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Original Article

Renal Sympathetic Ablation Using an Irrigated-Tip Catheter: An Attractive Option?

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ABSTRACT

Background: Catheter-based renal sympathetic denervation has emerged as an adjunct strategy to control refractory hypertension. No studies have yet compared the tissue effects of different catheters, powers and time periods of radiofrequency application, which was the objective of this study. **Methods:** Six porcine renal arteries were sectioned in their longitudinal axis and placed in the flow chamber designed to simulate physiological renal flow conditions. The catheters were placed obliquely to the artery with constant contact pressure. Radiofrequency ablations were performed using three different catheters: 4 mm/5 F solid-tip electrode, 4 mm/7 F solid-tip electrode, and open irrigated-tip 4 mm/7 F electrode. Two different powers were used (8 W and 15 W) for 30, 60 and 120 seconds. **Results:** A total of 18 ablations were performed. More significant nerve damage was observed with the 4 mm/5 F catheter and power of 8 W only when the application duration was extended to 120 seconds. On the other hand, significant nerve damage was observed with the 4 mm/7 F catheter with all power (8 W and 15 W) and duration (30, 60, and 120 seconds) options tested. Deeper lesions were observed with the use of the irrigated catheter, regardless of power and time periods of radiofrequency application. **Conclusions:** The irrigated-tip catheters produce deeper lesions than solid-tip catheters and their use might be more beneficial in treating patients with renal sympathetic denervation. The clinical applicability of these results, however, should be confirmed.

DESCRIPTORS: Hypertension. Renal artery. Sympathectomy. Catheter ablation.

RESUMO

Ablação da Atividade Simpática Renal com Cateter de Ponta Irrigada: Uma Opção Atraente?

Introdução: A denervação simpática renal por meio de cateteres surgiu como estratégia adjunta para o controle da hipertensão arterial resistente. Nenhum estudo até o momento comparou os efeitos teciduais de diferentes cateteres, potências e tempos de aplicação da radiofrequência, objetivo do presente estudo. **Métodos:** Seis artérias renais de porco foram seccionadas em seu eixo longitudinal e colocadas em uma câmara projetada para simular condições fisiológicas de fluxo renal. Os cateteres foram posicionados obliquamente à artéria, mantendo-se pressão de contato constante. Aplicações de radiofrequência foram realizadas utilizando-se três diferentes dispositivos: eletrodo de ponta sólida 4 mm/5 F, eletrodo de ponta sólida 4 mm/7 F, e eletrodo com ponta aberta irrigada 4 mm/7 F. Duas energias foram aplicadas (8 W e 15 W), durante 30 segundos, 60 segundos e 120 segundos. **Resultados:** No total foram realizadas 18 aplicações. Injúria neural renal mais significativa foi observada utilizando-se cateter 4 mm/5 F e energia de 8 W apenas quando a duração da aplicação foi estendida a 120 segundos. Por outro lado, significante dano neural foi observado com o cateter 4 mm/7 F com todas as potências (8 W e 15 W) e durações testadas (30 segundos, 60 segundos e 120 segundos). Lesões mais profundas foram notadas quando o cateter irrigado foi utilizado, independentemente da potência e da duração da aplicação. **Conclusões:** O cateter com ponta irrigada produz lesões mais profundas que os cateteres de ponta sólida e seu uso pode ser mais vantajoso na denervação simpática renal. A aplicabilidade clínica desses resultados, entretanto, deve ser confirmada.

DESCRITORES: Hipertensão. Artéria renal. Simpatectomia. Ablação por cateter.

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Radiofrequency ablation has been used in the percutaneous treatment of cardiac arrhythmias for several decades. Recent studies have shown the benefits of percutaneous renal sympathetic denervation as an alternative adjunct strategy for blood pressure control in hypertensive patients resistant to drug treatment.

