Macedonian Journal of Medical Sciences. 2009 Jun 15; 2(2):149-152.
doi:10.3889/MJMS.1857-5773.2009.0048
***Clinical Science***



# Value of Ultrasound Machine Settings Optimization for Better Diagnosis of Focal Liver Lesions

Petar Avramovski
*Clinical Hospital, Internal Medicine, Bitola, Republic of Macedonia*

**Key words:**
Focal liver lesions; Doppler; Optimization of parameters.

**Correspondence**:
Petar Avramovski, MD
Clinical Hospital, Internal Medicine,
Partizanska bb, 7000
Bitola, Republic of Macedonia
Tel.: +38970207187
E-mail: avramovski@gmail.com

Received: 03-Feb-2009
Revised: 15-Apr-2009
Accepted: 22-Apr-2009
Online first: 03-May-2009

**Abstract**

**Background.** Focal liver lesions and metastasis can be very hard to localize. For best imaging, customizing of several settings of the machine are necessary: brightness, contrast, probe frequency, focusing, dynamic range, time gain compensation, flow area, flow gain, sample volume, angle, peak repetitive frequency, filter adjusting and parallelogram of region of interest.

**Aim.** The aim of this study is to examine the influence of adjusted or not adjusted ultrasound scanner in diagnosing of focal liver lesions.

**Material and methods.** The study involves 129 patients from the group of focal liver lesions including a broad spectrum of benign, malignant, and infectious aetiologies. We made ultrasound examination with automatic factory settings of ultrasound machine parameters and after that all off them were examined with manual settings of the scanner.

**Results.** The results obtained from “auto” and “manual” mode settings were compared with CT and MRI imaging as a gold standard. In auto mode false positive results were seen in patients with hiperechoic metastases understood like FNH, patients with hipoechoic metastases treated like haemangioma, patients with anechoic metastases and patients with abscesses treated like cysts.

**Conclusion.** Manual mode ultrasound procedure is more accurate in detection of focal liver parenchymal lesions because of reduced specificity in auto mode compared with higher specificity and small percentage of false positive results within manually adjusted scanner. We show the great value of best performance manual setting of the scanner in liver parenchymal focal lesions detecting.

## Introduction

It can be very hard to localize focal liver lesions and metastasis (1). Also could be very difficult to distinguish isoechoic nodules and metastasis from adjacent liver tissue (2, 3). Ultrasound is quick, inexpensive, safe and easy to perform procedura, but Doppler ultrasound can provide additional information regarding vascularity of the lesion.

For the best imaging in B-mode, optimization of brightness, contrast, probe frequency, focusing, dynamic range, time gain compensation and gain is necessary. Brightness and contrast are display moni-

tor parameters for better shade visualization. Manual focusing is process of adequate ultrasound beam concentrating on preferred level of scan. The dynamic range (DR) in signal processing is the range between the minimum low intensity and maximum high intensity signals that a system is capable of displaying. Time gain compensation (TGC) is the signal processing control that allows the operating physician to extra amplify the returning signal from deeper structures in the body. The TGC control compensates for the attenuation of sound waves (4). Hipoechogenic metastasis in deep part of cirrhotic liver need extra manualy setting of TGC, to make metastatic node distinguishable from low echogenic liver tissue because of the deep US attenuation. Sometimes supplementary effort is need to enhance the received echoes in case where tissue attenuation is more expressed: fatty liver, cirrhosis. We can miss a metastasis localize in deep part of liver because attenuation of high density of cirrhotic liver. The gain is the ratio of input to output in an amplifier. The sensitivity of a probe is adjusted by changing the gain.

For the best imaging in Doppler mode, optimization of flow area, flow gain, sample volume (SV), angle, pulse repetition frequency (PRF) and filter adjusting are necessary. Flow area is space for colour mode presentation of blood flow in B-mode superposition. Flow gain is level amplification of colour coded signal from the vessels, represented as colour saturation. SV is area between two parallel lines to get information for blood flow measurement. PRF determines pulse frequency of repetition and time needed for commutation between emitter and receive. Filtering is selective band-pass of frequency (5).

