TREATMENT OF INTRACORONARY THROMBUS WITH MICROWAVE THERMAL BALLOON ANGIOPLASTY

Arye Rosen, Paul Walinsky, Donald Nardone, Barry Bravette, Yi Shi,
Antonio Martinez-Hernandez, Andrew Zalewski

Thomas Jefferson University Hospital

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ABSTRACT

We utilized microwave energy to evaluate the treatment of vascular thrombus in a canine model of coronary thrombus. We found that with microwave energy we were able to coagulate and laminate intracoronary thrombus providing a more effective resolution of intracoronary thrombus than with conventional balloon angioplasty.

Angioplasty of the coronary arteries and of arterial supply to the lower extremities and kidneys is now an established technique for the treatment of arterial stenosis. With this procedure one of the major complications is the presence or development of thrombus. Thrombus can result in complete occlusion of the vessel despite an adequate dilatation of the underlying vessel. Such thrombus may be present before an angioplasty procedure begins, or may form as a consequence of the procedure. It is possible to treat the thrombus through the installation of thrombolytic therapy such as streptokinase or tissue plasminogen activator. Mechanical means of treating such thrombus have also been previously investigated. In the current study we evaluated the feasibility of utilizing microwave thermal energy to more effectively resolve coronary thrombus than conventional balloon angioplasty.

In 13 mongrel dogs anesthesia was induced with pentobarbital. The chest was then opened and the heart exposed and suspended in a pericardial cradle. The left anterior descending coronary artery was isolated. The artery was occluded and thrombin was distilled into the artery in order to induce a thrombus. Verification of the presence of a stable thrombus was made by coronary angiography. Following the formation of a stable thrombus, the animals were observed for 30 minutes of stability. The artery was then traversed by a balloon angioplasty system. The arteries were treated with either conventional balloon angioplasty or microwave balloon angioplasty. The balloon inflation time was 1 minute. With microwave balloon angioplasty balloon inflation was for one minute with microwave energy delivery for 30 seconds. Microwave energy was delivered at 2450 MHz. The energy input was regulated by feedback from a thermocouple on the surface of the balloon so that the temperature as monitored on the internal balloon surface was 85^{o}C. Immediately after angioplasty animals were given 3000 units of intravenous heparin.

Angiography was performed before angioplasty, immediately after angioplasty and 30 minutes after angioplasty. Following the 30 minute angiography, the animals were sacrificed and the treated segment of vessel was removed for histologic examination.

Prior to angioplasty all animals demonstrated complete occlusion of the left anterior descending artery. On angiographic evaluation 2 out of 6 animals treated with microwave balloon angioplasty had evidence of thrombus. Five out of 6 animals treated with conventional balloon angioplasty had evidence of thrombus on angiographic evaluation. The angiographic findings varied from filling defects in the lumen to complete occlusion.

On histologic evaluation complete occlusion of the vessel was noted in 4 out of 7 animals treated with conventional balloon angioplasty. (Fig. 1) In addition, 2 out of 7

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animals with conventional angioplasty had thrombus in up to 50% of the vessel lumen. In contrast in 1 out of 6 animals treated with microwave balloon angioplasty complete occlusion of the vessel was noted. In addition, 2 out of 6 animals with microwave balloon angioplasty had thrombus in up to 50% of the vessel lumen. Histologic examination of the thrombus following microwave balloon angioplasty revealed coagulated thrombus with peripheral lamination of the thrombus (Fig.2) A patent central lumen was noted in the center of the laminated thrombus.

We have demonstrated that thermal angioplasty using microwave energy is an effective means, in conjunction with balloon angioplasty, in the treatment of intravascular thrombus. The combination of balloon angioplasty in which a thrombus is displaced to the periphery of the vessel along with thermal energy delivery to coagulate and stabilize the thrombus, therefore provides promise of application in a variety of clinical syndromes in which thrombus may complicate an angioplasty procedure and occlude a vessel. Such syndromes include acute myocardial infarction and unstable angina pectoris.

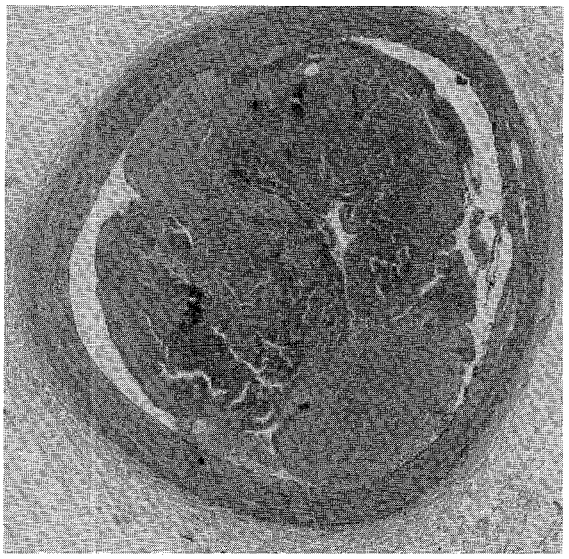

Figure 1. Canine left anterior descending artery following occlusion with thrombus and conventional balloon angioplasty. The vessel remains occluded with thrombus despite the previous application of balloon angioplasty.

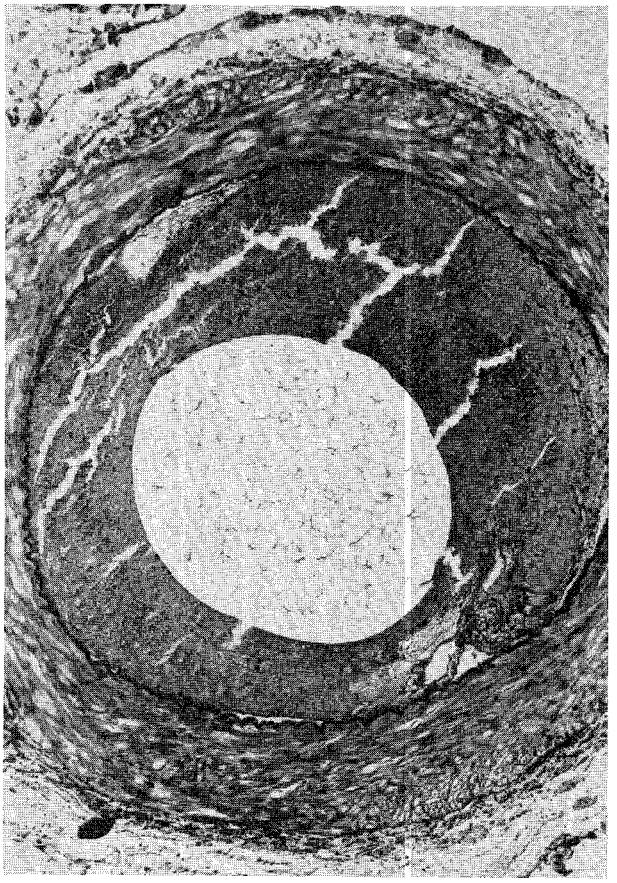

Figure 2. Canine left anterior descending artery. The artery was previously occluded with thrombus and has been treated with balloon angioplasty in conjunction with microwave energy thermal delivery. Note the peripheral lamination of thrombus. The thrombus has been coagulated and remains stable in a peripheral position. A central channel is patent and provides an adequate lumen for blood flow.