

EuroPCR 2021

EDITOR'S PICK

A New Approach to Percutaneously Treat Chronic Coronary Total Occlusions: The 'Minimalistic Hybrid Approach' Algorithm

INTERVIEWS

Interviews with Ankur Kalra and Kendra Grubb



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Welcome

Dear Readers,

Welcome to the latest issue of *EMJ Interventional Cardiology*, an eJournal dedicated to championing the latest advancements in this discipline. Despite the cancellation of last year's congress due to the COVID-19 pandemic, this year we were delighted to attend EuroPCR 2021 virtually. Our eJournal shares the most important developments in interventional cardiology through interviews and peer-reviewed articles from experts within the field, alongside a congress review presenting highlights from the 31st EuroPCR congress.

This year's congress delivered 120 hours of expert-led sessions and 10,000 videos on demand. Summaries of key abstracts presented at the congress are included in this issue, written by the presenters themselves and covering topics such as the short-term outcomes of periprocedural myocardial infarction following cardiac surgery, computational fluid dynamic used to evaluate the haemodynamic significance of a coronary stenosis, and many more.

This year's issue of *EMJ Interventional Cardiology* contains compelling peer-reviewed articles discussing the latest developments in the field. Our Editor's Pick by Vescovo et al. discusses a minimalistic approach to percutaneously treat chronic coronary total occlusions. James et al.

present a rare case report of right ventricular obstructing myxoma. Another interesting case report shared by Jariwala et al. explores a fatal cardiovascular collapse during trans-aortic transcatheter aortic valve replacement following intra-procedural retrograde transcatheter heart valve migration into the left ventricular outflow tract.

For this issue, we were delighted to interview Ankur Kalra and Kendra Grubb who walk us through their personal research interests and the impact of the ongoing COVID-19 pandemic for the field. We also had the wonderful opportunity to speak with PCR Chairman William Wijns and Bernard Prendergast, Course Director of PCR London Valves, about their respective roles within the society.

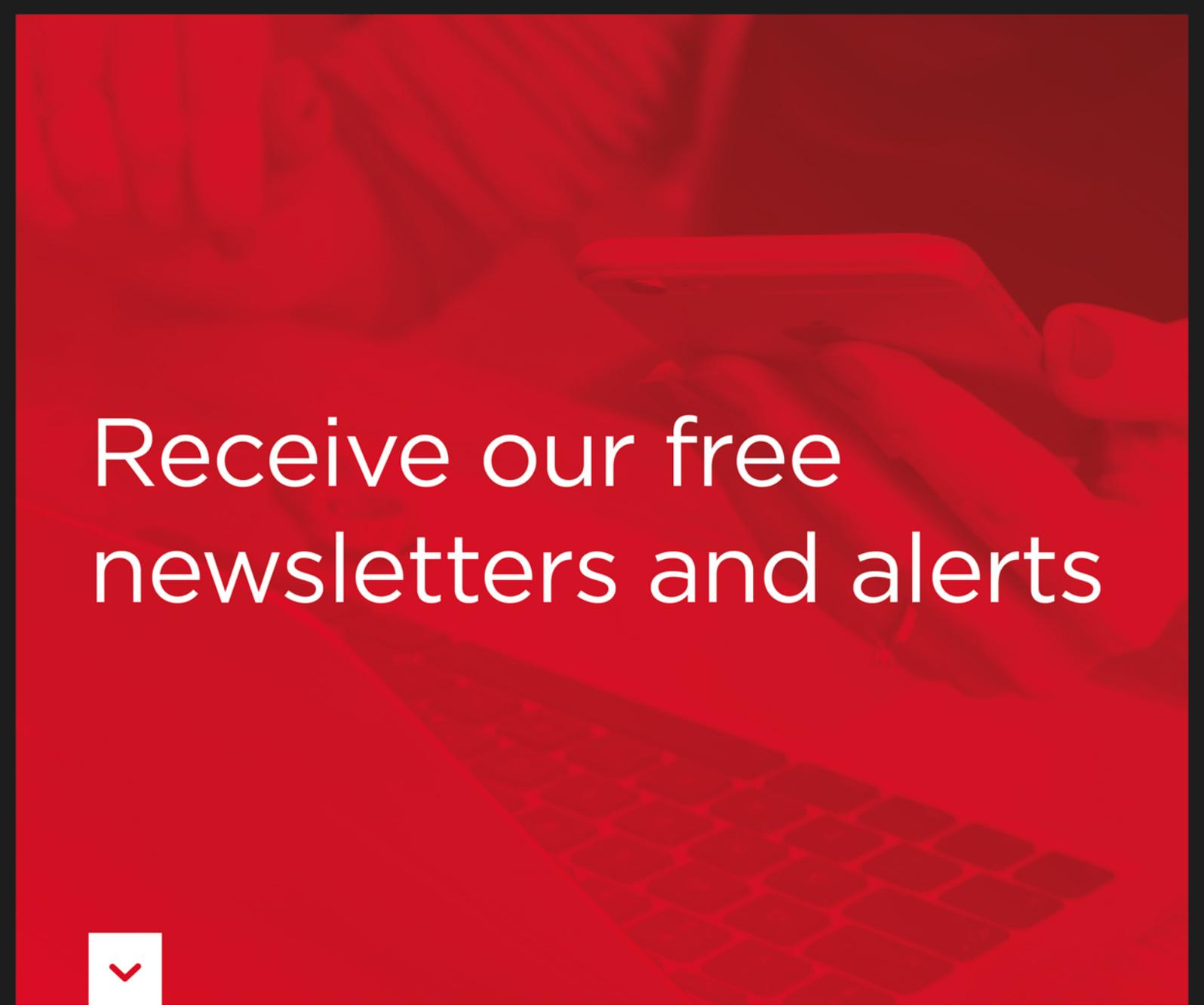
I would like to share my gratitude for the Editorial Board, authors, peer reviewers, and editorial team, without whom we could not publish such high-quality content. Finally, I would like to thank you, the readers, and we hope that you enjoy this latest issue of our *EMJ Interventional Cardiology* eJournal.



