

Evaluation of vasomotor activities under circulatory pathophysiologic conditions using Synchrotron Radiation microangiography

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1. Gender difference in coronary vasospasms

Introduction

Coronary vasospasm is defined as a reversible, focal, and intense coronary vasoconstriction that occurs typically in an epicardial arterial segment. Coronary vasospasm leads to variant angina and myocardial infarction. Estrogen is a hormone secreted by the ovaries, which affects many aspects of the female body, including menstrual cycles and pregnancy. Estrogen also acts as an endothelium-dependent vasodilator in the cardiovascular system. It is known that cardiovascular events including coronary vasospasm increase in females after menopause. Especially, microvascular spasm (MVS) is predominant in women after menopause. This is explained in relation to the withdrawal of estrogen. Although coronary angiography is an exclusive method to identify coronary vasospasm, conventional angiography can only be effective in arteries up to 500 μm in diameter. With the application of synchrotron radiation, which can provide high-quality X-rays, arteries up to 100 μm can be identified in our experimental system at PFAR-NE5A, KEK. In order to diagnose coronary vasospasms, it is necessary to visualize the entire coronary vasculature simultaneously rather than obtain a detailed visualization in a limited coronary artery. Our system was established to visualize the entire coronary vasculature up to 100 μm in accordance with the rapidly beating heart of small animals.

Method

The hearts of female Wistar rats were excised and attached in a Langendorff apparatus. The hearts were perfused with modified Krebs-Henseleit solution (KH solution), which did not contain estrogen. After 20 minutes of perfusion, 4-aminopyridine (4-AP), which is a spasm inducer, was added within 5 minutes, followed by the initial KH solution. Coronary angiography was performed at pre 4-AP administration, during 4-AP perfusion, and 10 minutes after cessation of 4-AP infusion.

Results

A resolution of 1024 x 1024 pixels was achieved in a 26 x 26 mm visual field using high-sensitivity CCD video camera (Model C4880, Hamamatsu Photonics, Hamamatsu, Japan). Female hearts were significantly

sensitive to the vasospasm inducer in comparison to male hearts, which were studied in 2002.

Conclusion

With the use of synchrotron radiation, coronary vasospasms of up to 100 μm in diameter were evaluated. Female hearts were sensitive to coronary vasospasm in relation to acute estrogen withdrawal.

2. Response of peripheral microcirculation to cold exposure

Introduction

Cold-induced vasodilation (CIVD) is defined as the reactive vasodilation of cold-exposed blood vessels, in particular that of small arteries. Cold exposure to the extremities was thought to promote initial vasoconstriction in order to prevent temperature loss followed by CIVD. CIVD has been evaluated by temperature or Doppler flow meter without direct visualization. The aim of this study was to visualize CIVD using synchrotron radiation microangiography, which can identify the arterioles up to 50 μm in diameter.

Method

The resolution and visual field were the same as those in the coronary angiography. The left renal artery was cannulated and infused with 35% non-ionized iodine as a contrast material at a rate of 1 ml/sec in two seconds. Cold exposure was achieved by cold spray for 5 seconds at a 10 cm distance from the left hindlimb. Angiography was performed at pre cold exposure, 0, 15, 30, 60 seconds, and 15 minutes after cold exposure.

Results

Peripheral small arteries were dilated up to 150% in comparison with to pre cold exposure. However, initial vasoconstriction was not confirmed as a prerequisite of CIVD.

Conclusion

From this study, it was clarified that CIVD was not always accompanied by the pre-existence of vasoconstriction due to cold exposure. This study is the first evidence of the variation of CIVD revealed.

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