Time to Echo (TE)

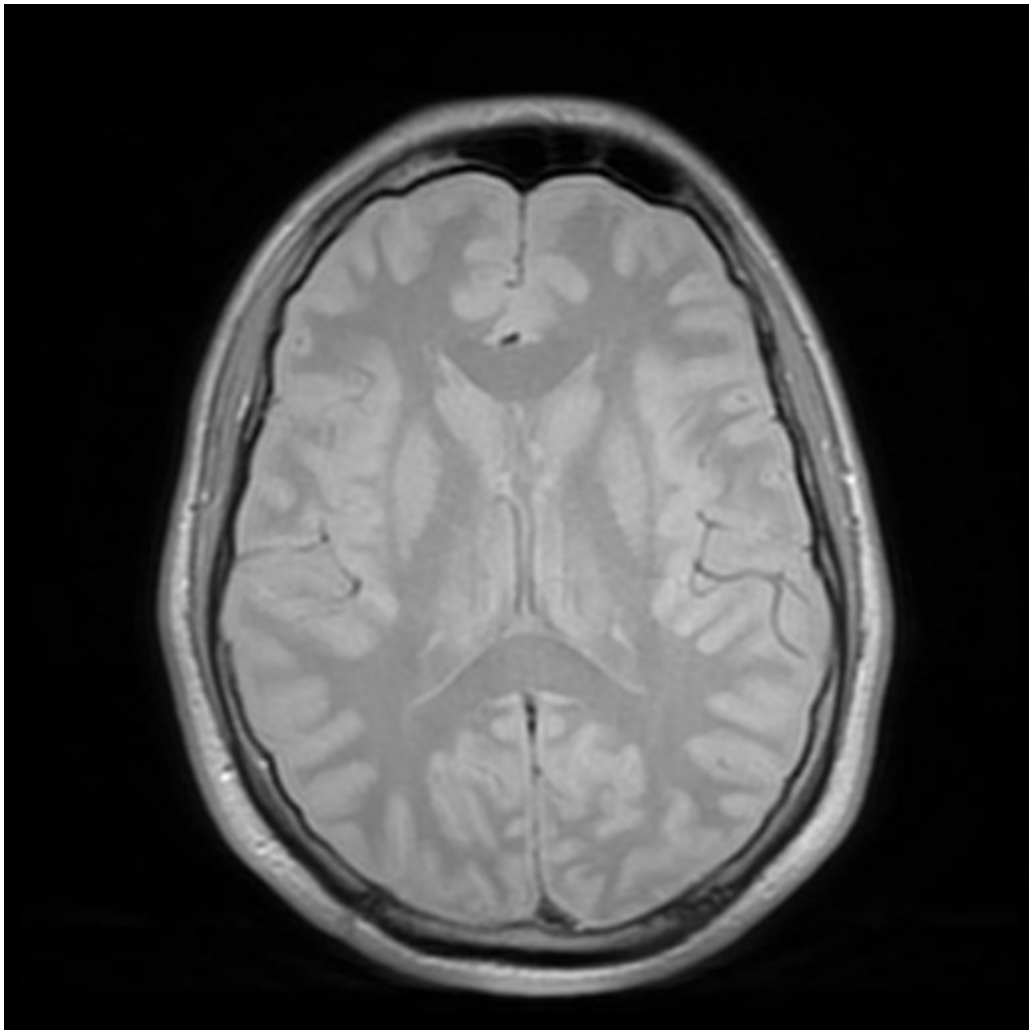
What is TE?

TE, meaning Time to Echo, is a user selectable parameter which determines when the MR signal should be sampled. Across different pulse sequences, TE selections can vary greatly, but generally determine how much dephasing is allowed to occur with the transverse magnetization ie the amount of T2 decay of signal.

TE in Spin Echo

The Spin Echo is the most straightforward example: TE will control how much T2 decay processes can influence image contrast. Long TE's (80-120) will allow a moderate amount of T2 decay to occur, allowing tissues with short T2 times to lose signal and become dark, creating contrast with long T2 tissues. Short TE's (<30) will restrict the amount of decay allowed, and reduce the influence of T2 decay processes to influence the image. Very long TE's (500+) will allow most tissues except for pure fluids to decay, creating myelographic contrast. Longer TE sequences will have less SNR than short TE sequences, all other parameters held constant. For this reason, sequences with inherently low SNR like STIR or T2 Fat sat may use reduced TE's in the 40-70 ms range.