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Foreword

Dear Readers,

Previous issues of *EMJ Interventional Cardiology* have published the most up-to-date developments in the speciality. Despite the widespread disruption caused by the coronavirus disease (COVID-19) pandemic, the latest publication is no exception, and stays faithful to our goal of disseminating expertly written, peer-reviewed articles and case reports.

The Editor's Pick for this publication is the manuscript by Vescovo et al. 'A New Approach to Percutaneously Treat Chronic Coronary Total Occlusions: The 'Minimalistic Hybrid Approach' Algorithm.' This strategy aims to limit the routine use of large-bore catheters, double access, and adoption of trans-femoral approaches, and may represent a valid alternative to the classic hybrid algorithm. Indeed, retrospective and prospective single-centre studies showed that this procedure reduced the risk of vascular complications without compromising efficacy. However, the authors highlight the need for further large-scale, multicentre trials to confirm these preliminary findings and assess the reproducibility of the novel algorithm by other operators.

Abstract summaries from EuroPCR 2021, held for the first time as a digital congress, are also contained within these pages and not to be missed. These feature alongside exclusive interviews with two leading PCR committee members: Prof William Wijns and Prof Bernard Prendergast. For those who missed the congress and wish to read the highlights, or simply want to be reminded of the great success of the 31st edition of EuroPCR, the congress review is highly recommended. This features late-breaking press releases from the congress on the non-inferiority of bioresorbable vascular scaffolds relative to metallic drug-eluting stents, as well as an evaluation of systemic mild hypothermia as an adjunctive therapy to primary percutaneous coronary intervention in patients with anterior ST-segment elevation myocardial infarction. Also included in the review of EuroPCR are two compelling in-house features based on congress sessions.

Colleagues, I hope that the 2021 issue of *EMJ Interventional Cardiology* will help to enhance your knowledge and that you are keeping safe during these unprecedented times. I would like to thank all the authors, contributors, and peer reviewers for devoting time to this eJournal, and look forward to receiving more high-quality submissions from you in the future.



