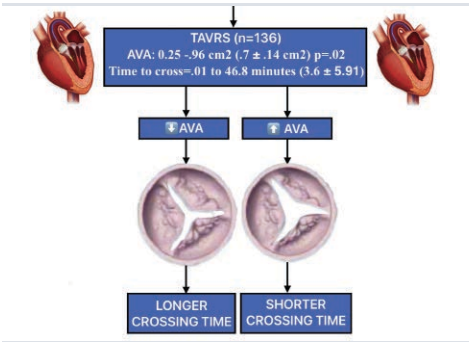
Cath Lab Digest

A product, news & clinical update for the cardiac catheterization laboratory specialist



TAVR

Aortic Valve Area and Time to Cross the Aortic Valve in Severe Aortic Stenosis During Transfemoral Transcatheter Aortic Valve Replacement

Richard Casazza, MAS; Joshua Fogel, PhD; Jacob Shani, MD

Abstract

Objective: Aortic valve area (AVA) may delay time to cross the aortic valve (AV) during transcatheter aortic valve replacement (TAVR). We study the association of AVA with time to cross stenotic AVs during TAVR.

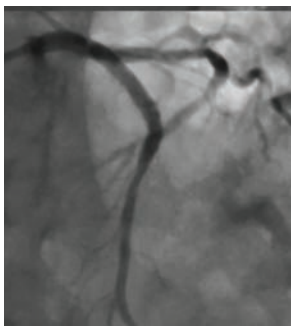
Methods: We studied 136 patients at a single center with severe aortic stenosis undergoing TAVR. Time to cross the AV was defined as the amount of time the operator was on fluoroscopy from the beginning of trying to cross the AV to the actual crossing of the AV with the catheter. Covariates included age, sex, body mass index, body surface area, valve orientation, and operator specialization.

continued on page 18

In This Issue

CORONARY IVL

Cracking Calcium on a Cliff-Hanger: Intravascular Lithotripsy for High-Risk Left Main PCI in STEMI



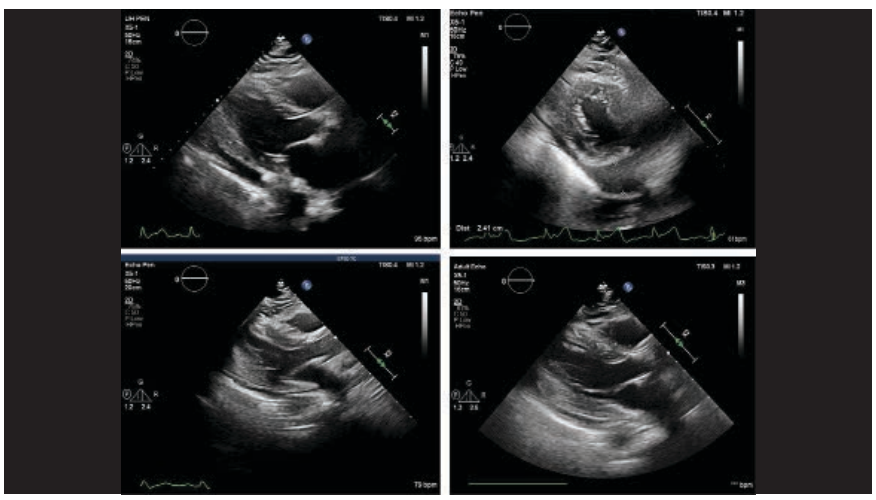
CLD talks with Dr. Kalaivani Mahadevan, MD, and Prof. James C. Spratt, BSc, MB ChB, MD.

continued on page 11

LEFT ATRIAL APPENDAGE CLOSURE

Delayed Pericardial Effusion Following Left Atrial Appendage Closure: A 5-Year Single-Center Experience

Akhil Mogalapalli, MD[1]; Sundeep Kumar, MD[2]; Tabitha Lobo, MD[1]; Joseph Reed, MD[1]; Luis Augusto Palma Dallan, MD, PhD[3]; Sung-Han Yoon, MD[3]; Steven J. Filby, MD[3]



continued on page 22

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Cracking Calcium on a Cliff-Hanger: Intravascular Lithotripsy for High-Risk Left Main PCI in STEMI

CLD talks with: Dr. Kalaivani Mahadevan, MD and Prof. James C. Spratt, BSc, MB ChB, MD.

Dr. Mahadevan, can you describe your coronary intravascular lithotripsy case?