These behaviors are relatively similar when considering the Fast Spin Echo, though there are important caveats discussed in more detail in the ETL section. Note in the image series below as TE is increased from 15-500 how different tissues decay at different rates, moving the contrast from Proton Density through to clinical T2 ranges, to very heavily T2 weighted myelographic contrast.

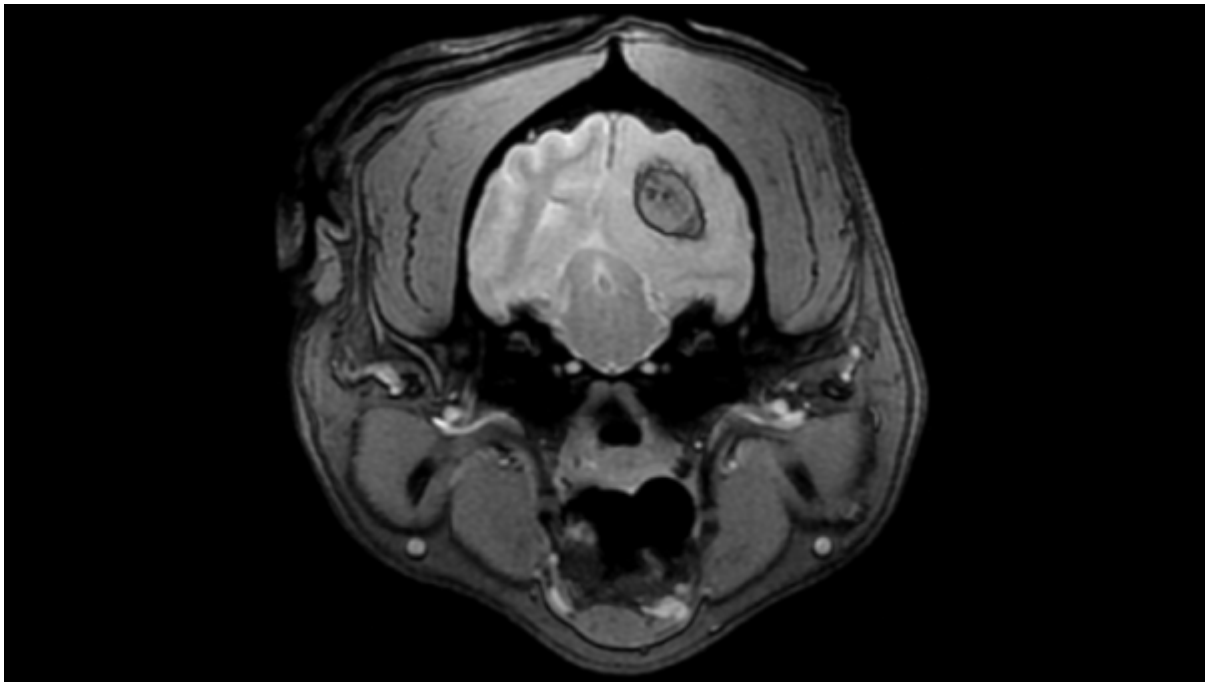


TE in Gradient Echo

The most commonly used gradient echo sequences are rapid steady-state 3D sequences, or T2* weighted sequences for detecting hemorrhage. The selectable TE's will vary, depending on the sequence chosen, and will be discussed in more detail below:

