The Open (Radial) Artery Hypothesis: How We Can Preserve a Better Arterial Access Site

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Radial artery occlusion (RAO) is one of the most common procedural complications of transradial cardiac catheterization, and is thought to be due to a combination of traumatic and nontraumatic factors including arterial spasm, endothelial injury, microthrombus formation and/or neointimal hyperplasia [1]. Although it is often asymptomatic, there are sporadic reports of digital ischemia in the presence of RAO. Whether the RAO is directly causing the ischemia or if it is due to the embolization of thrombotic material from the occlusive ‘plug’ is unclear. At a minimum, the development and persistence of RAO precludes subsequent transradial access in the affected arm. Over the past 20 years, operators have developed a number of strategies to minimize the incidence of arterial occlusion, including using smaller sheaths (if any), appropriate anticoagulation and ‘patent hemostasis’ techniques to allow antegrade blood flow through the radial artery during the hemostatic process [2]. Despite the established role of these strategies, survey data indicate that there is wide variation in postprocedure practice [3]. This is especially true regarding the type and dose of anticoagulation used in transradial diagnostic and interventional cases.

In this issue of *Cardiology*, Degirmencioglu et al. [4] present the results of a single-center, randomized trial

comparing 2 heparin dosing strategies. After screening 520 patients, they excluded 30 (5.7%) due to previous transradial access or factors associated with an increased risk of bleeding; another 86 (16.5%) underwent ad hoc angioplasty and were therefore also not included in the analysis. The remaining 404 patients were randomized equally to either a low-dose (2,500 units) or high-dose heparin strategy (5,000 units). Seven days after the procedure, there was no statistically significant difference in the rates of RAO (5.9 vs. 5.4%, $p = 0.83$) or hematoma of grade III or larger (4.0 vs. 7.4%), though the low-dose strategy was associated with a lower degree of bleeding during deflation of the radial hemostasis device, the TR Band (Terumo Interventional Systems, Somerset, N.J., USA; 6.4 vs. 18.3%, $p < 0.001$). There were no episodes of major bleeding in either arm of the study.

This study adds to the long-standing body of literature evaluating the appropriate dose of heparin during transradial cardiac catheterization. Some dose of heparin is used during a transradial cardiac catheterization by 95% of practising interventionalists [3] worldwide. The role of heparin in reducing the rate of RAO was initially described 20 years ago in a prospective, nonrandomized study of 415 patients. The rate of RAO at 2 months, assessed with Doppler ultrasound, was 71% among the first

49 patients who received no heparin, 24% among the next 119 patients who received 2,000–3,000 units of heparin and 4.3% in the subsequent 210 patients who received 5,000 units ($p < 0.05$) [5]. More recent studies have attempted to determine the most appropriate dose of unfractionated heparin to balance efficacy and bleeding. A weight-based regimen of 50 units/kg was tested against a fixed dose of 5,000 units in 162 consecutive patients in the AWARE (Adjusted Weight Anticoagulation for Radial Approach in Elective Coronarography) study [6]. No RAO was observed in either arm, though the patients randomized to the weight-based regimen displayed lower radial compression times and a trend toward decreased rates of local hematoma formation. The study by Degirmencioglu et al. [4] is consistent with findings from a prior study by Bernat et al. [7], in which 465 patients undergoing transradial cardiac catheterization were randomized to 2,000 and 5,000 units of heparin, respectively. Immediately after the procedure, there was no difference in RAO incidence between the 2 groups (5.9% of the low-dose group vs. 2.9% of the higher-dose group, $p = 0.17$), though ulnar artery compression to force blood flow through the radial artery resulted in significantly reducing the rate of RAO in the higher-dose arm (4.1 vs. 0.8%, $p = 0.03$). The study by Degirmencioglu et al. [4] did not test maneuvers to reduce RAO rates postprocedure, however.

The other critical aspect of preventing RAO is the use of ‘patent hemostasis’ techniques to allow for antegrade flow through the radial artery. Traditionally, operators use full occlusive compression for hemostasis following transradial procedures. As with determining the appropriate anticoagulation dosing, a compressive technique following transradial catheterization must balance appropriate hemostasis and bleeding; too little pressure may result in longer compression times and increased rates of local hematoma formation whereas full occlusion for an extended period of time may lead to increased rates of RAO. The first trial to assess the efficacy of patent hemostasis was the PROPHET (Prevention of Radial Artery Occlusion-Patent Hemostasis Evaluation Trial) [8], in which investigators randomized 436 patients to fully occlusive or patent hemostasis techniques using the Hemo-Band. Rates of RAO were lower in the patent hemostasis group than in the occlusive hemostasis group at 24 h (5 vs. 12%) and 30 days (1.8 vs. 7.0%, $p < 0.05$ for both). A similar study was performed using the TR Band [9], the hemostasis device also used by Degirmencioglu et al. [4], and this demonstrated similar reductions in RAO with patent hemostasis techniques (1.2 vs. 12.0%, $p < 0.001$).

It should be noted that the investigators used a nontraditional method to achieve hemostasis when using the TR Band. They report that they maximally inflated the TR Band to 18 ml and then deflated it until a radial pulse could be palpated, after which they deflated an additional 2 ml every 15 min. This is problematic because the presence of a pulse does not necessarily mean that antegrade flow is present in the radial artery – retrograde flow from the ulnar artery through the palmar arch can result in a palpable radial pulse distal to the hemostasis device. Therefore, it is not clear that they practised true patent hemostasis. Although the authors present rates of RAO that are similar to prior literature, the rate of grade III hematoma is much higher than previously reported [10] and suggests that inappropriate distal placement of the hemostasis device led to extravasation of blood proximally from the arteriotomy. Reassuringly, there were no reported episodes of major bleeding or other significant complications. While this study addresses an important issue, it cannot be taken as the final word on appropriate heparin dosing for transradial procedures.

More importantly, this analysis highlights the delicate balance between thrombosis and bleeding at the level of the arterial access site. Adequate anticoagulation is a fundamental part of a broader, multifaceted strategy to achieve radial hemostasis and reduce the incidence of RAO that includes minimizing arterial trauma by using small caliber sheaths, preventing and treating spasm and using patent, nonocclusive hemostasis to achieve antegrade flow through the radial artery. In addition, all patients should be evaluated for radial patency prior to discharge, with the potential use of ulnar artery compression to facilitate radial artery recanalization. As the popularity of radial access increases worldwide and it becomes the de facto standard of care for cardiac catheterization, the prevention and mitigation of the most common complications of the procedure are essential, and an appropriate anticoagulation dosing strategy is an integral component.

Acknowledgments

Dr. Vora was funded by NIH T-32 training grant No. 5 T32 HL 7101-38.

Conflict of Interest

Dr. Rao reports research funding from Bellerophon; consulting for Terumo Medical, the Medicines Company and ZOLL.

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