This case involved an 85-year-old gentleman suffering an anterior ST-elevation myocardial infarction (STEMI) who was brought directly to the cath lab out of hours, with a history of hypertension and medically managed significant peripheral vascular disease. He had a good quality of life, and had been cognitively and functionally independent. On arrival, he was hypotensive and hypoxic on 5-liter oxygen, with bedside echo showing severe left ventricular (LV) impairment, an ejection fraction of 25%, and mild aortic stenosis. Angiography (Figure 1A) revealed heavily calcified (apparent on dry cine) triple-vessel coronary disease with moderate distal left main (LM) disease and an occluded ostial left anterior descending (LAD) artery. Risk stratification revealed Society for Cardiovascular Angiography and Interventions (SCAI) Stage B shock and a Protected Percutaneous Coronary Intervention (PCI) Score of 5. The intensive care team was called for inotropic and physiological support to include intravenous (IV) metaraminol and IV furosemide to offload and improve oxygenation, and for input regarding airway monitoring +/- intervention if required.

With a 6 French (F) Extra Backup (EBU) 3.5 guide (Medtronic) and a guide extension catheter (GEC), it was eventually possible to deliver a small 1.1 mm Across CTO balloon (Acrostak) through the nodular distal LM and ostial LAD calcium, and then undertake sequential pre-dilatation with incrementally larger balloons up to 3.0 mm, with restoration of some flow and ST segment improvement.

Intravascular ultrasound (IVUS) imaging (Figure 1B) showed all varieties of calcium throughout the LAD and LM. A 4.0 intravascular lithotripsy (IVL) balloon (Shockwave Medical) was used to modify calcium with the support of intracoronary phenylephrine to elevate baseline blood pressure prior to each 10-pulse delivery (20-30 pulses given) across the LM. This enabled modification without grossly compromising hemodynamics. A 3.5 mm x 48 mm Xience stent (Abbott Vascular) was deployed and optimized, with a final IVUS run showing good expansion and apposition. There was some eccentricity to stent expansion as expected with nodular calcium, but with a good area within the LM of more than 12.5 mm^2. There was moderate disease in the circumflex that did worsen slightly after jailing with the stent. I briefly tried to cross, but with angulation and calcium, the support was not adequate.

We returned the patient to the coronary care unit with a plan to potentially bring him back for a staged procedure with 7F equipment to complete the circumflex and also to treat the right coronary artery. However, at 48 hours, he was walking down to the coffee shop, completely chest pain-free, and he pragmatically declined further intervention. After a PCI multidisciplinary heart team meeting and discussion with him and his family, we agreed that at 85 years and in accordance with his wishes, this was a reasonable decision. He has been medically managed since and is now over 2 years post PCI with an unlimited exercise tolerance. He has not returned with angina or a recurrent cardiac event.

What are some of the key takeaways for interventionalists from this case?

A knowledge of small profile and chronic total occlusion (CTO) balloons, use of GEC, and not assuming upfront that we had to rotablate were all

