MRI Features in a Canine Model of Intracerebral Hemorrhage

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Abstract. Intracerebral hemorrhage (ICH) is common and particularly lethal stroke subtype. The purpose of this study was to evaluate the diagnostic value of magnetic resonance imaging (MRI) in a canine model of ICH. ICH was induced by autologous blood injection and collagenase injection in four healthy beagle dogs. T1 and T2-weighted imaging of the brain was performed on 3 T and 7 T MR systems at 1 day after induction of ICH. In the acute stage of canine ICH, hemorrhagic lesions were characterized by hypointense on T2-weighted images, but the signal intensity of corresponding lesions was variable on T1-weighted images. Abnormal lesions of ICH were more evident at 7 T compared to 3 T. This study suggests that MRI may be a reliable diagnostic tool during the acute stage of canine ICH.

Keywords: dog, intracerebral hemorrhage, magnetic resonance imaging.

1 Introduction

Intracerebral hemorrhage (ICH) occurs in 15-20% of all stroke types and a devastating disease that has poor prognoses and high mortality [1,2]. If the patient survives from hemorrhagic attack, chronic disability in survivors is common due to the hematoma within brain parenchyma facilitating the cascade of harmful events and severe neurological deficits [3].

Even though various in vitro studies have focused on decreasing or inhibiting a series of events leading to secondary insults in ICH, proper animal models are needed to understand the underlying mechanisms of ICH-induced neuronal injury. To accomplish this purpose, a number of ICH models have been created in small and large animals [4]. In comparison with small animals (e.g., mice, rats, gerbils), large animals (e.g., cats, dogs, pigs, sheep, and monkeys) have gyrencephalic brains, which are structurally and functionally similar to the human brain [5]. Therefore large animals may be more suitable model for ICH, because they can mimic pathophysiologic processes in ICH of humans.

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Advances in neuroimaging techniques, such as computed tomography (CT) and magnetic resonance imaging (MRI), enable prompt diagnosis of hemorrhage on brain parenchyma, which is necessary for the treatment of acute cerebrovascular accidents. Even though MRI has become a useful imaging tool to detect acute hemorrhage of human [6], standard diagnostic protocols for canine ICH are deficient in experimental and clinical neurology.

Therefore the purpose of this study was to evaluate the diagnostic value of MRI in a canine model of ICH.

2 Materials and Methods

2.1 Animals

The study population comprised 4 healthy laboratory beagles (2 males and 2 females, 5-6 years old, weighing 10 to 12 kg) were used. All of the dogs were healthy without history of neurologic disease; they had no signs of neurologic problems on physical examination. They were screened for metabolic diseases by means of a complete blood count and serum chemistry analysis.

2.2 Animal Preparation, Monitoring, and Surgical Procedure

Dogs were fasted for 12 h before the induction of anesthesia, pre-medicated with atropine (0.02 mg/kg SC) and acepromazine (0.2 mg/kg IM), anesthetized 30 min after premedication by using propofol (5 mg/kg IV), orally intubated, and mechanically ventilated. Anesthesia was maintained with isoflurane at 2% to 3% of the inspired volume during surgery. The oxygen delivery and ventilation rates were monitored continuously and adjusted as needed to maintain heart rate, blood oxygen saturation and blood pH within normal limits. Rectal temperature was monitored continuously and maintained at 37 to 38 °C throughout surgery.

In 2 dogs, ICH was induced by injecting arterial autologous blood (1 mL) into the brain parenchyma through a burr hole using a 22-gauge spinal needle. In another 2 dogs, 625 U of bacterial collagenase from Clostridium histolyticum (Sigma, St. Louis, MO, USA) in 5 μl of sterile saline and 5 μl of heparin (10,000 U/ml) was delivered into the parietal lobe over 5 min with a micro infusion pump.

After completion of the imaging studies at 1 day after induction of ICH, all dogs were euthanized with sodium pentobarbital (80 mg/kg IV). The brains were carefully removed, and the hemorrhage was identified.

2.3 Imaging Protocol

Imaging was performed on 3 T (Oxford Instruments, Oxford) and 7 T (Magnetom 7 T, Siemens) MR systems at 1 day after induction of ICH. MR images were acquired with the dogs in sternal recumbency and under general anesthesia induced with propofol, and maintained with isoflurane and oxygen. At 3 T, T1 and T2-weighted images of the brain were obtained in blood injection model. In collagenase injection model, gradient-echo T2-weighted images and T1-weighted 3D magnetization prepared rapid acquisition gradient echo (MPRAGE) images of the brain were acquired in transverse plane at 7 T (Table 1).