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Fluid–fluid levels within focal hepatic lesions: imaging appearance and etiology

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Abstract
Purpose: To report our experience with fluid–fluid levels within focal hepatic lesions and determine if this finding indicates a specific diagnosis.
Materials and methods: We reviewed our experience with eight patients with focal hepatic lesions that showed fluid–fluid level on cross-sectional imaging. Seven CT scans, four MR examinations, and four sonograms were reviewed. The hepatic lesions included metastases (four patients), biliary cystadenoma (two patients), cavernous hemangioma (one patient), and hematoma (one patient). A histologic diagnosis was made in all cases.
Results: Fluid–fluid levels were found in both malignant and benign focal hepatic lesions. Fluid–fluid levels were seen on six CT scans, four MR examinations and on none of the four sonograms. Radiologic–pathologic correlation showed that fluid–fluid levels corresponded to internal hemorrhage in all but one case. In the case of cavernous hemangioma, a fluid–fluid level was found to correspond to a sedimentation effect within a large vascular space.
Conclusion: Fluid–fluid levels in focal hepatic lesions do not indicate a specific diagnosis but can be seen in both malignant and benign conditions affecting the liver.

Key words: Computed tomography, neoplasms—Liver, neoplasms—Neoplasm, liver—MR, liver.

Fluid–fluid levels have been frequently described in different types of tumors, including bone and soft-tissue tumors (1, 2). Conversely, this finding has been reported only anecdotally in hepatic tumors (3–6).

We have encountered fluid–fluid levels in eight patients with hepatic lesions. The goal of this study is to report our experience with fluid–fluid levels within focal hepatic lesions and determine if this finding is suggestive for a particular diagnosis.

Materials and methods

The study group comprised eight patients, two men and six women, aged 36–72 years (mean age, 59 years). Four patients had hepatic metasases from ovarian carcinoma, jejunal leiomyosarcoma, carcinoid tumor from unknown origin, and pulmonary adenocarcinoma (one case each). Two patients had a primary biliary cystadenoma, one patient had multiple cavernous hemangiomas of the liver, and one patient had hepatic hematomas. Specimens for histologic confirmation of the diagnosis were obtained by means of surgical resection in four patients and percutaneous biopsy in three patients. In the case of multiple cavernous hemangiomas that showed fluid–fluid levels, the diagnosis was based on surgical biopsy findings in one hemangioma and on the combination of sonographic, CT, and MR findings and the lack of enlargement with time in the other hemangiomas.

Imaging techniques

Seven CT examinations were performed on various CT units (Somatom Plus, Siemens, Iselin, NJ; CT Pace Plus, General Electric-Medical Systems, Milwaukee, WI; Somatom DR, Siemens; Elite Plus, Elscint, Haifa, Israel). The seven CT scans were performed during intravenous injection of iodinated contrast material, using a dynamic technique with 5–10 mm collimation at 5- to 10-mm intervals, respectively, (five examinations), or a spiral technique with 8-mm collimation and 4-mm overlapping reconstruction (two examinations). The contrast material was injected as a bolus into an antecubital vein, through a 18- or 20-G cannula, either manually or using an automatic injector. Ionic or nonionic iodinated contrast material was injected (total volume, 120–150 ml), containing 30–38 g of iodine/100 ml).

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Table 1. Summary of clinical imaging, and pathologic findings in eight patients with hepatic lesions featuring fluid–fluid levels

Patient no./ age (y)/sex	Diagnosis	Imaging features				
				MR[a]		
		CT	Sonography	T1-weighted	T2-weighted	Pathologic findings
1/72/F	Metastasis from lung carcinoma	FFL[c]	FFL[d]	NP	NP	Necrosis Hemorrhage
2/58/M	Cavernous hemangioma	FFL[c]	FFL[d]	Hyperintense[b]	Hypointense[b]	Clotted blood Necrosis
3/65/F	Metastasis from ovarian carcinoma	FFL[c]	NP	NP	NP	Hemorrhage Necrosis
4/71/M	Metastasis from carcinoid tumor	FFL[c]	NP	NP	NP	Hemorrhage
5/40/M	Metastasis from leiomyosarcoma	NP	NP	FFL[d]	Hypointense[b]	Hemorrhage
6/48/F	Biliary cystadenoma	FFL[c]	NP	NP	NP	Hemorrhage
7/36/F	Hematoma	FFL[c]	FFL[d]	FFL[d]	Hypointense[b]	Hemorrhage
8/35/F	Biliary cystadenoma	FFL[d]	FFL[d]	Hyperintense[b]	Hyperintense[b]	Hemorrhage

