# Development of Sodium-Imaging in Living Body Using Nuclear Magnetic Resonance and its Application to Analysis of Pathophysiology

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## Summary

Sodium ion ($Na^+$) plays a very important role in maintaining intra- and extracellular homeostasis. However, techniques to measure $Na^+$ in living body were limited to microelectrodes, and non-invasive method has not been available. Recently, nuclear magnetic resonance (NMR) is providing a new method to image the distribution of $Na^+$ in living body. This study focuses on the feasibility of $Na^+$ imaging using clinical NMR-CT machine (field strength: 1.5 Tesla). The changes in kinetics of intra- and extracellular $Na^+$ were also investigated from the viewpoint of pathophysiology.

In myocardium after the heterotopic heart transplantation, $T_1$ and $T_2$ relaxation times of proton ($^1H$) measured by H-MRI prolonged with the severity of rejection. Signal intensity of Na of myocardium rejected mildly was almost identical to normal one. Sodium signal increased in moderate rejection, and markedly increased in severe rejection. These results suggest that progress in rejection increases intracellular Na through irreversible damage and extracellular one through edema, resulting in the increase of signal intensity in Na image. In patients with cerebral infarction or hemorrhage, the lesion showed no signal of Na during early acute phase as was observed in normal tissue. However, signal intensity of Na at the lesion increased after late acute phase. These results suggest that the function of $Na^+$ pump deteriorates with progress of tissue damage, resulting in the increase of Na signal.

Our results strongly indicate that it is possible to get Na image from myocardium rejected after transplantation and brain tissue in infarction or hemorrhage by clinical NMR-CT machine. Furthermore, the pathophysiological condition of the lesion could be estimated by the analysis of Na image. The temporal resolution of Na-MRI is clearly less than that of H-MRI. Nevertheless, Na-MRI has the remarkable advantage to diagnose pathophysiological condition involving the change in intra- and extracellular $Na^+$, observed in myocardium rejected after transplantation or in brain tissue with ischemia and necrosis. Recent progress in Na-MRI makes it possible to get Na image in human brain, but its application to human hearts has several problems to be solved such as ECG-gating. Improvement of S/N ratio, optimization of pulse sequences, and reduction of artifacts due to blood flow are necessary to clinical application of Na-MRI in cardiology. New chemical shift reagents with high safety to human body, or new technique to discriminate intra- and extracellular $Na^+$ without chemical shift reagents are also requested. Once these new techniques required are developed, Na-MRI will come to be a powerful tool in clinical medicine.