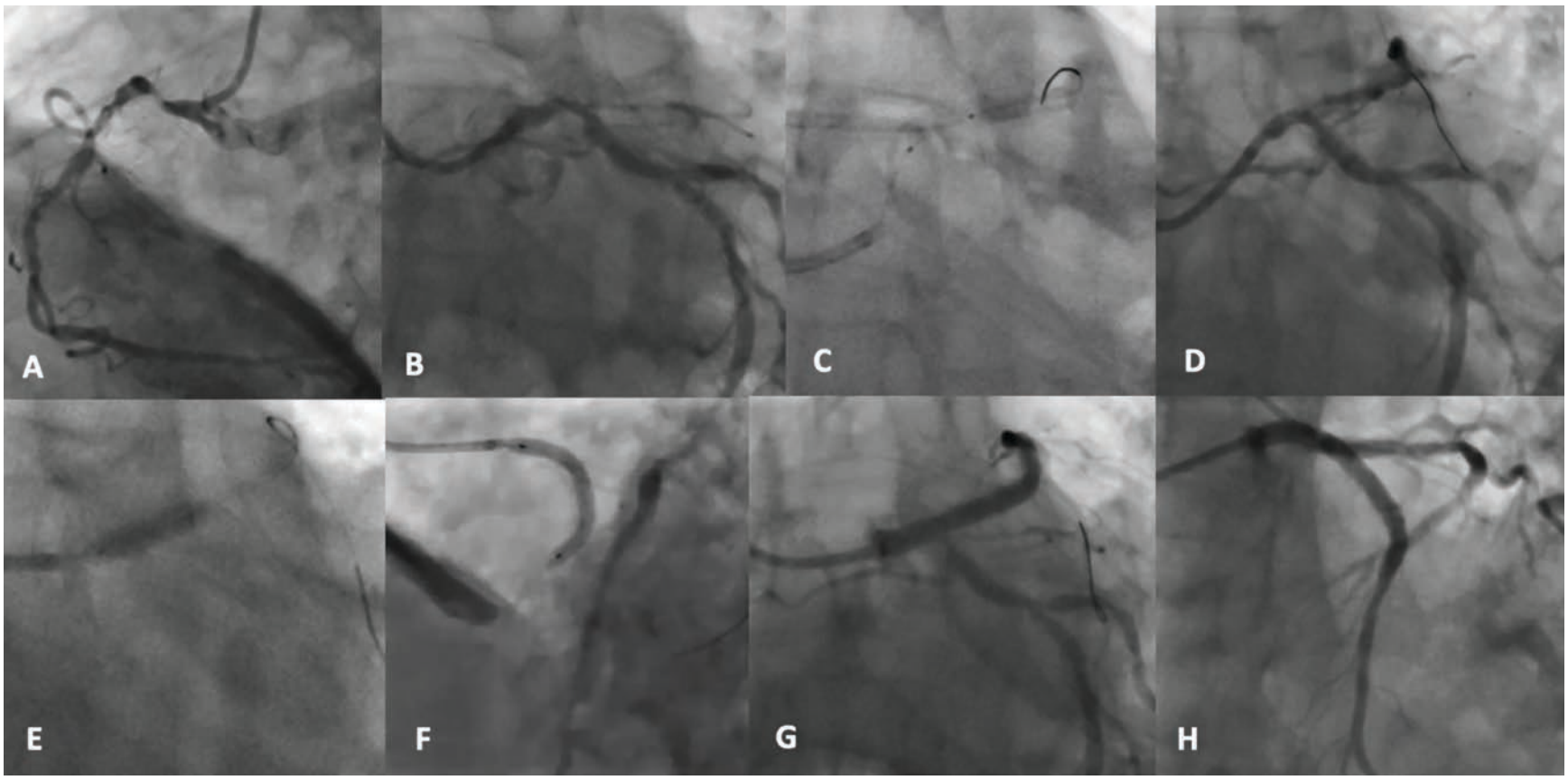

Figure 1A. Angiographic image panel. (A) Severe proximal right coronary artery, (B) moderate distal left main (LM), and circumflex disease with occluded ostial LAD. (C) A 2.0 semicompliant balloon not delivering, (D) reperfusion following a 1.1 mm Across chronic total occlusion (CTO) balloon (Acrostak) via guide extension catheter. (E) Inotrope-supported 4.0 intravascular lithotripsy catheter in the LM (20-30 pulses), (F) 3.5 mm x 48 mm Xience stent (Abbott Vascular) deployed. (G-H) Final result after post dilatation with 4.0 noncompliant balloon to the LAD and 5.0 noncompliant balloon using proximal optimization technique to the LM.