[a] A fluid–fluid level was depicted on MR imaging in all the cases in which it was performed
[b] Hypo- or hyperintensity refers to the inferior fluid relative to the superior one
[c] Present
[d] Absent
FFL, fluid–fluid level; NP, not performed

Four sonographic examinations were obtained with real-time scanners (Radius, General Electric-Medical Systems; or Acuson 128 XP, Mountain View, CA), with 3.5-MHz probes. Hard-copy images of routine scan planes obtained at the time of the sonographic examination were reviewed.

Four MR imaging examinations were obtained at either 1.5-T, or 2-T with a commercially available imaging system (Signa 1.5, General-Electric-Medical System, Milwaukee, WI; Gyrex, Elscint, Haifa, Israel, respectively), using a body coil. The four patients had axial T1-weighted spin-echo (SE) MR images with a repetition time (TR) of 400–600 msec and an echo-time (TE) of 11–20 msec. T2-Weighted MR images were obtained in the four patients, with a conventional SE technique (TR = 2000–3000 msec, TE = 80–120 msec). Section thickness was 7–10 mm, with a gap of 1–3 mm. Respiratory-ordered phase-encoding and craniocaudal spatial presaturation were used for SE images in two patients. Gradient moment nulling was used for T2-weighted SE images in the four patients. The number of signals averaged was 4 for the T1-weighted images and 2 for the T2-weighted SE images. Image matrix size was 128–192 × 256.

Results

Findings in the eight cases are summarized in the Table 1. Five patients had malignant hepatic lesions and three patients had benign hepatic lesions.

Fluid–fluid levels were seen in six of the seven cases in which a CT scan was obtained (Figs. 1A, 2, 3); in one case, CT scan failed to depict fluid–fluid level (Fig. 4A). Fluid–fluid level was noted in all four cases in which MR imaging was performed (Figs. 1B,C, 4B,C, 5), and in none of the four cases in which sonography was done (Fig. 1D). Of the four patients who had fluid–fluid levels visible on MR imaging, two patients had fluid–fluid levels visible on CT scan.

In the case of cavernous hemangioma, the inferior fluid layer was hyperintense on T1-weighted MR imaging and hypointense relative to the superior fluid layer on T2-weighted MR imaging, suggesting the presence of methemoglobin or high-protein content within the inferior fluid layer and serous fluid within the superior fluid layer (sedimentation effect) (Figs. 1B,C). In the case of biliary cystadenoma, the inferior fluid layer was hyperintense relative to the superior fluid layer on both T1- and T2-weighted MR imaging, suggesting the presence of methemoglobin in the inferior layer (Figs. 4B,C). In the other two cases that had MR imaging (one case of metastasis from leiomyosarcoma and one case of hematoma), no fluid–fluid level was seen on T1-weighted MR imaging because the inferior fluid layer was isointense to the superior fluid layer. In addition, in these two cases, the inferior fluid layer was hypointense relative to the superior fluid layer on T2-weighted MR imaging, suggesting serous fluid in the superior fluid layer and deoxyhemoglobin within the inferior fluid layer (Fig. 5).

Pathologic correlation showed that fluid–fluid levels corresponded to recent internal hemorrhage in all but one case. In the latter case (cavernous hemangioma), clotted blood was found within a single large vascular space. In three cases of malignant tumor, liquefactive necrosis was associated to internal hemorrhage.

Discussion

There are three conditions that must be met to observe fluid–fluid levels on cross-sectional imaging within fo-