TE for T2* weighting

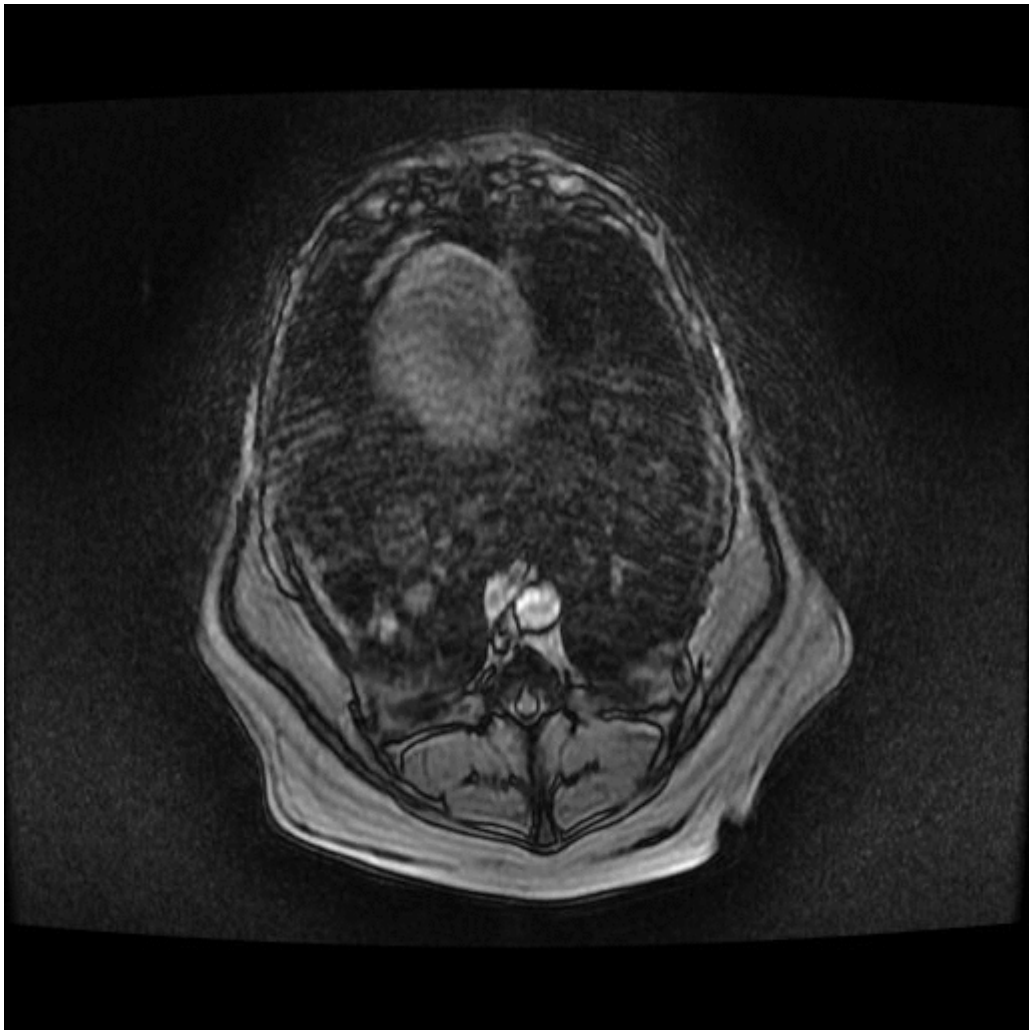
Without the strong refocusing pulses of a fast spin echo, transverse magnetization will decay rapidly due to the compounding effect of both T2 and T2* processes. This much shorter decay time means that TE's need to be much shorter, generally less than 30ms, or all the signal will have been lost. The most common method of achieving T2* weighting is to use a 2D gradient echo with a TE of ~20ms. It may be necessary to reduce the receiver bandwidth to recover SNR as well as allow for later TE selections. There are gradient echo sequences with special modifications that allow for enhanced T2* imaging such as Multi-echo GRE and SWAN. Note the T2* weighted image below demonstrating hemorrhage, TE ~18ms.



In and Out of Phase TE

When utilizing fast 3D gradient echo sequences, a TE time may no longer be selectable, and instead the options may be limited to an 'in-phase' or 'out-of-phase' option. In-phase and out-of-phase describe the relationship between fat and water vectors as they rapidly precess; at certain time points, fat and water vectors may be pointing in the same direction (in-phase) or opposite directions (out-of-phase) and the resulting images will demonstrate characteristic differences. In out-of-phase images, voxels containing both fat and water will will have signals that cancel out, resulting in the 'india ink' artifact that looks like a black line outlining most organs. In-phase images will not have the black outlines. The specific times where fat and water are in and out of phase depend on the field strength, but at 1.5T are approximately 2.2ms, 4.4ms, 6.6ms etc with the out of phase TE occurring earliest. Unless imaging the abdomen, typically select in-phase whenever possible for the highest readability.

Out of Phase



In Phase