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Microwave coagulation therapy and drug injection to treat splenic injury

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ABSTRACT

Background: The present study compares the efficacy of 915- and 2450-MHz contrast-enhanced ultrasound (CEUS)–guided percutaneous microwave coagulation with that of CEUS-guided thrombin injection for the treatment of trauma-induced spleen hemorrhage.
Materials and methods: In a canine splenic artery hemorrhage model with two levels of arterial diameter (A, <1 mm and B, between 1 and 2 mm), hemostatic therapy was performed using 915- and 2450-MHz microwaves and drug injection. Therapy efficacy was measured by comparing bleeding rate, hemostatic time, bleeding index, bleeding volume, and pathology.
Results: The most efficient technique was CEUS-guided 915-MHz percutaneous microwave coagulation therapy in terms of action time and total blood loss. The success rate of the 915-MHz microwave group was higher than that of the 2450-MHz microwave and the drug injection groups (except A level, $P < 0.05$). Hemostatic time, bleeding index, and bleeding volume were significantly less in the 915-MHz microwave group than those in the 2450-MHz microwave and drug injection groups ($P < 0.05$). Obvious degeneration and necrosis of parenchyma and large intravascular thrombosis were observed in the cavity of larger vessels in the 915-MHz microwave group, but pathologic changes of light injury could be seen in the other groups.
Conclusions: The present study provides evidence that microwave coagulation therapy is more efficient than thrombin injection for the treatment of splenic hemorrhage. Furthermore, treatment with 915-MHz microwaves stops bleeding more rapidly and generates a wider cauterization zone than does treatment with 2450-MHz microwaves.

1. Introduction

Previously, the treatment of choice for splenic trauma was splenectomy, even for minor injuries. This was because of the misguided belief that the spleen does not play a major role in normal adult physiology [1]. Recent recognition of the essential role of spleen in the immune system, coupled with the overwhelming risks of postsplenectomy infection, ischemic diseases,

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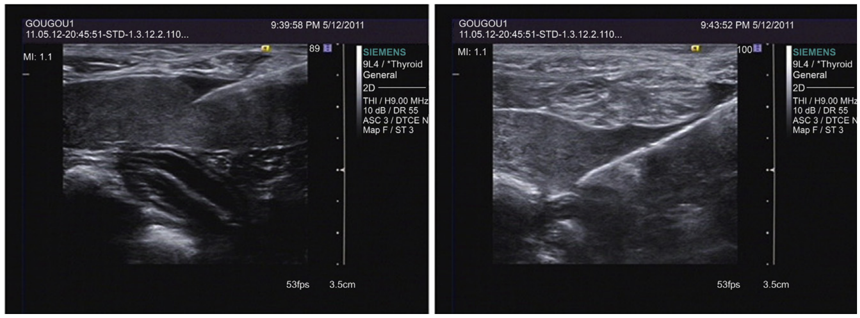

Fig. 1 – CEUS sonograph of the canine model of splenic vascular injury. The ultrasound-guided 14-G needle percutaneously pierced spleen parenchyma and established the trauma model. The ultrasound image shows that the needle pierced the spleen parenchyma precisely and penetrated the selected blood vessel. (Color version of figure is available online.)

and atherogenesis, warranted the development of more conservative treatments. Nonsurgical approaches are considered for hemodynamically stable patients; however, potentially life-threatening hemorrhage may occur from delayed splenic rupture [2]. Therefore, efficient techniques must be available to rapidly and efficiently stop the bleeding of an injured spleen.

Treatment of splenic hemorrhage is designed to control active bleeding and maximize the retention of spleen parenchyma [3–5]. Therefore, minimally invasive treatments such as fiber wrapping, drug injection, and thermal coagulation therapy have been widely applied. Microwave therapy is one of the most important thermal coagulation treatments and has good ablation results. In most hospitals, the most commonly used microwave frequency for clinical coagulation is 2450 MHz. In this study, we compared the treatment outcomes between 915- and 2450-MHz microwaves to determine whether the longer wavelength microwaves provide quicker and better hemostatic therapy for trauma-related splenic bleeding [6,7]. A canine model of spleen trauma was used to compare the efficacy of these microwaves with that of the commonly used contrast-enhanced ultrasound (CEUS)–guided drug injection.

2. Materials and methods

2.1. Animal housing and ethics

Experiments were performed in 56 Shandong dogs weighing 16–22 kg (mean, 19.38 ± 2.57 kg). Dogs without injury to the splenic arteries were obtained from and fed by the Experimental Animal Center of The General Hospital of Jinan Military District. The study was approved by the Jinan Institutional Animal Care Committee. All animals were subjected to splenic trauma and randomly assigned to the following groups: (1) control (untreated; $n = 14$), (2) 915-MHz microwave ($n = 14$), (3) 2450-MHz microwave ($n = 14$), and (4) drug injection ($n = 14$) groups.

2.2. Ultrasound scanner and microwave system

The ultrasound scanner was a Siemens S2000 (Siemens Medical Systems, Seoul, Korea) and included a convex array 4C1 and linear L9-3 probes. For CEUS, we used contrast pulse sequence (CPS; mechanical index range, 0.16–0.18), with a puncture bracket and software. The 915- and 2450-MHz microwave ablation systems (KY2000-915 and KY2000-2450; Kang-you Medical, Nanjing, China) included a microwave generator, flexible coaxial cable, and a cooled-shaft antenna. The generators were able to engender 1–100 W of power. A 2-mm slit-radiating segment was placed at 25 mm from the tip; this was optimal to minimize power feedback and maximize energy deposition into the tissue. Inside the antenna shaft, there were dual channels through which distilled water at 0°C was circulated by a peristaltic pump to continuously cool the shaft. During the procedure, the temperature of each antenna was kept <43°C.

2.3. Animal model of spleen trauma

Before the procedure, animals were fasted overnight. After the animals were anesthetized, a solution of sodium heparin was injected at a dose of 5 mg/kg. The ultrasonic probe was used to

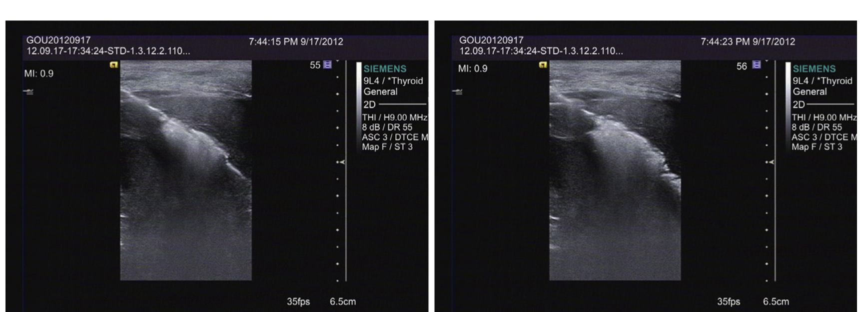

Fig. 2 – Microwave electrode (915 MHz) inserted in the trauma area. After the microwave electrode emission slot was placed on the active bleeding site, microwave ablation therapy was initiated. (Color version of figure is available online.)