The formation of lesions by radiofrequency (RF) depends on several factors; the most important are the appropriate electrode-tissue contact, the power used, the application duration, and the type of catheter used. In clinical situations such as ventricular tachycardia, it is essential that the lesion is deep enough to penetrate the myocardial tissue. However, the excessive temperature at the catheter tip can result in thrombus formation, which in turn limits the release of energy and reduces lesion amplitude. Based on these facts, efforts have been made to optimise energy delivery to the tissue without any substantial increase of temperature at the catheter tip. Currently, catheters with continuous irrigation systems are often employed in the treatment of cardiac arrhythmias in order to increase the depth of RF penetration into the tissue. Considering the location of the renal nerves in the vessel adventitia, sometimes located more than 4 mm from the intima, it is postulated that irrigated catheters could offer advantages in the setting of renal sympathetic denervation. This study aimed to evaluate the performance of irrigated-tip catheters compared to conventional solid-tip catheters in an *in vitro* experiment.

METHODS

Study setting

An acrylic chamber specifically designed to mimic blood flow conditions was used in the study, into which 7 L of Ringer's lactate solution were inserted, constantly circulating through a pump to simulate the renal blood flow and heated at 37°C. Six porcine renal arteries were used, each of which was sectioned in its longitudinal axis and attached to the chamber, and then submitted to radiofrequency application.

Procedure

Three radiofrequency applications were performed in each artery, at different points, with a minimum distance of 10 mm between them, using different catheters, power settings, and durations of application, resulting in a total of 18 lesions. In each application, the tip of the catheter was placed obliquely to the luminal surface of the artery under constant contact pressure. Three types of catheters were used: 4 mm/5F solid tip (Marinr®, Medtronic -Minneapolis, Minnesota, United States), 4 mm/7F solid tip (Marinr®, Medtronic), and 4 mm/7F open tip irrigated (Sprinklr®, Medtronic) (Figure 1). Saline solution (0.9% NaCl) at a flow rate of 17 mL/h at room temperature was used in the irrigation system of the irrigated-tip catheter. Two powers were applied (8 W and 15 W) for 30 seconds, 60 seconds, and 120 seconds.

Microscopic analysis

Each of the 18 points of RF application was sectioned into fragments of approximately 1 cm², using a sharp razor to avoid tissue damage; they were then chemically fixed in a formaldehyde 10% solution in individual and numbered vials, with a solution volume of no less than 40 times the volume of each fragment. Thereafter, each fragment was dehydrated in absolute ethanol, cleared in xylene, and embedded in paraffin blocks. They were then sliced into serial 4 mm sections using a semiautomatic microtome. Thus, 18 slides for microscopic analysis were made with several serial sections of each tissue and were stained with hematoxylin-eosin. An additional slide with a fragment of porcine renal artery not submitted to RF application was prepared and analysed as control. In cases of doubt regarding the presence of nerve/blood vessels, an immune histochemistry was performed using the S-100 marker protein to precisely identify the location and distribution of nerve fibres. The analysis by optical microscopy was performed in blinded fashion at an independent laboratory, by an experienced professional from the Department of Pathology of Universidade Federal de São Paulo (São Paulo, SP, Brazil).

RESULTS

In total, 19 slides were analysed, of which 18 had lesions caused by RF application and one served as a control (Figure 2). The RF application with 5F/8W catheter for 30 seconds or 60 seconds resulted in neural damage; however, the presence of multiple nerve fibres, although small, was also observed (Figure 3). When

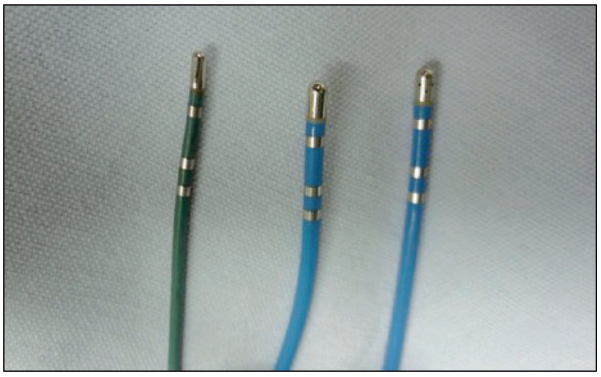

Figure 1 – The three types of catheters used, from left to right: 4 mm/5F solid tip (Marinr®); 4 mm/7F solid tip (Marinr®); and 4 mm/7F open tip irrigated (Sprinklr®).