It is certain that working with manual optimized ultrasound machine settings is much more accurate in diagnosing focal liver lesions and metastasis, then automatic optimized settings. The aim of this study is to compare the results of ultrasound examination obtained in auto and manual mode, with results with CT and MRI in order to see which mode gives more precise results. We will use CT and MRI imaging as a gold standard for evaluating results obtained from ultrasound examination in „auto" and „manual" mode.

## Material and methods

The study involved 129 patients (69 male and 57 female), with focal liver lesions, with a broad spectrum of benign, malignant, and infectious aetiologies. We used colour Doppler ultrasound machine Toshiba SSA-340A (Toshiba Medical System Corporation, 1385, Shimoishigami, Otara-Shi, Tochigi, Japan). Age distribution of patients was 43 to 75 years. Every patient with suspicious ultrasound signs for focal liver lesions was afterwards examined with one of relevant imaging technique CTM or EMR.

We made first B-mode ultrasound examination and after that we made colour Doppler ultrasound, at every single patient, with automatic factory settings of ultrasound machine parameters (brightness, contrast, focusing, dynamic range, time gain compensation and gain at B-mode; flow area, ROI, angle, PRF and filtering at Doppler mode).

All of them, were examined by ultrasound with manual settings parameters, twice.

### *B-mode manual settings*

Brightness and contrast were adjusted before every ultrasound examination for better display of all 256 shadows of grey scale. When we worked with multi frequency probe, we selected low frequency for deep tissue exploring and low resolution of image. At high image resolution and surface exploring of tissue we proposed high frequency adjustment of the ultrasound probe. The next process of settings for better image quality is manual focusing. When we saw some area of interest, we set focus and time gain control at the same distance, increasing of TGC at that depth, and decreasing of TGC at depth without correlating that area.

### *Doppler mode settings*

First step in Doppler mode adjustment is flow area setting position and size. We set the minimal size to cover explored vascular vessel so we can get the maximal frame rate of the screen. We set adequate flow gain in dB with flow gain button to get a colorized blood flow only inside the vessel. In the center of the vessel up to the vessels margins we put sample volume with angle of 45 – 60°. In case the flow signal is poor or week we switch on Power Doppler mode. Appropriate value of Peak Repetitive Frequency from 3 to 6 KHz and filter from 22 to 697Hz were selected. The ROI parallelogram was delineated around spectral wide broaden signal with minimal noise. Sometimes, for better visualization of small vessels of metastized vascularization, we switch on colour enhancement mode with colour persistence, colour angio and colour capture mode (Fig. 1).

The results of findings that we compared with computed tomography, electromagnetic resonance or intraoperative histological analysis of liver tissue. We

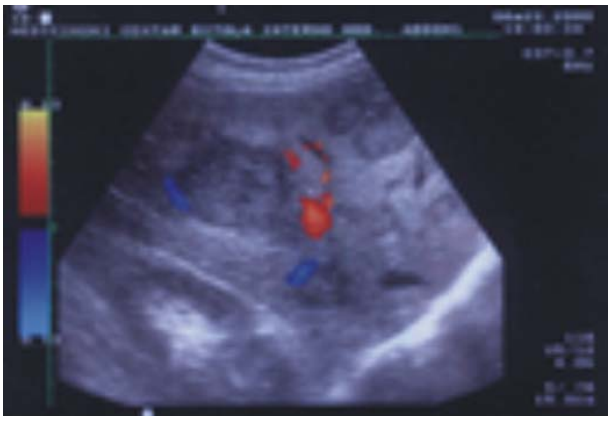

Figure 1: Colour Doppler imaging of liver metastasis.

calculated sensitivity as quotient of number of patients with related disease in auto mode and confirmative diagnosis by CTM (Computed Tomography) or EMR (Electromagnetic Resonance); sensitivity at patients examined in manual mode in the same way, respecting.

## Results

All of 129 patients were examined by B- mode and Doppler ultrasound and the results were compared with the results of CTM or EMR. We used a simple statistical method for sensitivity calculation by following formula: $Se = \frac{TP}{TP + FN}$. TP=true positive, FN=false negative.