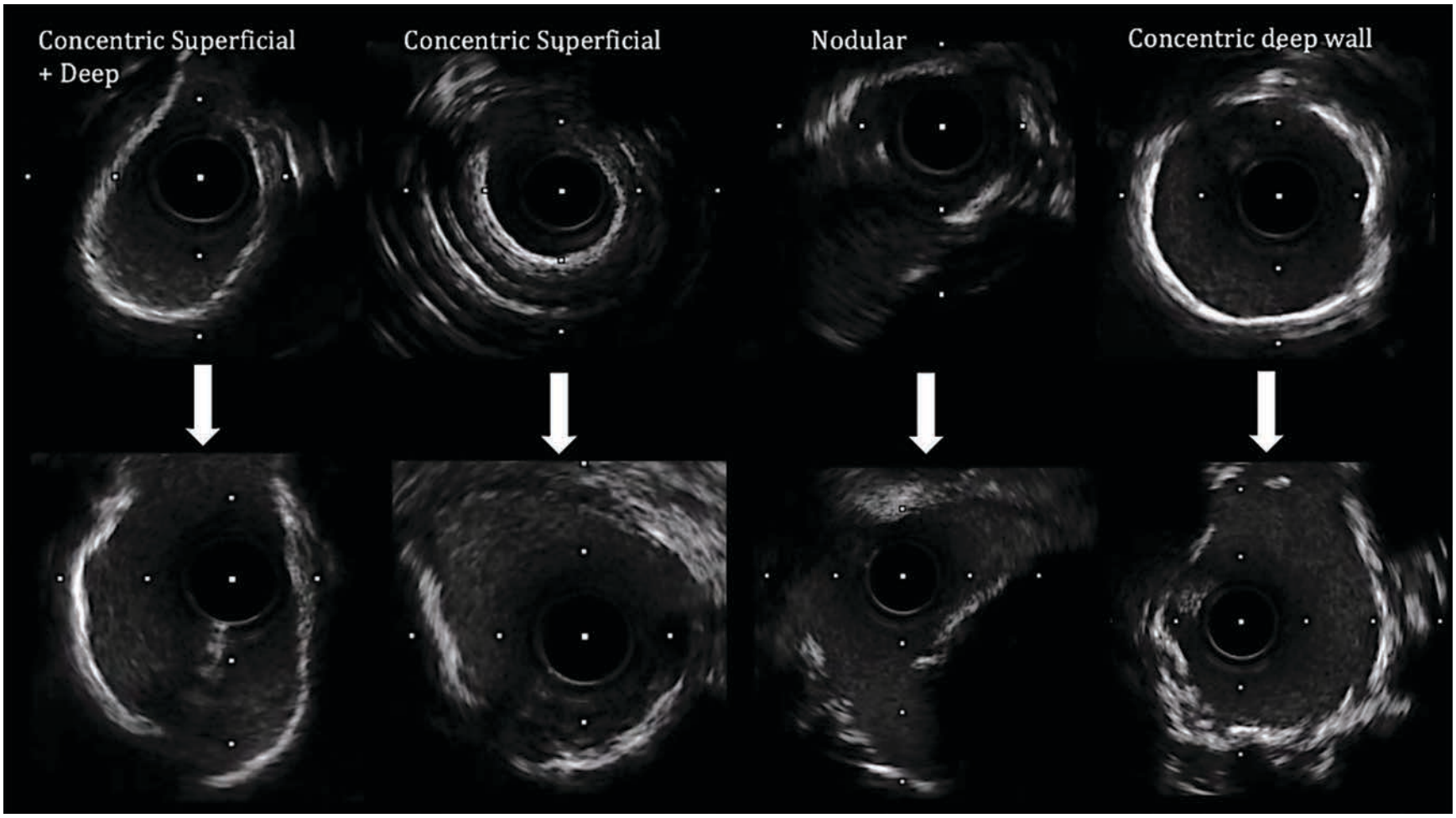

Figure 1B. Intravascular ultrasound image panel. (Top) Before and (bottom) after inotrope-supported calcium modification with 4.0 IVL balloon catheter (Shockwave Medical).

In order to understand how best to modify calcium, we need to appreciate its characteristics, severity, and how it might best respond — so for me, intravascular imaging is everything.

