INTRODUCTION
A change in brain tissue potassium concentration, $[K^+]_{br}$, has been suggested as an index of progressive ischemic damage (1). To monitor $K^+$, partial K replacement with its congenor $^{87}$Rb, which possesses higher MRI-sensitivity, and, thus, a possibility of $^{87}$Rb MRI in vivo, have been demonstrated (2). MRI quantification of $^{87}$Rb in the brain still poses a significant challenge, however, because of its very short T2 (~0.4 ms), natural abundance of only 28%, and, therefore, relatively low tissue concentration. In this study our goals are to: 1) perform the first $^{87}$Rb MRI in a rat model of focal ischemic stroke; and 2) prove the suitability of $^{87}$Rb MRI at high fields (7 T) to obtain quantitative data on the $[K^+]_{br}$ dynamics in this model.

RESULTS AND DISCUSSION
Fig. 1 shows the first $^{87}$Rb MRI of ischemic rat brain, which demonstrates a drop in brain tissue rubidium concentration, $[Rb^+]_{br}$, in ischemic rat cortex after MCAT. For MRI to provide a quantitative measure of $[Rb^+]_{br}$, the MRI protocol utilized ultra-short TE (0.07 ms) to minimize a quantization bias caused by the $^{87}$Rb fast biexponential relaxation, and the use of calibration standards with $T_1$ and $T_2$ characteristics approximating those in brain tissue. To obtain $[Rb^+]_{br}$ concentrations, average $^{87}$Rb MR image intensities over selected ROIs in the brain were referenced to those from ROIs placed over the reference tubes (6). The changes in $[Rb^+]_{br}$ after MCAT were analyzed in the ipsilateral and homotopic cortex. In agreement with an earlier flame photometry report (2), $[Rb^+]_{br}$ data showed a decrease in ischemic brain, and no statistically significant changes in contralateral ROIs over time were observed (Fig. 2). To convert $[Rb^+]_{br}$ into physiologically meaningful values of $[K^+]_{br} + [Rb^+]_{br}$, different degrees of Rb$^+$/K$^+$ replacement in different animals were taken into account (2). The average dynamics of $[K^+]_{br} + [Rb^+]_{br}$ in all animals (Fig. 3) displays the net $K^+$ efflux from the ischemic brain, in agreement with $K^+$ dynamics studied earlier by traditional techniques (1).

CONCLUSIONS
These findings represent the world’s first successful $^{87}$Rb MRI in vivo co-registered with anatomic images. These data demonstrate the potential of 7 T $^{87}$Rb MRI to assess the dynamics of $K^+$ efflux from the ischemic brain with 13-min temporal resolution in a single animal. This technique may become a unique tool to approach the mechanisms of the progression of ischemic damage, as well as to address a need for novel early biomarkers of tissue viability and for therapy monitoring.

REFERENCES

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Fig. 1. Left: a coronal anatomic GRE image featuring an ischemic lesion ROI (outlined); right: a $^{87}$Rb MRI in the same plane obtained in 13.1 min at 5.8 hours after MCAT and showing lower $[Rb^+]_{br}$ in the ischemic ROI.

Fig. 2. $[Rb^+]_{br}$ in the ischemic cortex ROI ($[Rb^+]_{br}$, red) and homotopic normal cortex ROI ($[Rb^+]_{br}$, black) in the rat #2. $T_a$, time after MCAT.

Fig. 3. $[K^+]_{br}$ efflux from the ischemic cortex ($[K^+]_{br}$, red) after MCAT assessed by $^{87}$Rb MRI in vivo. $[Rb^+]_{br}$, black, shows $[K^+]_{br}$ in the homotopic normal cortex. The data are averaged over all 6 animals. $T_a$, time after MCAT. Error bars are SEM.

Fig. 4. $[Rb^+]_{br}$ concentration in the ischemic ROI ($[Rb^+]_{br}$, red) and homotopic normal cortex ROI ($[Rb^+]_{br}$, black) after MCAT. $R^2$ = 0.746.