The results of examination are entered in three main columns: auto mode, manual mode and real definitive findings by CT or EMR. The numbers of patients with focal parenchymal liver lesions are showed in nine rows divided according to type of lesions: metastasis, haemangioma, abscesses etc (Table 1).

The misinterpreted results of various diseases are shown as false positive findings, as percent of overlap with correct valid diagnoses by relevant imaging techniques and preoperative biopsy at patients with colorectal carcinoma (for patients with liver metastasis only) is showed right side of sensitivity value.

In auto mode (factory preset) we saw: improperly examined 3 patients with hiperechoic metastases understood like FNH, therefore the real number (6) of patients with FNH is increased to 9 in this mode; improperly examined 4 patients with hipoechoic metastases treated like haemangioma, therefore the

**Table 1: Numbers of focal parenchymal liver disease and percent of sensitivity at ultrasound examination at auto and manual mode compared with CTM or EMR imaging.**

| focal lesions \ examination mode | | Auto | | Manual | | Real |
|---|---|---|---|---|---|---|
| | | case num. | sensitivity | case num. | sensitivity | (CT,EMR) |
| metastasis | hyperechoic | 33 | 91,6% | 35 | 97,2% | **36** |
| | hypoechoic | 34 | 89,5% | 37 | 97,4% | **38** |
| | isoechoic | 7 | 58,3% | 11 | 91,6% | **12** |
| | anechoic | 15 | 83,3% | 17 | 94,4% | **18** |
| HCC | | 2 | 50,0% | 3 | 75,0% | **4** |
| Hemangioma | | 12 | 100,0% i.p.50% | 8 | 100,0% | **8** |
| Focal NH | | 9 | 100,0% i.p.50% | 5 | 83,3% | **6** |
| Cystae | | 9 | 100,0% i.p.200% | 4 | 100,0% i.p.33,3% | **3** |
| Abscessus | | 1 | 25,0% | 3 | 75,0% | **4** |

real number (8) of patients with haemangioma is increased to 12 in this mode; improperly examined 3 patients with anechoic metastases and 3 patients with abscesses treated like cysts, because of that the real number (3) of patients with cysts is increased to 9 in this mode. There are false positive results during examining patients with haemangioma, focal NH, cysts and abscesses in auto mode (Table 1).

In manual preset mode, only one patient with abscesses of the liver was misinterpreted as liver cyst, so the real patient number (4) with liver abscesses decreased to 3 cases. In this mode we omitted one patient with FNH, one patient with HCC and one patient

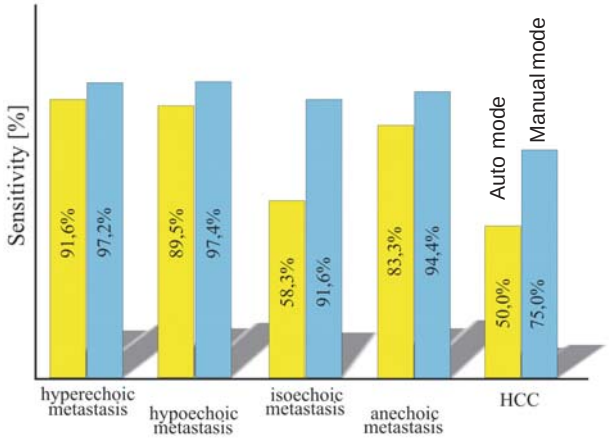


*Figure 2: Sensitivity of examination during preset or auto mode on malignant parenchymal liver lesions compared with the golden standard technique.*

from every type of liver metastasis: hyperechoic, hypoechoic, isoechoic and anechoic.

The fatty liver background resulted in being invisible 3 hyperechoic metastasis, because of equalization of acoustic gradients of fatty liver parenchyma with acoustic gradients of metastasis. Only one me-

tastasis was invisible in manual mode. The second gratest difference between sensitivity of auto (58.33%) and manual mode (91.66%) was expressed during imaging of isoechoic metastasis. Similar ultrasound characteristic of anechoic hydroid cysts with US characteristics of mixed echogenicity of abscesses gives the gratest sensitivity difference between auto (25%) and manual (75%) mode (Fig. 2).