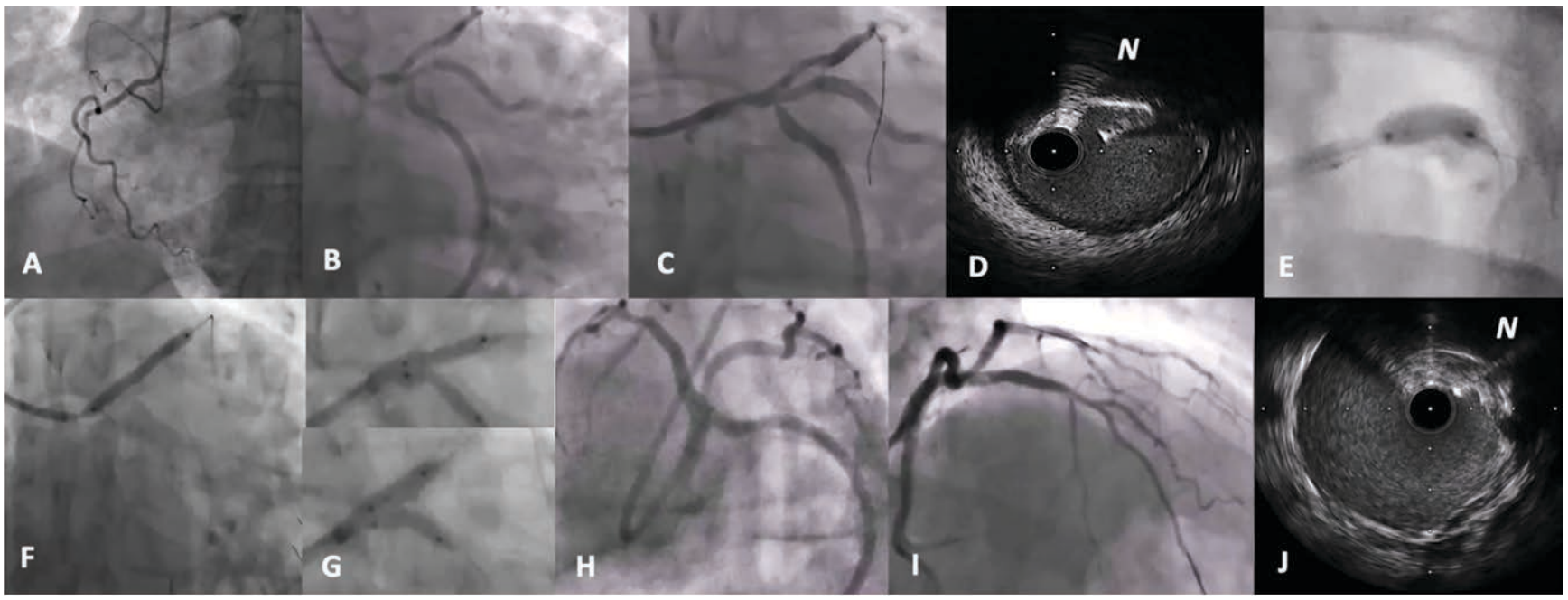

Figure 2. Nodular calcium modified with IVL in a left-dominant system with trifurcating left main (LM). This is a 60-year-old male who had ongoing chest pain, high risk non-ST elevation myocardial infarction (NSTEMI), with an electrocardiogram showing ST elevation in leads aVR/V1, and an ejection fraction of 35%-40%. (A) A recessive right coronary artery with (B) culprit trifurcating LM after (C) 2.5 semicompliant balloon pre-dilatation. Intravascular ultrasound (IVUS) showing nodular calcification, *N*, in a (D) large lumen 3 mm x 4 mm LM. (E) A 4.0 IVL balloon delivering 40 pulses supported by intravenous metaraminol. (F) A 3.5 mm x 38 mm Xience stent (Abbott Vascular) was deployed. (G) Sequential kissing balloon inflation after use of proximal optimization technique and challenging recross with aid of dual lumen microcatheter. (H-I) Final angiographic and (J) IVUS result, with eccentric expansion and a LM minimum stent area of 16 mm^2.

A knowledge of small profile and chronic total occlusion balloons, use of guide extension catheters, and not assuming upfront that we had to rotablate were all important to the successful use of IVL in this case.

important to the successful use of IVL in this case. I considered that if I could make some space with a small balloon, then with sequential pre-dilatation, we could create enough space to allow delivery of IVL as appropriate. Reestablishing some flow down the LAD automatically put us in a better position. If we hadn't been able to get that initial small balloon across with supportive techniques, this case would have required the use of rotational atherectomy (RA). A few factors swayed me to persist in the initial strategy, including that there was only TIMI-1 to 2 flow in the LAD, the patient being fluid overloaded with an oxygen requirement, and a very junior cath lab team with no real experience in RA. In STEMI, we know there is thrombus, embolization, no reflow, and microvascular obstruction (MVO). Whilst increasing age and increasing time from the onset of chest pain to vessel reperfusion exacerbate no-reflow, so too do atherectomy techniques. Here, we had an elderly, agitated, unstable patient — the aim was to open the occluded culprit vessel and get him off the table as quickly as possible!

Atherectomy takes time to set up and is most safely done with a team that is familiar with the technique. IVL in this setting was rapid and easy to set up with no additional skillset required. Of course, if we had needed to, we would have bailed out with RA, but the GEC and CTO balloon were a real game changer, allowing delivery and use of IVL to obtain a good stent result with TIMI-3 flow, safely and quickly in an emergency.

Are there additional benefits that IVL provided over other treatment modalities?

Yes, in addition to those already mentioned, there are a few that come to mind from clinical experience. First, IVL offers the operator full control — for example, when delivering pulses in the LM, if the hemodynamics start to become compromised, one can deflate the balloon immediately, allow the vessel to breathe, and the blood pressure to recover/reset. In my practice, I always trial a noncompliant balloon up in the LM prior to opening the IVL balloon. This allows an understanding of hemodynamic implications and potential strategy to pre-optimize (including use of inotropes to elevate baseline blood pressure). From experience, patients with preserved ejection fraction tolerate prolonged balloon inflation in the LM well, whilst those with severe left ventricular impairment or severe valvular disease with an impaired LV usually need some hemodynamic support and can suffer quite rapid decompensation. It is here anecdotally that Impella (Abiomed) can be very helpful, but in the U.K., access is restricted to clinical trials and via charitable funding, so in most units, we do not have that luxury.

Second, IVL is very helpful when treating vessels with a large lumen where severe calcium is present. We see this sometimes, where the lumen diameter may be 3 mm x 3 mm, bound by calcium in a vessel that is actually 5 mm. Here, a 2 mm RA burr is less likely to make an impact unless the wire bias is highly favorable, whilst IVL, if sized appropriately with imaging, we know will make contact with and modify the calcium in a more consistent and reliable manner (Figure 2). That doesn't mean to say atherectomy doesn't have a role: RA is crucial when you cannot cross a lesion or when there is significant intraluminal nodular calcium, where if wire bias is favorable and the lumen not too large, it can have a very good debulking effect. Not infrequently, both modalities can work synergistically to provide excellent modification and an optimal stent result. We are much earlier on the learning curve with orbital atherectomy (OA) in the U.K. than in the U.S., and I'm at the start of this journey, so have not had much personal experience yet with how OA may work to debulk nodular calcium in larger lumen vessels.

Lastly, a major benefit of IVL is preservation of side branch wires, particularly helpful during high-risk LM PCI, where, for example, side branch loss of a large circumflex where LV impairment is severe could be catastrophic or where challenging re-cross into the side branch due to angulation, calcium, or tortuosity is anticipated.

How do you determine the best technique for calcium modification in an individual case?

