

**CONTRAST-ENHANCED POWER DOPPLER SONOGRAPHY  
IN DETECTION AND DIFFERENTIATION  
OF FOCAL LIVER LESIONS**

**Magdalena Genadieva-Dimitrova, Metodija Neškovski,  
Rozalinda Popova, Nenad Joksimović, Meri Trajkovska,  
Mitko Miloševski, Vladimir Serafimoski,**

*Clinic of Gastroenterohepatology, Medical Faculty,  
Skopje, R. Macedonia  
Macedonian Academy of Sciences and Arts, Skopje, R. Macedonia*

**Abstract:** The aim of the study is to evaluate the contrast enhanced power doppler technique as a method to detect and differentiate vascular patterns of focal liver lesions.

Forty-nine patients with focal liver lesions were included in the study, twenty-nine of them with malignant liver lesions (9 HCC, 20 metastatic), twenty patients with benign lesions (12 haemangiomas, 5 focal nodular hyperplasia, 3 focal steatosis). In all patients classic B-mode and power doppler sonography was performed prior to administration of the contrast medium Levovist (300 mg/ml) and a power doppler examination subsequent to medium administration.

Contrast administration led to lowering the number of "no-flow" lesions from 19 to 11. Postcontrast scan analysis revealed markedly enhanced flow in 15 cases in comparison to only 4 in pre-contrast examinations. The pre-contrast power doppler showed central flow in 7, and peripheral in 26 focal liver lesions. On the other hand, the postcontrast study revealed a central flow in 14, and peripheral in 34 focal liver lesions. Statistical significance between pre- and post-contrast power doppler detection of vascularization existed in malignant focal liver lesions and haemangiomas. The same pre- and post-contrast evaluation proved to be statistically non-significant in the focal nodular hyperplasia and focal steatosis groups.

Administration of contrast medium enables a better visualization of intra-tumour blood vessels in focal liver lesions. This, in combination with the power doppler technique, brings such scans close to angiographic findings.

**Key words:** focal liver lesions, power doppler sonography, contrast agent.

### *Introduction*

The Color Doppler imaging technique has been developed by Namekawa and his collaborators who have used it to evaluate the dynamics of blood flow in the heart and the major blood vessels. Its application in hepatic tumour evaluation was initiated by Sukigara in 1985 who presented a successful color image of the arteries around and in the tumour in two cases of advanced hepatocellular carcinoma. A significant contribution in this field was made by Tanaka who described the color doppler features of malignant and benign focal liver lesions identifying four types of blood flow in hepatic tumours: basket pattern, vessels in tumour, spot pattern and detouring pattern [1].

The introduction and development of power doppler sonography enabled greater sensitivity while detecting the flow in comparison with classic doppler imaging, though still insufficient in cases of low and slow flow. Thus, the intravenous contrast media are of interest, especially in cases of "slow", "low" and "no" flow [2].

In that context, the aim of the study is to evaluate whether the ultrasonographic contrast medium helps in the visualisation of flow in focal liver lesions with power doppler.

### *Material and methods*

49 patients with focal liver lesions are analyzed in the study: 29 of them with malignant lesions (9 HCC, 20 metastatic) and 20 with benign lesions (12 haemangiomas, 5 focal nodular hyperplasia, 3 focal steatosis). Patients were treated at the Clinic of Gastroenterohepatology in Skopje and in all of them lesions were histologically verified. Classic 2D realtime and power doppler sonography using Aloka SSD-2000 Multiview (convex probe 3,5 MHz) was performed in all patients prior to contrast application. A suspension of the contrast medium Levovist – Schering AG (4 g in 11ml aqua destilata) with a concentration of 300 mg/ml was administered intravenously through the cubital vein. Levovist (Schering AG) is non-toxic, biodegradable, contains 99.9% galactose and 0.1% palmitic acid. The suspension bubbles are 2–8  $\mu\text{m}$  in diameter, being bigger than 6  $\mu\text{m}$  in 97%. The low content of palmitic acid stabilizes the intra-

vascular bubbles and blocks their resorption through the pulmonary capillaries which in turn results in higher echogenicity of the blood. The galactose which is in fact the medium itself, is swiftly metabolized in the liver. No side effects of the medium were registered except the feeling of flow and a slight burning at the spot of administration in a few patients. After administration of the medium, power doppler examination of the lesions was performed in all patients.