## Discussion

Monitor view setting is the first step of parameters settings to get all of 256 grey scales shades. We missed a number of cases with hiperechoic and anechoic metastases in reduced shades which are result of improperly chosen dynamic range (6). We missed more cases of deep liver level abscesses because of unadjusted focus and time gain control. Low gain control adjustment is a cause of equalizing or mask effect in hipoechoic and anechoic liver nodules, but high gain control adjusting of equalizing or masking effect in hiperechoic liver nodules and reduce the phenomena of distal amplification in cysts.

The best visualization of metastasis was acquired with manual adjusted dynamic range (DR) and times gain controls on the same level that metastasis were appeared and selected high frequency probe for better resolution. TGC is used for compensation of the attenuation of ultrasound echo signals along the depth, and DR is for controlling the image contrast. Every time during exploration of liver metastasis with anechogenic ring, we can loose this early sign of metastasis detection, if we do not properly adjust brightness, contrast, dynamic range, gain and focus property.

For better metastasis diagnosis we usually examine its vascularization: feed, drenaige, penetration and spotty signals. With correct flow gain adjustment we can prove real colour signals from vessels (7, 8). Low flow gain result with missed signal and high flow gain result with colour signal of unexistable flow. Using a small PRF in high speed blood flow is incorrect and produces aliasing and other artefacts. In that case we made incorrect diagnosis for some metastasis, a haemangioma and other nonvascular structure. High PRF reduces the depth of penetration of US signals. The large ROI results in small frame rate, a suitable condition for missing the speed movement of vascular pulsation in metastasis and its missinterpretation like benign nodule. The slow and chaotic spotty signals are possible for visualization only with correct manual filter settings on low frequency of filter. In all cases sensitivity of US investigations the results were better in manual mode settings then auto mode.

Reduced value of sensitivity in auto mode with high percent of false positive results compared with more higher sensitivity and small percentage of false positive results within manually adjusted scanner, during ultrasound imaging procedure, allow us to conclude that manual mode US procedure is more accurate in examination of focal liver parenchymal lesions. Good performance setting of US scanner gives us reliable information for exact imaging of nodules, flows, size and positions of liver lesions.

We conclude that the value of optimization of Doppler ultrasound machine settings for diagnosis of focal liver lesions is substantial. The manual settings of the machine have to be the first step in every ultrasound examination.

## References

1. Semelka RC, Martin DR, Balci NC. Focal lesions in normal liver. J Gastroenterol Hepatol. 2005;20(10):1478-87. doi:10.1111/j.1440-1746.2005.03854.x PMID:16174062

2. Lee C-Y, Freiburger PD, Magrane MG. Automatic optimization in spectral Doppler ultrasound imaging. http://www.faqs.org/patents/app/20080242995.

3. Evans DH, Mc Dicken WN, Skidmore R et al. Doppler Ultrasound: Physics, Instrumentation, and Clinical Applications. Chichester: Wiley, 1989.

4. Duhgoon L, Kim YS, RA JB. Automatic time gain compensation and dynamic range control in ultrasound imaging systems. Proc SPIE. 2006;6147:614708 doi:10.1117/12.653000

5. Principles of Doppler: Pulsed-Wave Doppler (PW), Color Doppler, Power Doppler. http://www.visualsonics.com/vevo2100/Doppler%20Imaging%20Principles.pdf.

6. Glover C, Douse P, Kane P, Karani J, Meire H, Mohammadtaghi S, Allen-Mersh TG. Accuracy of investigations for asymptomatic colorectal liver metastases. Dis Colon Rectum. 2002;45(4):476-84. doi:10.1007/s10350-004-6224-y PMID:12006929

7. An atlas of ultrasound color flow imaging?. Ed by Barry B. Goldberg, Daniel A. Merton, Colin R. Deane . Taylor & Francis, 1997:290.

8. Grigorov N, Nikolova S. Klinichna Dopler ehografia. Sofia: Medicinsko izdatelstvo, 1997:94-95.

9. Shvarts A. Automatically adjusted presets for an ultrasound machine. Siemens corporation. Fresh Pattent com. 2007.