In order to understand how best to modify calcium, we need to appreciate its characteristics, severity, and how it might best respond — so for me, intravascular imaging is everything. If I can't cross a lesion, then typically, I will use RA and image afterward for decision-making around further adjunctive techniques. The benefits of intravascular imaging are multiple, including the ability to assess calcium arc, depth, and length, and demonstrate the presence of nodular calcium and the extent to which it encroaches on the vessel lumen, thereby allowing us to predict areas both at risk of stent underexpansion and areas at risk of nodular exit perforation with overzealous postdilatation if we chase concentric stent expansion. Imaging also tells us where the wire is located in relation to a nodule, whether the bias is favorable, and therefore, how likely we will be to make meaningful inroads into debulking with the use of atherectomy. The advent of IVL has, at least from my observations during fellowship and over the last few years in consultancy, led to increased intravascular imaging uptake as operators attempt to make sensible and informed decisions around choice of calcium modification strategy, and this can only be a positive thing.

How does calcium morphology or other lesion characteristics influence your selection of a calcium modification tool?

As noted, intravascular imaging is key here. Historically, I think atherectomy techniques have been favored for the ability to rapidly modify long segments of heavily calcific disease. However, the 120 pulses with the C^{2+} IVL catheter certainly allows for modification of equally long disease segments with ease. In very tortuous or highly angulated or retroflexed anatomy, where perhaps there is a slightly higher risk of burr shearing or vessel exit with atherectomy, as long as the IVL can be delivered (almost always possible with GEC support), it potentially carries a safety advantage.

How do you manage your pulses across lesions with heterogeneous calcium that includes concentric, eccentric, and nodular calcium?

In this case, 80 pulses in total were utilized to treat concentric, eccentric, and nodular calcium in the LM and LAD. I have had recent cases with very long, heavily calcified segments where all 120 pulses available with the C^{2+} catheter were utilized. The additional pulses have been helpful in moving us towards a strategy of complete vessel preparation. Intravascular imaging allows calcium detection and characterization, alongside identification of distal and proximal landing zones. The entirety of the planned stent segment can then be modified, focusing two-thirds to three-quarters of the pulses within the most heavily calcified areas, with the remainder of pulses less intensely delivered over areas of the vessel that are less calcified. Recent data from globally recognized imaging core labs have demonstrated that whilst modifying the areas of heaviest calcific disease does bring about a good result in these areas, ignoring seemingly less calcified areas can pose a problem in terms of downstream target lesion failure. Our stent failures won't necessarily come from where the most pulses were delivered, but rather from areas of the vessel that we underestimated and didn't optimally modify. The C^{2+} allows us to adopt a strategy of entire vessel preparation, in order to optimize overall stent result and minimize risk of downstream stent failure. As operators we have a common goal in ensuring we strive to get it right the first time, every time, for every patient. ■

Disclosure: Dr. Mahadevan reports she has received honoraria from Shockwave Medical.

Read the article online by scanning the QR code:

Dr. Kalaivani Mahadevan, MD
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CASE COMMENTARY

An Interview With Professor James C. Spratt, BSc, MB ChB, MD.

Professor Spratt, can you share your main take-away from Dr. Mahadevan's case?

This was a high stress case that underlined a major advantage of intravascular lithotripsy (IVL), which is that it is very safe and easy therapy to use. The learning curve with IVL is not steep. You can use IVL in a in a high-risk environment without having to learn on the spot or worrying about getting everything perfect for a new technique that you have only just read about. After a case, we ask, have I treated this patient safely? Have I treated this patient adequately? Here, IVL was the right technology for the right patient. The key fundamentals were correctly assessed: imaging was done in a systematic fashion with the goals of the case in mind and wasn't overcomplicated. From a patient perspective, if you were on that table, do you want somebody treating you with a technology that is difficult to use, and the physician might not get it right? Or do you want somebody to treat you with something that is easy to use, and they can't get it wrong? When patients come in to the cath lab very unwell, you don't want to make things more complicated. You want to keep it as easy as possible.

You mentioned safety as one important aspect of IVL treatment. What are the other benefits you consider when using IVL to modify coronary calcium?

We use IVL to modify coronary calcium with the goal of changing vascular compliance. When the calcium reaches a certain volume, the confluence of the calcium is what makes it important for vascular compliance. It's like a lake which freezes over in winter. At the start, when the lake is starting to freeze, there are bits of ice floating about in the lake. Each chunk of ice is still as stiff as the whole lake would be if it was frozen, but you don't walk on it, because the total compliance of the lake is still very low because of the water. When calcium becomes confluent, it forms plates, just like the ice in a lake, and that is when it adversely affects vascular compliance. When IVL fractures the calcium into little pieces, it doesn't change the compliance of each piece, but it does change the compliance of the artery.

We use IVL to fracture calcium, not only to improve vascular compliance, but also because the fractures lessen the volume of the calcium. The analogy is the jar full of stones. Is the jar full? It looks full, but you can add some pebbles and it fills up jar even more. Then you can add sand. So, if we fracture calcium from a single large piece into, say, 20 little pieces, then it will take up less volume. That is important because to be able to fully expand a stent, it requires reducing the volume of the plaque as well as improving vascular compliance.