The flow in the lesions was graded as: absent, minimal and marked in both pre- and post-contrast studies. According to localization, flow was determined as peripheral or central. The morphological characteristics of the blood vessels were also evaluated and categorized as: punctate, short or long segments. The presence of blood vessels which feed or drain the lesion was also registered.

Statistics were achieved with Fischer's exact test,  $p < 0.05$  being of statistical significance.

### Results

Enhanced vascularity after Levovist administration was noticed in all focal liver lesions in this study (Table 1).

Table 1 – Табела 1

*Changes in vascularity on power doppler images after Levovist administration  
Промени во васлураониот приказ на power doppler по администрација  
на контрастен медиум Levovist*

	<i>Precontrast study – flow</i>			<i>Postcontrast study – flow</i>		
	<i>Absent</i>	<i>Minimal</i>	<i>Marked</i>	<i>Absent</i>	<i>Minimal</i>	<i>Marked</i>
<i>Metastasis (20)</i>	8	10	2	4	11	5
<i>Hemangioma (12)</i>	5	6	1	1	7	4
<i>HCC (9)</i>	1	7	1	1	2	6
<i>FNH (5)</i>	3	2	0	3	2	0
<i>Focal steatosis (3)</i>	2	1	0	2	1	0
<i>Total</i>	<i>19</i>	<i>26</i>	<i>4</i>	<i>11</i>	<i>23</i>	<i>15</i>

Half of the lesions (4 of 8) that did not display any intralesional flow on pre-contrast images clearly showed flow on contrast-enhanced images. Many lesions with a minimal flow signal in the pre-contrast study showed marked flow signals after contrast administration. These findings were somewhat more obvious for HCC and haemangiomas but otherwise did not vary greatly among diagnostic groups. The difference in vascularity between pre-contrast and post-contrast doppler analysis in these groups proved to be of statistical significance ( $p < 0.05$ , Fischer exact test). The statistical differences in the groups with focal nodular hyperplasia and focal steatosis were not significant.

The changes in distribution of flow are shown in Table 2. In two patients with metastatic lesions blood vessels in the center of the lesion were shown only with contrast enhancement. Furthermore, in four more patients from the same group peripheral blood vessels were detected in the same way (Figure 1).

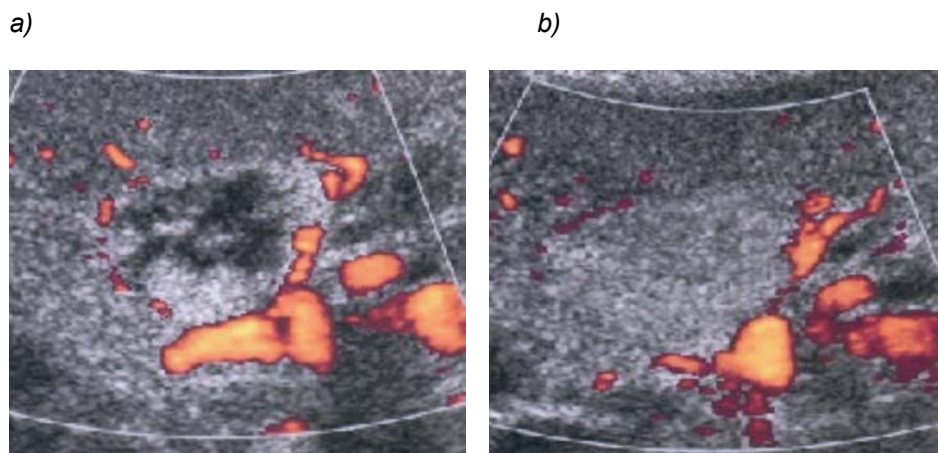


Figure 1 – *Metastasis (a, b) – vascular signals at the periphery of the lesion*

Слика 1 – *Метастатска промена (а, б) – васкуларни сигнали на периферијата на лезијата*

Moderate central flow after administration of contrast was noticed in four patients.