A handwritten signature in black ink, appearing to read 'N. Kipshidze' with a stylized flourish at the end.

Dr Nicholas Kipshidze

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Congress Review

Review of EuroPCR 2021

Location:	EuroPCR 2021
Date:	18 th -20 th May 2021
Citation:	EMJ Int Cardiol. 2021;9[1]:11-18. Congress Review.

ICONIC Parisian landmarks such as the Eiffel Tower and Arc de Triomphe were a sorely missed backdrop for this year's annual meeting of EuroPCR, the first to be held entirely online. Although attendees at the 31st iteration of this world-leading congress in interventional cardiovascular medicine were unable to stroll the city's famous boulevards and take in the beauty of the River Seine, the sense of community and collaboration, so typical of previous events, was not diminished. This was underscored by William Wijns, Chairman of EuroPCR, addressing the audience during the Opening Ceremony: "Welcome to PCR. Welcome home." A similar sentiment was echoed by PCR Vice-Chairman Jean Fajadet: "Hello companions. So happy to meet you again this particular year, and to share with you this new, innovative format of EuroPCR 2021."

While delivering the inaugural session, Wijns surmised: "We have decided to transform the obligation of digital into an opportunity. In many ways, as a result, I think EuroPCR

is bigger than it was in previous years." Indeed, at the end of the exceptional 3-day event, over 8,000 healthcare professionals had connected to the digital platform for between 45 minutes and 30 hours each. In addition, more than 4,000 questions and contributions were received via the chat functions. Clearly, the transition to a virtual course allowed for greater global participation and fostered a collegiate atmosphere, crucial in enabling PCR to "serve the needs of each individual patient by helping the cardiovascular community to share knowledge, experience, and practice."

Wijns used the welcome address as an opportunity to highlight the We CARE advocacy scheme: "Fear of COVID-19 is keeping 40% of heart patients with severe disease, such as critical aortic stenosis and acute infarction, away from their doctors. The situation is getting worse when hospital administrators or healthcare authorities are deciding to shut down cardiovascular care all over."

"In total, EuroPCR 2021 broadcast 120 hours of programmes, without counting the 10,000 videos on demand."



For this reason, PCR and Stent – Save a Life! launched a joint initiative, akin to previous efforts led by cancer research organisations, to restore patients' faith in pursuing timely medical care. Fajadet also took a moment to address the ongoing spread of COVID-19: "We are with all of you in the spirit, and we are notably very concerned for you in India and Brazil, particularly. I know I speak, and we speak, for the world community when I say that we send you our best wishes from our hearts."

In total, EuroPCR 2021 broadcast 120 hours of programmes, without counting the 10,000 videos on demand. Presentations spanned across the speciality and included superficial femoral artery and popliteal interventions, the treatment of coronary artery disease in patients undergoing transcatheter aortic valve implantation, the double-kissing-crush stenting technique for bifurcation percutaneous coronary intervention, transcatheter mitral valve replacement and repair, revascularisation for chronic coronary syndrome and multi-vessel disease, and a review of the current status of renal denervation techniques for the treatment of hypertension.

Media engagement remained strong over the course of the congress, with over 41 million impressions across social platforms using the hashtag "#EuroPCR" alone. In particular, late-breaking trials on the topics of bioresorbable vascular scaffolds, the safety and effectiveness of systemic mild hypothermia as an adjunctive therapy to primary percutaneous coronary

intervention in ST-segment elevation myocardial infarction, and the potential role of elective revascularisation plus medical therapy to reduce cardiac death attracted much attention.

The 2021 Andreas Grüntzig Ethica Award was presented to Marie-Calude Morice, Cardiovascular Institute Paris Sud, Massy, France, in recognition of her contribution to clinical research, education, and training in interventional cardiology. Morice was chosen as the recipient of this year's award for visionary contributions to the field, including identifying an 'orphan' group of patients with high bleeding risk and establishing the boundaries of targeted antiplatelet therapy to reduce bleeding without enhancing ischaemic risk.