Can you share some of your experience with the use of the C^{2+}?

The C^{2+} offers 40 extra pulses, so 50% more energy, but otherwise it is the same as the original C^2 catheter. Previously, we tended to focus on a very tight lesion and use up all of our pulses there. We now know how important it is to treat the entire vessel where you plan to implant a stent. With the additional pulses of the C^{2+}, we have been able to target noncritical calcium that would still affect stent expansion and therefore treat longer lesions.

What is your process when determining which modality is most appropriate for calcium modification?

We use intravascular imaging to characterize the morphology of the calcium and then we have an algorithm that helps us determine the treatment (Figure).

What do you recommend for an operator who may be considering the use of IVL for coronary calcium modification?

Learn the basics of plaque biology: why calcium matters and how you can treat it successfully with IVL. Understand the basics of acoustic therapy with IVL and how to optimize its efficacy. ■

Disclosure: Professor James Spratt reports he is a consultant for Shockwave Medical.

Read the article online by scanning the QR code:

Professor James C. Spratt, BSc, MB ChB, MD

St George's University Hospitals NHS Foundation Trust; The University of Manchester; London, United Kingdom

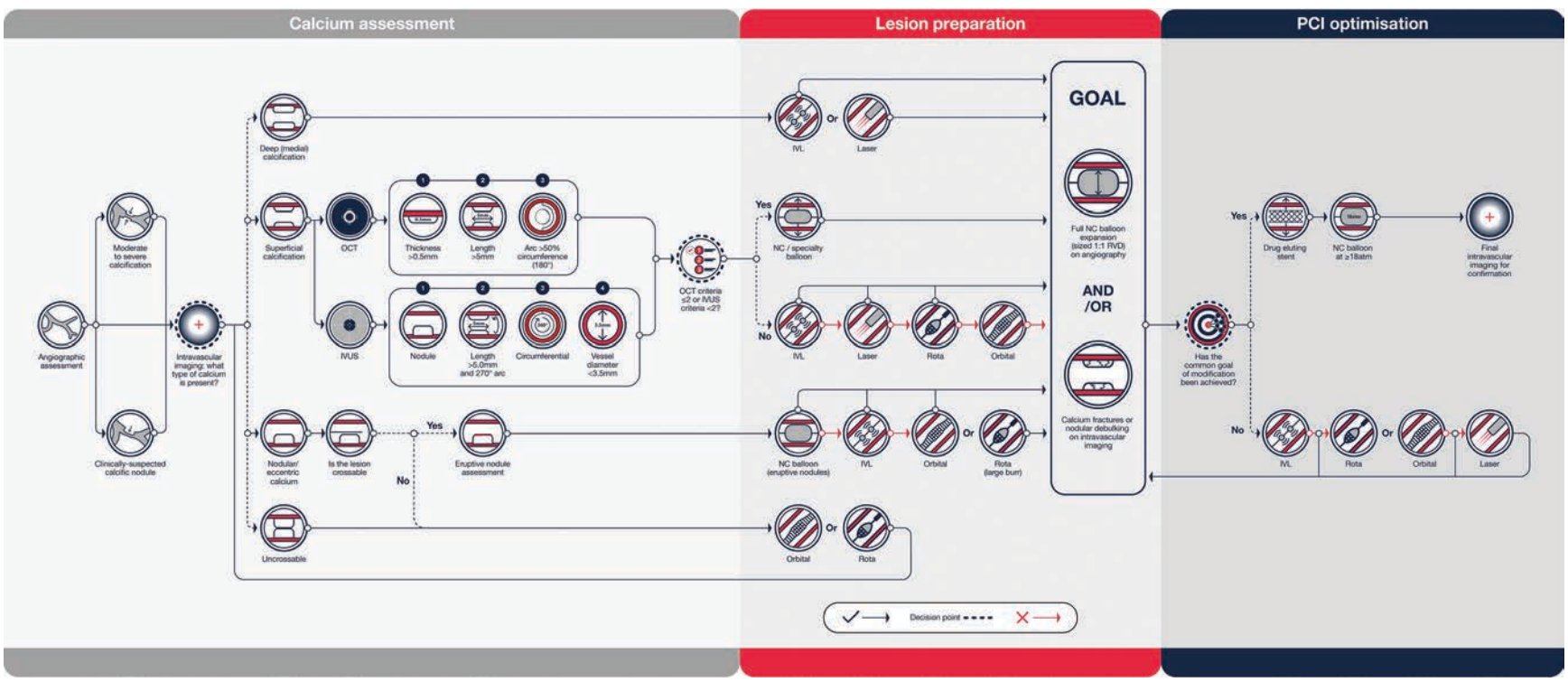
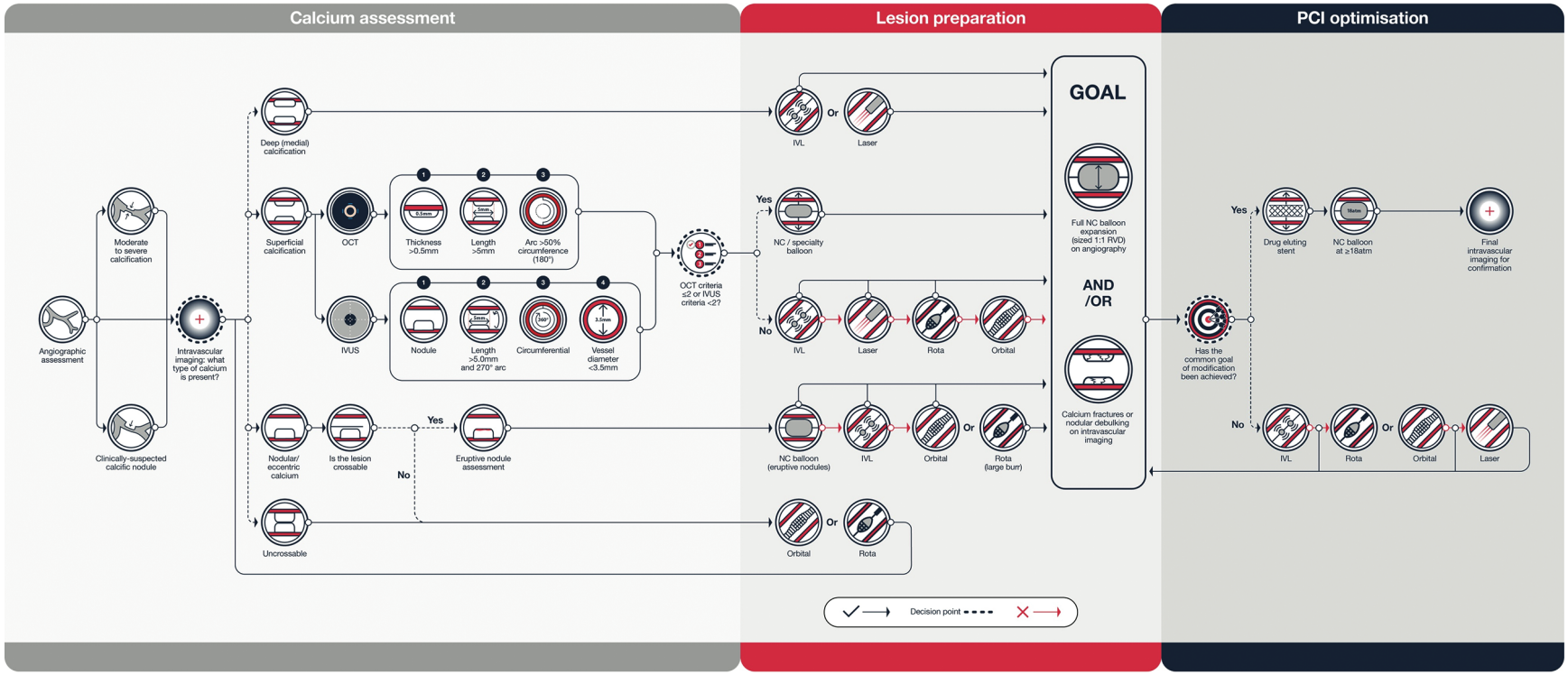


