Detecting reperfusion myocardial hemorrhage with T2 and T2* maps at 1.5T

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Introduction
Reperfusion into severely ischemic myocardium can lead to myocardial hemorrhage (MH). Recent studies have employed T2- and T2*-weighted imaging to assess MH. However, a direct comparison of myocardial T2 and T2* changes in the setting of MH is not available.

Purpose
To examine the T2 and T2* changes associated with MH and thereby determine the effectiveness of each method for detecting MH.

Methods
Canines (n = 9) were subjected to a 3-hour occlusion of the LAD followed by reperfusion. Serial CMR studies (1.5T Siemens Espree) were performed post-reperfusion on days 2, 5 and 7. Short-axis images of the entire LV (resolution = 1.1x1.1x8mm3) were obtained using T2-prepared SSFP (T2-preparation= 0, 24 and 55ms), multi gradient-echo (TE=3.43ms, 6.42ms, 9.41ms, 12.40ms, 15.39ms and 18.38ms) and PSIR Late-Enhancement (LE-PSIR) imaging. T2 and T2* maps were computed from T2-prepared and gradient-echo acquisitions. Hemorrhagic infarctions (MH+) were determined by the presence of hypointense territories on T2* maps within the infarcted zones identified from LE-PSIR images. In the MH+ group, manually drawn ROIs on the T2* maps around the hemorrhagic cores and remote territories were copied to the T2 maps. In non-hemorrhagic infarctions (MH-), manually drawn ROIs on LE-PSIR images around the infarcted zones and remote territories were copied to T2 and T2* maps. T2 and T2* values from the MH+, MH-
and remote territories were measured and compared (p<0.05).

**Results**
MH was observed in 6 dogs (MH+), but not in the remaining 3 dogs (MH-). Figure 1 shows a representative set of T2* and T2 maps and the corresponding LE image in a canine with MH. Figure 2 shows the mean T2* and T2 values from MH+, MH-, and remote territories. Table 1 lists the respective relaxation values and the change in T2 and T2* between MH+, MH-, and remote territories. In the MH+ group, T2* values decreased by 46% compared to the MH- group, while T2 decreased by only 16% (p<0.05).

**Conclusion**
T2* of MH+ territories were significantly lower than those of MH- and remote territories. This was not the case amongst T2 of MH+, MH- and remote territories. The reduced conspicuity of MH on T2 maps is likely due to the refocusing effects of the 180° pulses and its intrinsic sensitivity to myocardial edema. We conclude that the potential insensitivity of T2*-weighted CMR to myocardial edema and strong sensitivity to hemorrhagic byproducts makes T2* mapping a more effective approach for detecting MH.

### Table 1 Mean T2* and T2 values from hemorrhagic, non-hemorrhagic and remote territories were computed by averaging across all the days from all the animals

| Region                  | Remote Myocardium | Hemorrhagic infarction (MH+) | Non-hemorrhagic infarction (MH-) | % Change with respect to remote myocardium |
|-------------------------|-------------------|------------------------------|---------------------------------|---------------------------------------------|
| Technique               |                   | MH+                          | MH-                             |                                             |
| T2* (ms)                | 40.5 ± 5.0        | 23.0 ± 4.9                   | 43.3 ± 5.6                      | -42.1 ± 14.1%*                             |
| T2 (ms)                 | 54.9 ± 6.0        | 62.3 ± 5.1                   | 72.5 ± 4.3                      | 12.8 ± 14.4 %                             |

Mean percentage changes of T2* and T2 values in hemorrhagic and non-hemorrhagic infarctions with respect to remote territories are shown. Statistically significant changes (p<0.05) are denoted with an asterisk (*). While there was a significant decrease in T2* in hemorrhagic infarctions with respect to remote territories, T2 changes were insignificant. In non-hemorrhagic infarctions T2 was significantly higher, while T2* change was insignificant.

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