EuroPCR adapted to these unprecedented circumstances in a truly spectacular fashion by completely rethinking and rebuilding its 2021 congress. In the Closing Ceremony, Fajadet emphasised: "EuroPCR has been, this year, really an important step. I am convinced that there will be a before and an after EuroPCR 2021 in terms of format, in terms of global reach, and engagement of the community. The participants this year were more engaged and more active compared to the previous year, particularly what we saw on the chat." Despite the virtual nature of this year's annual meeting, attendees were, in many ways, more together than ever at EuroPCR 2021. The following studies were presented as press releases at EuroPCR 2021 on 18th–20th May 2021. ■

The FUTURE-II Trial and Implications for Bioresorbable Vascular Scaffolds

RESULTS from the FUTURE-II study, a randomised clinical trial comparing the safety and efficacy of a thin-strut bioresorbable scaffold (BRS) to an everolimus-eluting cobalt-chromium stent (EES), could reignite interest in the use of BRS technology.

The first studies to investigate the use of BRS in percutaneous coronary interventions revealed that such devices could overcome several of the drawbacks associated with metallic drug-eluting stents, including impaired vasomotion. Through the resorption process, BRS were shown to provide a restoration of vascular physiology, which was especially beneficial in the treatment of diffuse coronary artery disease. However, subsequent large-scale randomised trials and meta-analyses noted that polylactic acid-based BRS exhibited a higher rate of target-lesion revascularisation, especially scaffold thrombosis, compared with metallic drug-eluting stents. Consequently, BRS produced from polylactic acid were withdrawn from the market.

Despite this, there is still the need for BRS, which allow for vascular restoration therapy, in the treatment of coronary lesions. Therefore, the FUTURE-II trial aimed to demonstrate the non-inferiority of a newer-generation BRS relative to an EES, with research findings presented by Bo Xu, Fu Wai Hospital, National Center for

Cardiovascular Diseases, Chinese Academy of Medical Sciences, Beijing, China, at the late-breaking trials session of EuroPCR 2021.

The study, which enrolled 433 patients with *de novo* obstructive coronary artery disease across 28 Chinese centres between 2017 and 2019, succeeded in showing that BRS was non-inferior to EES for the primary surrogate endpoint of angiographic late lumen loss at 1 year (0.17 ± 0.27 and 0.19 ± 0.37 mm, respectively; $p_{\text{non-inferiority}} < 0.0001$). The major secondary endpoint of 1-year proportion of covered struts by optimal coherence tomography, which was evaluated in a subgroup of 80 patients, was also found to be similar in the BRS and EES group (99.3% versus 98.8%, respectively; $p_{\text{non-inferiority}} < 0.0001$). Lastly, the FUTURE-II trial investigators concluded that there was no statistical difference in terms of target lesion failure between groups, with a very low rate of events (1.9% and 3.3%, respectively; $p = 0.37$) and no definite or probable device thrombosis.

Going forward, this study has the potential to revitalise the concept of a polylactic acid-based BRS and promote the design of new pivotal trials using this second-generation bioabsorbable device, with a focus on improving physical and mechanical properties. ■

"This study has the potential to revitalise the concept of a polylactic acid-based BRS and promote the design of new pivotal trials using this second-generation bioabsorbable device"





"This meta-analysis indicates the benefits of combined elective revascularisation and enhanced medical therapy are complementary"

Cardiac Death Rates Reduced with Combined Revascularisation and Medical Therapy

ELECTIVE cardiac revascularisation and medical therapy are key interventions for the reduction of cardiac death, states a recently developed meta-analysis presented at EuroPCR 2021. Despite the ISCHEMIA randomised clinical trial finding no outstanding contrast between invasive and conservative approaches in patients with chronic coronary syndromes, the cumulative difference in the estimates of cardiac death was notable. Cardiac mortality rates and long-term follow-up were not key influences in the ISCHEMIA trial, however the invasive strategy proved favourable in reducing cardiac death 0.3% at 2 years and 1.3% at 5 years.