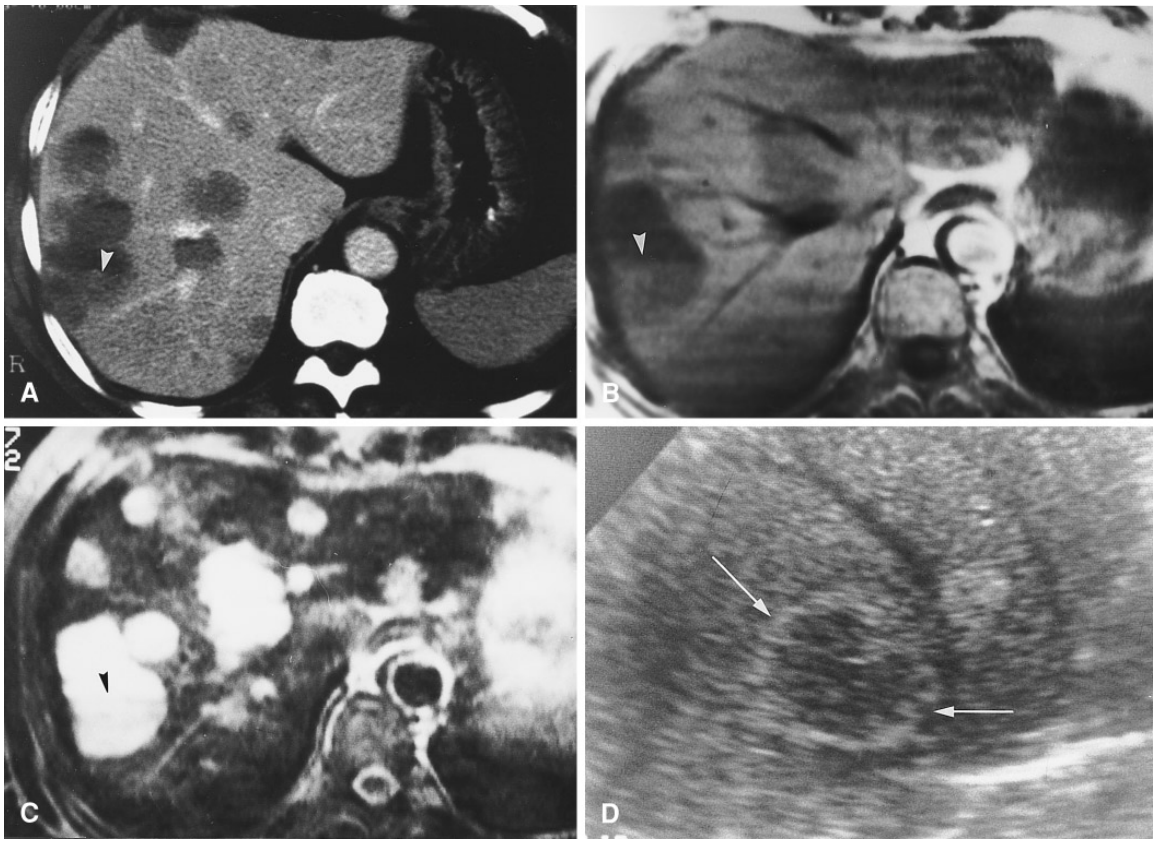

Fig. 1. Fifty-eight-year-old-man with hepatic cavernous hemangiomas. **A** CT scan showed multiple lesions within the liver with some of them displaying internal horizontal fluid–fluid levels (*arrowhead*). **B** T1-weighted (450/15 msec) spin-echo MR image showed a fluid–fluid level (*arrowhead*) with inferior fluid layer hyperintense to muscle. Superior fluid layer was nearly isointense to muscle and hypointense relative to the inferior layer. **C** T2-weighted (2000/80 msec) spin-echo MR image shows a fluid–fluid level (*arrowhead*) with inferior layer fluid being hypointense relative to the superior layer fluid. **D** Sonogram showed the corresponding lesion (*arrows*) as an atypical hepatic cavernous hemangioma (hypoechoic to the liver with hyperechoic rim), but failed to depict any fluid–fluid level. Pathologic examination confirmed the diagnosis of cavernous hemangioma, with a single vascular space filled with blood.

cal hepatic lesion. First, the lesion must contain substances of differing densities so that a sedimentation effect can occur. Second, the different fluid layers must have different echogenicity, attenuation values or signal intensity depending on the imaging modality being considered. Third, the imaging modality must be performed in a gravity-dependent plane.

The presence of fluid–fluid levels in association with bone tumors (1, 7–9), soft-tissue tumors (2, 10), bronchogenic cysts (11), and ovarian tumors (12) has been frequently reported. Conversely, presence of fluid–fluid levels within focal hepatic lesion has been reported only occasionally. The different histologic diagnoses of the focal hepatic lesions featuring fluid–fluid levels included simple hepatic cyst (3, 13), biliary cystadenoma (5, 14), cavernous hemangioma (4), and cystic hepatocellular carcinoma (6). Results of our study showed that hepatic metastases may also display this finding. In our study, we found fluid–fluid levels in hepatic metastases from jejunal leiomyosarcoma, lung adenocarcinoma, carcinoid tumor, and ovarian carcinoma.

