

Identification of microvascular coronary spasm using synchrotron radiation microangiography

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Introduction

Coronary vasospasm, which brings about ischemic chest pain and myocardial infarction, is defined as a temporary, intense narrowing of the coronary artery. Although coronary spasms in conduit artery can be visualized by conventional coronary angiography, microvascular spasm due to small arteries down to 50 μm in diameter has not been visualized yet. The aim of this study is to visualize microvascular spasms using synchrotron radiation coronary angiography (SRCA) utilizing unique properties of synchrotron radiation such as high photon density and straightness of the beam.

Materials and Methods

Synchrotron Radiation

The SRCA technique makes use of an asymmetrically cut silicon crystal to vertically expand the monochromatic beam, a fluorescent screen, a CCD camera (Model C4880, Hamamatsu Photonics), and a computer data storage system. The system is used to record two-dimensional images with a spatial resolution of 26 μm , and the visual field is 26 mm x 26 mm. Exposure times used ranged from 50 msec to 150 msec, with a maximum acquisition rate of 3 images/sec. Inorganic iodine with an iodine concentration of 32% by weight is used as the contrast material. Imaging energy is 33.21 KeV, which is 40 eV above the iodine K edge.

Coronary Angiography

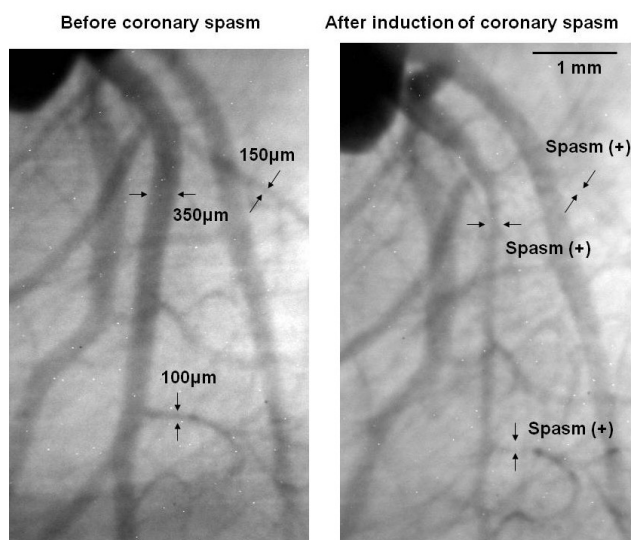
Male Wistar rats weighing 250 g to 500 g were used. The Langendorff perfusion system with isolated rat hearts was employed. Krebs-Henseleit solution (KH solution) was used for the perfusate. 10 mM/L of 4-aminopyridine (a voltage-gated potassium channel blocker; as a spasm inducer) was added to the KH solution. Coronary spasms were defined as a temporal 75% reduction of coronary arterial diameter.

Induction of coronary spasms in the beating heart

An excited heart was maintained for 20 minutes with KH solution and followed by 5 minutes perfusion with KH solution with 10 mM/L 4-AP. Then the heart was perfused with KH solution without 4-AP for 10 minutes. Images were taken at pre-, during and 10 minutes after cessation of the 4-AP solution perfusion.

Results

Coronary spasms were induced by 4-AP in most cases in various sizes. Conduit coronary spasms were found in all three major coronary arteries, namely the right coronary artery (RCA), the left anterior descending artery (LAD) and the circumflex artery (Cx). These spasms were seen in arteries ranging from 200 to 400 μm in diameter. In addition, spasms of arterial branches were also seen. Microvascular spasms were observed changing from 100 μm to 50 μm .



Conclusion

Coronary microvascular spasms are seen in the arterioles (50-400 μm). Coronary microvascular spasms may be diagnosed with the use of synchrotron radiation coronary angiography.

References

- [1] S. Matsushita et al., Nuclear Instruments and Methods in Physics Research A 548, 94 (2005)
- [2] S. Matsushita et al., Eur. J. Radiol. 68S: S84 (2008)

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