Figure. Full Calcium algorithm (see online article for downloadable PDF). ***Reprinted with permission from Optima.***


Calcium assessment
Lesion preparation
PCI optimisation
Angiographic assessment
Moderate to severe calcification
Clinically-suspected calcific nodule
Intravascular imaging: what type of calcium is present?
Deep (medial) calcification
Superficial calcification
OCT
Thickness >0.5mm
Length >5mm
Arc >50% circumference (180°)
IVUS
Nodule
Length >5.0mm and 270° arc
Circumferential
Vessel diameter <3.5mm
OCT criteria ≤2 or IVUS criteria <2?
Nodular/ eccentric calcium
Is the lesion crossable
Yes
No
Eruptive nodule assessment
Uncrossable
IVL
Or
Laser
Yes
NC / specialty balloon
No
IVL
Laser
Rota
Orbital
NC balloon (eruptive nodules)
IVL
Orbital
Or
Rota (large burr)
Orbital
Or
Rota
GOAL
Full NC balloon expansion (sized 1:1 RVD) on angiography
AND /OR
Calcium fractures or nodular debulking on intravascular imaging
Has the common goal of modification been achieved?
Yes
Drug eluting stent
NC balloon at ≥18atm
Final intravascular imaging for confirmation
No
IVL
Rota
Or
Orbital
Laser
Decision point