In our study, fluid–fluid levels were observed in association with widely varying types of focal hepatic lesions, thus suggesting different mechanisms of formation. Cavernous hemangioma is composed primarily of large vascular lakes and channels lined by a single layer of flat endothelial cells and separated by fibrous septa, which contains very slowly flowing or even stagnant blood (15). Therefore, as seen on CT and MR imaging in our case of cavernous hemangioma, stagnant blood might be responsible for the sedimentation effect, with the superior fluid layer made of serous unclotted blood and the inferior fluid layer made of red blood cells. This hypothesis was further supported by the fact that clotted blood was found within the hemangioma displaying fluid–fluid level. In the cases of malignant tumors, fluid–fluid levels were due to internal hemorrhage in all cases, and in association with tumor necrosis in three

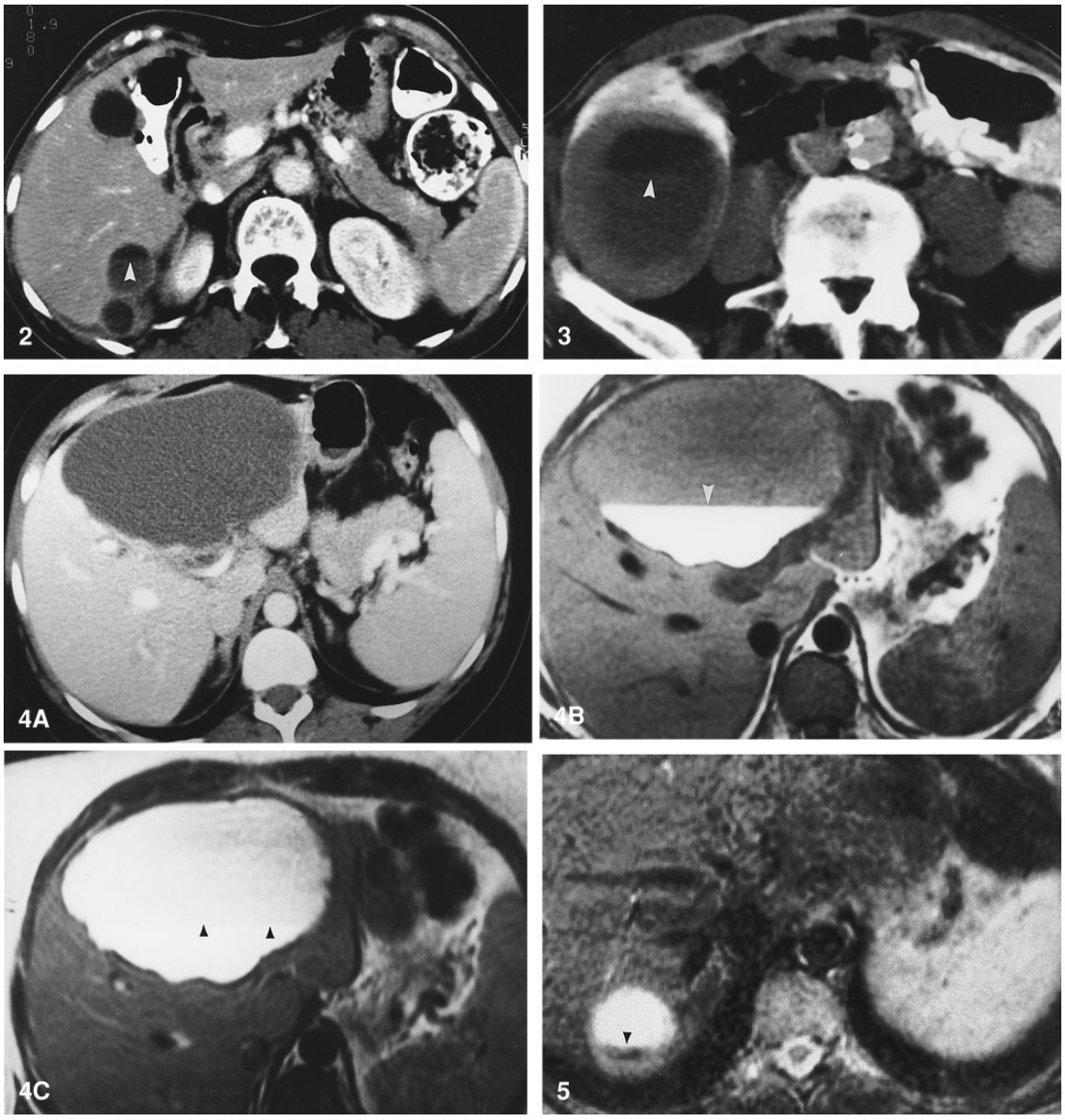

Fig. 2. Sixty-five-year-old woman with hepatic metastases from ovarian carcinoma. CT scan obtained after IV contrast material showed subcapsular hepatic lesions. One lesion displayed an internal fluid–fluid level (*arrowhead*). Pathologic examination showed metastasis with internal hemorrhage.

Fig. 3. Seventy-one-year-old man with hepatic metastases from carcinoid tumor. CT scan obtained after IV contrast material showed large hepatic lesion containing fluid–fluid level (*arrowhead*). Pathologic examination confirmed internal hemorrhage.

Fig. 4. Thirty-five-year-old woman with biliary cystadenoma. **A** CT scan obtained after IV contrast material showed large hepatic cystic mass. No fluid–fluid level was seen. **B** T1-Weighted (600/17 msec) spin-echo MR image showed a fluid–fluid level (*arrowhead*) with inferior fluid layer hyperintense to muscle. Superior fluid layer was hypointense to muscle and hypointense relative to the inferior layer. **C** T2-Weighted (2700/80 msec) spin-echo MR image shows a fluid–fluid level (*arrowhead*) with inferior layer fluid being slightly hyperintense relative to the superior layer fluid.

Fig. 5. Forty-year-old-woman with hepatic metastasis from jejunal leiomyosarcoma. T2-Weighted (2700/80 msec) SE MR image showed hyperintense hepatic mass with horizontal a fluid–fluid level (*arrowhead*). The inferior fluid layer is nearly isointense to muscle and hypointense to superior fluid layer. Pathologic analysis showed areas of necrosis and internal hemorrhage.

cases. In the two cases of biliary cystadenoma, fluid–fluid levels were secondary to internal hemorrhage; neither of these tumors contained necrosis.

