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Editorial

Portal and splanchnic blood flow measurements *in vivo*: US Doppler or MR angiography?

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In this issue, Lycklama à Nijeholt et al. (1) present an interesting paper which compares the variability of magnetic resonance imaging (MRI) and Doppler in measuring portal blood flow. The study of portal hemodynamics is of critical importance in physiological studies and in several pathological conditions. Before Doppler ultrasonography (US) was available, portal and hepatic blood flow could be measured only by clearance techniques with indocyanine green or sulfobromophthalein. However, these techniques are invasive and require catheterization of a hepatic vein and a peripheral artery to evaluate perfusion precisely. Moreover, they are insensitive to perfusion changes (2). Doppler US and the more recently introduced MR angiography, may provide *in vivo* measurements of the modifications of portal flow. This paper is the first to compare the variability of these two techniques in measuring portal blood flow in various physiological conditions. In order to highlight the original information in the paper of Lycklama à Nijeholt et al., we here clarify the indications and limits of these two techniques.

Doppler US is a non-invasive method for flow measurement. It combines real-time B-mode imaging with pulsed Doppler blood-flow analysis in a selected sample volume chosen on a regular B-mode image. Moving targets, when hit by a sonic (or ultrasonic wave), return a frequency shifted wave. The frequency shift is proportional to the velocity of the targets (i.e. the red blood cells in Doppler). As ultrasound imaging allows measurements of the vessel cross-sectional area, it is possible to calculate the blood-flow volume. Four main causes of error may decrease the accuracy of Doppler measurements (3):

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1. The angle between the Doppler beam and the vessel is of critical importance. Its cosinus is contained in the formula with which the velocity is calculated from the measured Doppler frequency (4). If this angle is greater than 60°, a small error in angle estimation induces a large error in the flow estimation. A 5° error in measurement of an angle of 60° would lead to a 15% error in the estimation of volume blood flow, and a 50% error at an angle of 80°.
2. The second concern is the estimation of mean velocity. Mean velocity can be calculated by time averaging of the spatial averaging mean velocity (the whole lumen of the vessel must be taken into consideration). This is usually extracted from spectral analysis by built-in software. A recent study published by Sabba et al. has demonstrated that the interequipment coefficient of variation is very high, up to 20% for the estimation of velocity (5). This is probably one of the main causes of the discrepancy observed by Lycklama à Nijeholt between the Doppler US and dilution techniques.
3. The third type of error occurs in estimating the vessel area. As an approximation, the area is calculated from diameter measurements. In fact, not all vessels are circular, and some are oval-shaped. This is especially true for the portal vein. Measurements of two perpendicular diameters may be difficult because the image plane is not necessarily perpendicular to the vessel axis.
4. A fourth possible error is positioning the caliper for diameter evaluation. An error of 0.5 to 1 mm is often encountered and almost unavoidable. If the vessel diameter is less than 4 mm, then the error may be important.

These are some of the explanations for a high interobserver variability, mostly in patients with cirrhosis, whereas intraobserver variation was acceptable (<10%) (6,7). However, a recent study has shown that inter-observer variability could be decreased to under 10% if instead of following a personal methodology of measurement common rules defined in a cooperative training program are observed (5).

MRI is a new non-invasive technique. It allows the evaluation of vessel patency and morphology and the measurement of flow velocity by the phase contrast method. In this method, the signal intensity of a vessel is proportional to its blood velocity. Flow can then be calculated by mean velocity and vessel area. Experimental studies in phantoms (8) have demonstrated the accuracy of this technique in slow velocity flow as in the portal system. However, there may be some limitations with this technique.

- This "velocity" image is acquired in a plane previously defined as perpendicular to the vessel axis. If the main axis of this vessel, as occurs in the portal vein, changes during respiration, this image will no longer be strictly perpendicular, and flow quantification may be compromised.
- Acqusition of data takes a long time and is not appropriate when repeated measurements are necessary in a limited period of time.
- Acquisition parameters are of critical importance. The flip angle and velocity encoding are critically important to the signal-to-noise ratio (8). A slice thickness greater than 5 mm may give inadequate measurements if the vessel is imaged obliquely. Spatial resolution should be selected to provide at least 10 pixels across the diameter of the vessel of interest. In the study of Lycklama à Nijeholt et al., this may explain in part the inaccuracy of measurements of the superior mesenteric artery (SMA), since the pixels measured 2.91 mm×2.1 mm which is too large compared to the 8 and 9 mm diameter of the SMA. In the study by Lycklama à Nijeholt et al., the authors compared the values obtained by MRI and Doppler of the portal vein. Since MRI values were closer to the result obtained with the dilution techniques, they concluded that MRI may be more accurate than US Doppler for measuring absolute flow. However, to our knowledge, there are no data in the literature comparing MRI and dilution techniques which support this statement. If this is confirmed, it will be a major advantage of MRI over Doppler. The limitations of these two techniques clearly define their indications. Doppler is widely available and can be used in every laboratory for experimental work. It allows sufficiently accurate measurements but requires operator skill. MRI is more complex but permits probably more absolute measurements for a higher price. It is operator independent.

The paper of Lycklama à Nijeholt et al. is a major advance since it has demonstrated that MRI and Doppler are of similar accuracy. Further studies comparing MRI flowmetry, Doppler and the gold-standard dilution techniques are mandatory.

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