Eliano Navarese and team presented results of the meta-analysis that involved a total of 19,806 patients diagnosed with chronic coronary syndromes undergoing elective revascularisation, from 25 randomised trials with the longest available follow-up. The results showed a remarkable 21% risk reduction in cardiac death with revascularisation combined with medical therapy (risk ratio: 0.79; 95% confidence interval:

0.67-0.93; $p < 0.01$), with no major fluctuation across the selected trials. Spontaneous myocardial infarction following the combined medical therapy and revascularisation within the study showed a consequential reduction (risk ratio: 0.74; 95% confidence interval: 0.64-0.86; $p < 0.01$). A meta-regression of this study revealed an interrelation between the reduction in both cardiac death and spontaneous myocardial infarction following the combined strategies.

Additionally, the meta-analysis results showed that within each 4-year increase in the length of follow-up in the available studies, the risk of cardiac death decreased by 19%. A follow-up analysis showed that additional future trials would not contradict the benefit of combined revascularisation and medical therapy on cardiac death. In conclusion, this meta-analysis indicates the benefits of combined elective revascularisation and enhanced medical therapy are complementary and are essential to achieving optimal and long-term prevention of adverse events such as cardiac death. ■

True Bifurcation Distal Left Main Disease: Single-Stent or Double-Stent Strategy?

PROVISIONAL single-stent versus upfront double-stenting strategy clinical outcomes in 467 patients with true bifurcation distal left main disease, of the EBC MAIN trial, were presented at EuroPCR 2021. This is the second randomised clinical study to address a similar research question; the first was the DKCRUSH-V trial, which indicated better end results with an upfront two-stent strategy: the double-kissing-crush technique. The previous 2018 guideline recommendations from the European Society of Cardiology (ESC) were largely based on the results of single randomised study, the DKCRUSH-V trial; the EBC MAIN trial adds important data for the evolution of this guideline recommendation and clinical practice.

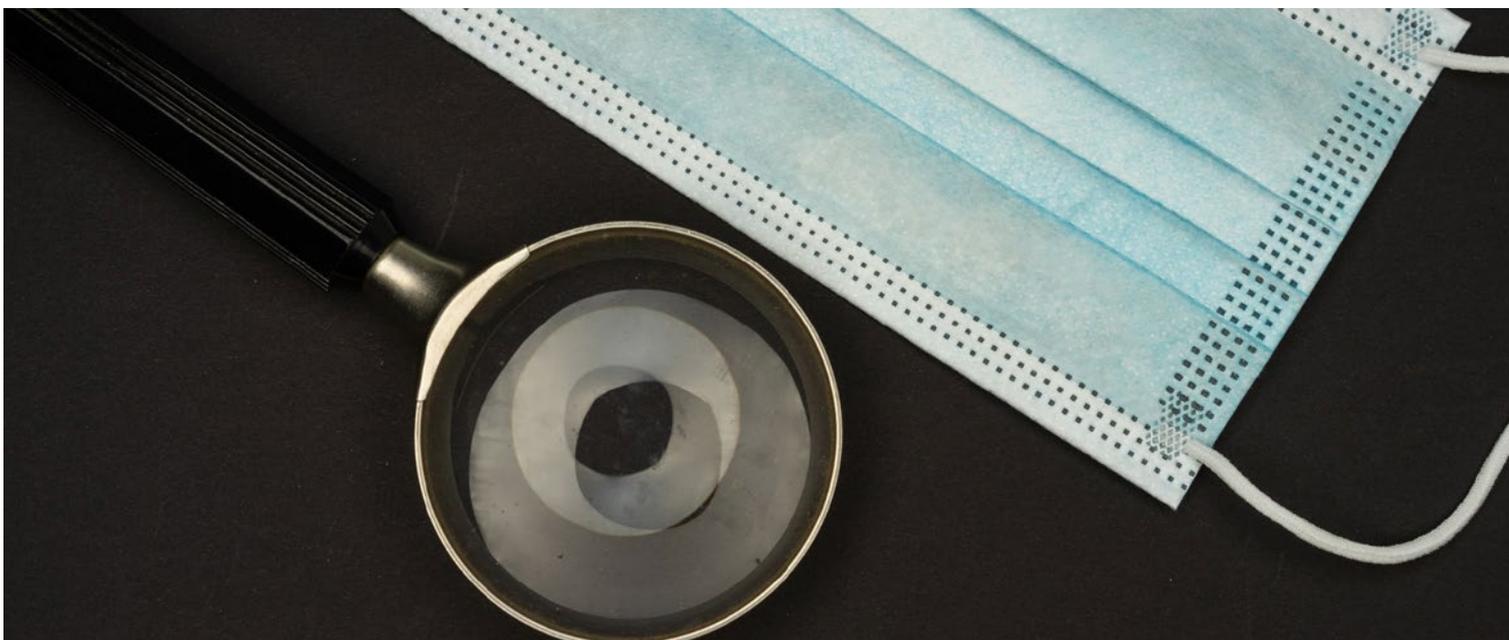
The EBC MAIN trial focused on two main characteristics in the methodology, which should be considered to ensure accurate interpretation of the results. Firstly, all the patients involved in the study had left anterior descending artery and