In our study, fluid–fluid levels within hepatic lesions were seen either with CT or MR imaging, but it was never seen with sonography. Theoretically, MR should have the advantage of being more sensitive to hemorrhage than CT, because the blood products resulting from the hemoglobin degradation have different signal characteristics (16). Therefore, as suggested by Tsai et al. (10), fluid–fluid levels should be depicted more frequently on MR imaging than on CT scan. Our study included too few cases for which both MR imaging and CT scan was performed to draw any significant conclusion about the respective merits of these two techniques for depicting fluid–fluid levels. However, for the three patients who had both CT scan and MR imaging, fluid–fluid levels were visible on MR images in three cases and in two cases on CT scan.

In our study, MR imaging was obtained with a conventional SE technique. It has been suggested that, due to the use of many closely spaced RF refocusing pulses, fast SE imaging would demonstrate less sensitivity to magnetic susceptibility effects than would conventional SE imaging (17). In addition, Gomori et al. (18) demonstrated that the T2 value of some blood products varied substantially as echo spacings ranged from 2 to 64 msec. This suggests that hemorrhage within hepatic lesions are likely to display different features on fast SE imaging compared to conventional SE imaging. Therefore, the MR findings observed in our cases may be different using a fast SE technique.

A limitation of our study is that correlation between MR appearance and the exact nature of blood products was not performed. Although we agree that the categorization of blood products remains an incompletely explained problem, prior studies, however, found a high degree of correlation between biochemical structures of blood products and their MR appearances (19, 20). Therefore, with the understanding that biochemical correlation was not possible due to the retrospective nature of the study, we defined blood products according to their MR appearance using previously defined categories.

In conclusion, fluid–fluid levels in focal hepatic lesions do not indicate a specific diagnosis but can be seen within malignant or benign tumors, and within other types of lesions such as hepatic hematoma. In the majority of cases, fluid–fluid levels indicate internal hemorrhage, but other mechanisms are also possible. Further studies including correlation between imaging findings and biochemical analysis of internal fluid are needed to fully explain the imaging appearance of fluid–fluid levels.

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