, Mo CJ, Su RQ. Clinical Study of the Prediction of Malignancy in Thyroid Nodules: Modified Score versus 2017 American College of Radiology's Thyroid Imaging Reporting and Data System Ultrasound Lexicon. Ultrasound Med Biol 2019;45:1627-37.
34. Abd ellah MMH, Bamidele JO, Debbage P, Taljanovic M, Jaschke W, Klauser AS. Future of musculoskeletal ultrasound. Curr Radiol Rep 2015;3:21.