In the group of hepatocellular carcinoma identification of vascularity was satisfactory on the pre-contrast scans, however on post-contrast analysis a larger number and longer segments of blood vessels were detected (Figure 2).

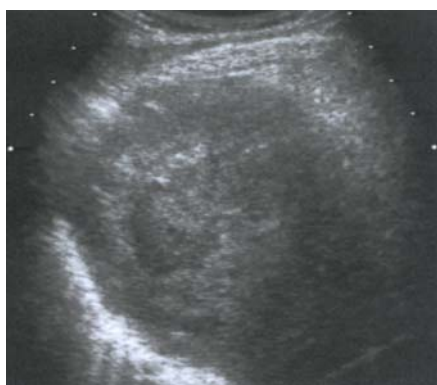
Table 2 – Табела 2

*Changes in flow distribution on power doppler images after Levovist administration*

*Промени во дистрибуцијата на проток при power doppler приказ по администрација на Levovist*

	<i>Precontrast study – flow</i>		<i>Postcontrast study – flow</i>	
	<i>Absent</i>	<i>Minimal</i>	<i>Absent</i>	<i>Minimal</i>
<i>Metastasis (20)</i>	0	12	2	16
<i>Hemangioma (12)</i>	2	5	6	6
<i>HCC (9)</i>	4	6	5	9
<i>FNH (5)</i>	1	2	1	2
<i>Focal steatosis (3)</i>	0	1	0	1
<i>Total</i>	7	26	14	34

a)



b)



Figure 2 – *Hepatocellular carcinoma a) intensive and homogeneous enhancement in arterial phase, b) large arterial blood vessel supplying the mass is clearly visible*

*Слика 2 – Хепатоцелуларен карцином а) интензивно и хомогено појакнување во артериската фаза, б) јасен голем крвен сад во масата*

In the focal nodular hyperplasia and focal steatosis groups differences were not statistically significant pre- and post-contrast.

The peripheral blood vessels which are characteristic of metastatic liver lesions in our study were punctate or shortly segmented in 10 out of 18 metastatic lesions. Long segments of blood vessels were registered in 8 hypervascularized metastatic lesions. In 7 out of 12 haemangiomas vessels were punctate, but in only 2 out of 7 lesions were long segments detected. Long segments of blood vessels in the post-contrast study proved to be characteristic of hepatocellular carcinoma (detected in 7 out of 8 cases).

### *Discussion*

Slow flow is the main limitation while implementing doppler for characterization of focal liver lesions [3, 4]. To overcome this, two possibilities are currently available. First, the introduction and development of power doppler produced greater sensitivity in comparison to conventional doppler imaging. Secondly, contrast media implementation is giving a chance better to detect low and slow flow.

The results of our study show that adding a contrast medium to a power doppler scan improves the detection of flow in focal liver lesions. In the pre-contrast study "no- flow" was detected in 19 out of 49 focal liver lesions, while in 11 in the post-contrast group. Marked flow signal was detected in 4 focal lesions prior to contrast administration, while in 15 after. These results are similar to those of Tapo *et al.* [4]. They analyse 10 hyperechogenic focal liver lesions, in none of them detecting flow with classic doppler. Nevertheless, after injection of Levovist they detect flow in 4/4 HCC and 2/4 haemangiomas, but in none of 2 focal steatosis. Fujimoto *et al.* and Ernst *et al.*, using the same contrast medium, find that the detection of flow is better with higher concentrations of Levovist. Intratumour arterial flow is detected in 61% of HCC with a Levovist concentration of 200mg/ml and in 83% with 400mg/ml [5, 6].

In their study, Lin *et al.* compare vascular profiles of HCC, metastatic lesions and haemangiomas. They point out the possibility of overlapping of the findings of HCC with hypervascular metastases [7]. In our contrast enhanced power doppler study, we detected a moderate to marked flow signal in metastatic lesions. Except in 2 cases of hypervascular metastases, all the other metastatic lesions showed peripheral to lesion blood vessels. In hepatocellular carcinoma, the detected blood vessels were of moderate diameter and mainly in long segments, while in metastatic lesions the detected blood vessels were more densely packed [8].