circumflex artery affected by significant disease, confirmed via angiography. Secondly, EBC MAIN did not compare the implantation of one versus two stents; instead, the study compared a provisional single-stent strategy to an upfront assignment to the two-stent technique. There

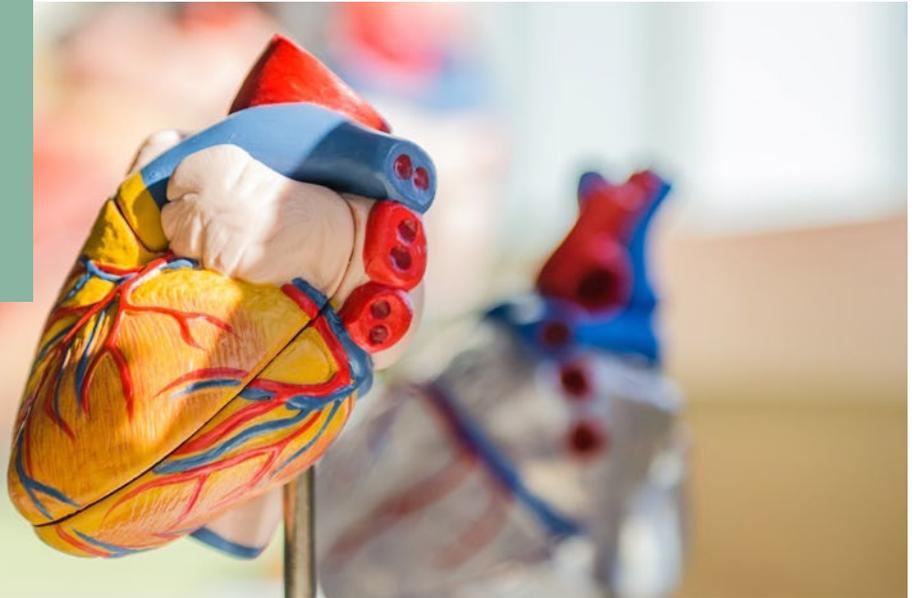
was no clear distinction in the studied clinical outcomes between the provisional single stenting and the upfront use of two-stent technique. Furthermore, 22% of patients from the trial who were initially scheduled for a single-stent treatment eventually underwent the two-stent treatment.

The primary outcome for the trial, 1-year death, myocardial infarction, and target lesion revascularisation, occurred at a rate of 14.7% in the provisional group versus 17.7% in the upfront two-stent group (hazard ratio: 0.8; 95% confidence interval: 0.5 -1.3). The rates of stent thrombosis were 1.7% and 1.3% in patients treated with provisional single stent and upfront double stenting, respectively. ■

"The overall findings of the EBC MAIN trial may suggest that even in true left main bifurcations, the single-stenting strategy does not have adverse 1-year outcomes compared with an upfront two-stent technique."



"The results of the interim analysis [...] showed significant differences among the treatment groups, which justified the trial's early discontinuation."



