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**Contrast-enhanced ultrasonography - An indispensable tool in the hands of any hepatologist**

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Vascular complications after liver transplantation may lead to graft dysfunction and liver failure, which in turn results in need for retransplantation and death risk. Therefore, their early diagnosis is critical. Major vascular complications include hepatic artery thrombosis, stenosis and aneurysms; portal vein thrombosis and stenosis; and potential additional complications in hepatic veins and vena cava. Of all these vascular complications, hepatic arterial thrombosis, which involves approximately 5% of transplant recipients, is the most significant (1). Portal complications, which are second in significance, are less common (2%) (2).

Conventional ultrasonography and Doppler ultrasound represent must-have, first-line tests both in the assessment of transplant-eligible patients and postoperatively (3). They are routinely used in these patients. Their usefulness as screening tools for vascular complications in transplant recipients is of utmost importance for diagnosis and early treatment. Doppler ultrasound accuracy is considered to be very high and, in case of hepatic arterial thrombosis, provides a sound diagnosis for approximately 90% of patients. Ultrasonographic suspicion of hepatic arterial thrombosis or other vascular complications in transplant recipients must be confirmed with angio-CT or arteriography in most cases. It is here that contrast-enhanced ultrasound (CEUS), which represents a major advance for ultrasonography in recent years, plays a relevant

role (4,5). This technique will help us establish a more accurate diagnosis, thus facilitating the right indication of other imaging tests (arteriography, CT) as well as treatment decision-making, whether with surgery or interventional radiology.

In this issue of *Revista Española de Enfermedades Digestivas*, Chen et al. report on the first systematic review and meta-analysis on the usefulness of CEUS for the study of post-liver transplant vascular complications (6). This meta-analysis includes 13 studies where CEUS was used to assess potential vascular complications in transplant recipients. SonoVue was used as contrast medium in all instances. Study quality and heterogeneity were moderate. CEUS sensitivity was 0.9, specificity was 1, and Q index, reflective of diagnostic value, was 0.92. Therefore, CEUS was confirmed as a highly accurate modality in the study of vascular complications associated with liver transplantation, with a remarkable specificity at 100%. Interestingly, the analysis showed no influence of operator expertise on CEUS accuracy.

CEUS is presently a routine procedure for patients with gastrointestinal conditions (5). Microbubbles are used as contrast agent since ultrasonography may take advantage of their specific response to sound waves. The characteristic of second-generation agents, currently in use, is that microbubbles do not contain air but another hydrophobic gas. At present, the primary second-generation agent in our setting is SonoVue (Bracco, Italy). Recent advances using harmonic, reverse-pulse technologies have improved images by separating microbubble and tissue signals. Using ultrasound devices and software programs specific for this technique the circulating contrast agent may be assessed during the different vascular phases of the target organ. Following its administration, it is the presence of the contrast agent within the vessels that provides ultrasonographic images according to the structures through which it diffuses (arteries, parenchyma, portal vessels, etc.). Its use is straightforward and only requires a few minutes.

CEUS offers big advantages and few drawbacks (7,8). It is a non-invasive, non-radioactive, low-cost technique, and a clear alternative to CT and MRI, particularly in children, in patients with renal failure, and when a fast bedside evaluation is needed. It has the same disadvantages of conventional ultrasonography: patient habitus, presence of intestinal gas, and obesity that may render the procedure difficult; deep

level of some organs; and operator dependency. Side effects and contraindications are dependent on contrast agent, but are usually rare.

The study by Chen et al. (6) reported in this issue of the *Revista Española de Enfermedades Digestivas* places emphasis back on CEUS. Today, CEUS is a widespread option for multiple abdominal and extra-abdominal conditions. Several scientific societies, including the European one (9), which involves gastroenterologists, radiologists, etc., have published CEUS guidelines establishing good practices for its use in the assessment of multiple organs (9-11), including the study of transplant recipients (9). As already mentioned, early diagnosis and treatment should improve prognosis for liver transplant-related vascular complications. While Doppler ultrasound is key, the procedure may be incomplete in a number of cases, and as an example, may provide every so often (13%) inconclusive information regarding the hepatic artery, which is in contrast with CEUS (12). CEUS complements Doppler in assessing patients, the latter test being usually performed first. CEUS is usually performed when no Doppler signals are collected or Doppler findings are uncertain, as pointed out by Chen et al. CEUS does not exclude Doppler assessments, and their joint use may improve Doppler signal itself, hence the accuracy of its results (13). The use of CEUS in liver transplantation protocols modifies the role of other more complex and expensive techniques such as CT, MRI, and arteriography (14). CEUS may avoid angiograms, which could be reserved for cases where CEUS findings are inconclusive or when a hepatic arterial condition is suspected (15). Therefore, it seems reasonable to include CEUS in post-liver transplant protocols, at least in some instances, to provide an early diagnosis of potential complications. Importantly, it will on occasion prevent the transfer of critically ill patients from the ICU to the radiology room.

Complementarily, CEUS may result in relevant clinical findings in addition to those provided by CT in transplant recipients (16). The use of CEUS together with Doppler ultrasound after an initial contrast-enhanced examination allows a more accurate diagnosis and a collection of additional evidence such as non-occlusive hepatic hypoperfusion (splenic artery steal syndrome) (17). Finally, CEUS may provide additional extravascular information in these patients, including the presence of hepatic infarctions, bilomas, or abscesses (18).

Besides CEUS, recent technical advances in the field of ultrasonography, including double harmonic, Doppler, color Doppler, power Doppler, 3-D/4-D imaging, quantitative CEUS, and elastography, the latter with different types of integration with ultrasonography, have turned ultrasound into a highly helpful technique for any gastroenterologist, and most particularly hepatologists. Because of all this, the fact that gastroenterology units may still be found without this technique in their armamentarium, for which they must rely on other units, seems clearly unreasonable (19). We believe that, in a world so much dependent on technology, hepatologists should routinely use this technique for the management of their patients, or at least have it handy in their departments. Common sense dictates that proximity to a given technique will make it more accessible and efficient, even if only because of increased common understanding among stakeholders.

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