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Excimer Laser – The Great Plaque Modifier

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Dr. Nakabayashi and colleagues from Kasukabe Chuo General Hospital in Kasukabe, Japan, who authored the paper "Simplifying percutaneous coronary interventions using the modification of complex coronary lesion with excimer laser" in the current issue of *Cardiovascular Revascularization Medicine,* are to be commended for the high quality of their interesting article [1]. Specifically, the content is relevant to the management of a growing number of challenging patients with complex coronary lesions encountered globally by interventional cardiologists.

The 6 exemplary cases by Nakabayashi and coworkers focus on debulking by the pulsed-wave, ultraviolet biomedical excimer laser. The well-documented interventions precisely demonstrate the great capability of the excimer laser to "simplify" or, to use a better term, modify unfavorable anatomic morphologic features of complex plaques. Accordingly, the excimer laser was applied to patients whose lesions were judged by the interventionalists as challenging, high-risk targets carrying predicted propensity for procedure-induced major adverse cardiovascular events. The main thrust of the authors' findings is that the excimer laser successfully modifies the plaque's morphology to the extent that subsequent lesion response to treatment with standard adjunct technology, such as balloons and stents, is enhanced. This process then significantly improves procedure outcome.

The cardiovascular excimer laser technology had been repeatedly shown to be a safe and efficacious plaque modifier [2–4].This laser uniquely interacts with the major components of atherosclerotic plaques in the coronary and peripheral arterial circulation [5]. Of note, the excimer laser can also be successfully applied in venous vasculature interventions [6], as well as in electrophysiology applications such as pacemaker and implantable cardioverter defibrillator leads removal [7]. In essence, the excimer laser exerts major biophysical impact on plaque by induction of photo mechanical processes that culminate in vaporization of the atherosclerotic material and, concomitantly, the accompanying thrombus dissolves [8,9]. Angiographically, from the interventionalist's perspective, the laser creates an anatomic tunnel, which we have termed the "pilot tunnel." This debulking phenomenon is well-demonstrated in the appearance of the laser recanalized plaque in the first case describe in the paper by Nakabayashi et al. The diameter of most "pilot tunnels" corresponds with the size of the laser catheter's tip. The prominent, most common angiographic feature of this recanalization tunnel is the round smoothness of its walls and the morphologic stability it offers. The tunnel accommodates and readily yields to deployment of balloons or stents. Another common observation associated with laser debulking is the absence of distal embolization and "no reflow," provided that proper laser debulking is used [10].

The complex targets that were impressively modified by Nakabayashi and coworkers included severe left main stenosis (case #1), severe long eccentric stenosis (case #2), a chronic total occlusion (case #3), a nondeployable stent (case #4), recurrent severe in-stent restenosis (case #5), and heavy thrombus burden (TIMI thrombus grade 5) in late-presentation acute myocardial infarction (case# 6). In each case, the initial high-risk morphologic features of the plaque (or stent) were crafted and modified with careful laser catheter selection and utilization of adequate lasing technique. In turn, the resultant creation of less complex morphologic features and/or characteristics ensured safe and successful completion of an otherwise high–risk, challenging percutaneous coronary intervention.

Several crucial parameters of laser activation govern safe and successful procedures. While the authors correctly mention the user-friendly, effective design of second-generation laser catheters and the incorporation of "saline flush," these are secondary to the most important factor: the lasing technique. Proper laser debulking technique incorporates 2 crucial elements:

1] Slow advancement of the catheter during emission of energy, a step that accommodates sound laser physics principles. Slow advancement translates into effective absorption with resultant adequate debulking [11]. Otherwise, in case of hasty advancement, the plaque's "modification" will be limited to uncontrolled and unpredicted Dotter effects. Moreover, rapid advancement can easily cross the entire length of the plaque yet without any biological tissue impact or, alternatively, it can cause unwarranted tissue heating and spasm.
2] Intermittent laser activation (e.g., deposition of energy trains consisting of 5 sec activation time alternating with 5 sec pauses) is

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always required along the delivery of laser emission. The inevitable vapor gas bubble that arises from the lased plaque reaches maximum dimension while exerting very high intra-plaque pressures [12]. The pauses enable gradual shrinkage and eventual collapse of the bubble and, subsequently, the microscopic atheromatous debris can safely be swept by the circulation downstream. Otherwise, a relentlessly expanding vapor bubble (i.e., when the laser is delivered without any emission pauses) exerts a deleterious physical impact on both the plaque and surrounding vessel's wall in the form of spasm, dissections, and perforations [13].

The basic research on the fascinating interaction of excimer laser (as well as other medical lasers) with thrombus and its major constituents has been repeatedly translated into clinical successful utilization [14]. The unique ability of ultraviolet wavelength to suppress platelet aggregation [15] can indeed be considered an associated benefit stemming from the interaction of ultraviolet wavelength with specific platelet receptors. Nevertheless, this should not be considered a specific indication or justification for select laser application because the extent of suppression of the circulating platelets remains unknown. The high cost of the laser technology should be considered as well. Thus, this laser is not a substitute for the administration of heparin, direct thrombin inhibitors, or glycoprotein IIb/IIIa receptor antagonists.

Altogether, the experience with the 6 cases presented by Nakabayashi and associates confirms that proper selection of laser catheters and utilization of adequate lasing techniques can assist in contemporary challenging coronary interventions. Accordingly, the series carries clinical importance because it adds robust testimony to the existing data on the usefulness of lasers in cardiovascular interventions. The interested reader of the paper by Nakabayashi et al. certainly notices that in addition to their excellent technical prowess, the authors submitted photographs of excellent quality, illustrating so well the laser's role as the great plaque modifier.

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