Characterising the vascular patterns of focal liver lesions, Tanaka *et al.* pointed out the "basket pattern" [1] as typical of hepatocellular carcinoma, as it was in our study, too. We detected this pattern in 6/9 cases of HCC. Similarly, we detected Tanaka's "spot pattern", typical of haemangiomas, in half of the post-contrast scans [9, 10] (Table 3).

Table 3 – Табела 3

*Typical flow patterns for three most frequent focal liver lesions*

*Карактеристични прикази на проток кај трите најчести фокални црnodробни лезии*

<i>Type of lesion</i>	<i>No lesions</i>	<i>Flow pattern</i>	<i>Precontrast study</i>	<i>Contrast-enhanced Study</i>
<i>Metastasis</i>	20	Detour	6	11
<i>Hemangioma</i>	12	Central spots	4	7
<i>HCC</i>	9	Basket	2	6

*Conclusion*

Administration of a contrast medium enables better visualisation of intratumour blood vessels in focal liver lesions. Power doppler sonography is a useful, non-invasive tool to evaluate the flow and differentiate liver tumours, superior to conventional doppler sonography. Furthermore, contrast-enhanced power doppler sonography moves a step closer to angiography in the differentiation of certain types of focal liver lesions.

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#### Резиме

### КОНТРАСТНО-ЗАСИЛЕНАТА POWER DOPPLER СОНОГРАФИЈА ВО ДЕТЕКЦИЈАТА И ДИФЕРЕНЦИЈАЦИЈАТА НА ФОКАЛНИТЕ ЦРНОДРОБНИ ЛЕЗИИ

Магдалена Генадиева-Димитрова, Методија Нешковски,  
Розалинда Попова, Ненад Јоксимовиќ, Мери Трајковска,  
Митко Милошевски, Владимир Серафимоски<sup>1</sup>

*Клиника за гастроентерохепатологија, Клинички центар,  
Скопје, Р. Македонија*

*Македонска академија на науките и уметностите, Скопје, Р. Македонија*

Цел на студијата беше да се евалуира контрастно-засилениот power doppler во проценката на карактеристичната васкуларизација кај фокалните црнодробни лезии. Во тек на студијата анализирани се 49 пациенти со фокални црнодробни лезии – 29 пациенти имаа малигни црнодробни лезии (9 хепатоцелуларни карциноми, 20 метастатски промени), а 20 бенигни лезии (12 хемангиоми, 5 фокална нодуларна хиперплазија, 3 фокална стеатоза). Кај сите е направена класична B-mode и power doppler сонографија



пред администрација на контрастниот медиум Levovist (во концентрација од 300 мг/мл), како и power doppler евалуација по администрација на медиумот.

По администрација на контрастен медиум при power doppler сонографија бројот на лезии со отсуство на проток се намали од 19 на 11 случаи. На пост-контрастната анализа забележан е маркантен проток кај 15 случаи на фокални црнодробни лезии, за разлика од 4-те во предконтрастната студија. При power doppler скенирањето централен проток е детектиран кај 7, а периферен кај 26 случаи. Пост-контрастната анализа пак утврди централен проток кај 14, а периферен кај 34 фокални црнодробни лезии. Кај малигните фокални црнодробни промени, како и кај хемангиомите разликата во васкуларизацијата помеѓу пред-контрастните и контрастните power doppler евалуации беше статистички значајна. Кај фокалната нодуларна хиперплазија и фокалната стеатоза не е забележана статистички значајна разлика.

Администрацијата на контрастниот медиум обезбедува подобра визуелизација на интратуморските крвни садови кај фокалните црнодробни лезии. Ова во комбинација со power doppler техниката обезбедува приближување до ангиографските наоди.

**Клучни зборови:** фокални црнодробни лезии, power doppler ултрасонографија, контрастен медиум.