Results from the COOL AMI EU Trial Following Interim Analysis After Trial Discontinuation

THE FINAL results from the pivotal Phase II randomised controlled trial Cool AMI EU, evaluating the safety and effectiveness of systemic therapeutic hypothermia as an adjunctive therapy in anterior ST-segment elevation myocardial infarction (STEMI) undergoing percutaneous coronary intervention (PCI) in comparison to PCI alone, have now been published after the trial was discontinued following an interim analysis. The results of the interim analysis, which was performed after 12 months in the first 111 patients (58 treatment arm, 52 controls), showed significant differences among the treatment groups, which justified the trial's early discontinuation.

In animal models, infarct size has shown to decrease when therapeutic mild systemic hypothermia is achieved before infarct-related vessel reperfusion; despite promising results in the initial *in vivo* model and in the early presenters with anterior STEMI, various earlier randomised controlled trials reported neutral effects.

The primary efficacy endpoint of the trial was a 20% relative decrease in mean anterior myocardial infarct size, which was established from a cardiac MRI at days 4–6 post-infarct in the cooling plus PCI. The secondary safety endpoint was established as the combination of myocardial infarction,

cardiac death, and clinically indicated target lesion revascularisation at 30 days follow-up.

Marko Noc, University Medical Centre of Ljubljana, Slovenia, presented the interim analysis results at the late-breaking trial sessions of EuroPCR, which showed significant differences between the two groups; there was longer randomisation-to-balloon time (61 ± 21 versus 32 ± 18 min; $p < 0.001$) and total ischaemic time (232 ± 63 versus 188 ± 64 min; $p < 0.001$) in the treatment arm, with similar delays in onset-to-randomisation, the delays of which possibly related to impact on outcomes and not to cooling manoeuvres. Neither the primary nor secondary endpoints saw significant differences between the two groups. The treatment arm saw a significant increase in the incidence of two specified serious adverse events per protocol (cardiogenic shock: $n=6$ [10.3%] versus $n=0$ [0%]; $p=0.028$; and new-onset paroxysmal atrial fibrillation: $n=25$ [43.1%] versus 2 [3.8%]; $p < 0.001$).

The early discontinuation of the trial limits any statistical power in regard to safety and efficacy in patients with anterior STEMI. While the trial will aid in the design of future clinical trials assessing the effects of systemic hypothermia, more evidence and data will need to be collected to support its adoption. ■

Does Imaging Guidance Cancel Out Differences in Target Lesion Failure?

MECHANISMS underpinning a potential difference in target lesion failure (TLF) between ultra-thin strut biodegradable polymer sirolimus-eluting stents (BP-SES) and durable polymer everolimus-eluting stents (DP-EES) are unknown. The randomised, multicentre CASTLE study aimed to assess the role played by imaging-guided percutaneous cardiac intervention (PCI) in this difference in clinical outcomes, with findings shared at EuroPCR 2021, 18th–20th May 2021.

Randomised controlled trials of BP-SES have had mixed results, and the variation in trial findings may be related to the use of intracoronary imaging. These stents, which have ultra-thin struts (60 µm) and biodegradable polymer, potentially have reduced vessel inflammation and thrombogenicity compared to DP-EES, however clinical trials have shared mixed findings for TLF rates, with some studies showing lower risk of TLF with BP-SES and other studies having neutral results.

A non-inferiority clinical trial in Japan used an investigator-initiated, single-blinded, randomised approach across 69 centres to assess for the role of imaging-guided PCI. This CASTLE study included patients with acute and

chronic coronary syndromes, randomised 1:1 to receive BP-SES (intervention group) or DP-EES (control group) PCI with imaging guidance via intravascular ultrasound or optical coherence tomography. The study involved 12-month follow-up to assess for the primary outcome of TLF, including cardiovascular death, target-vessel myocardial infarction, and clinically driven target lesion revascularisation, with a pre-specified non-inferiority margin of 3.3%.

After approximately 70% of follow-ups were completed, interim results were shared; for the 1,440 patients (BP-SES: 722; DP-EES: 718), there was no significant difference in TLF between the two groups (hazard ratio: 0.59; 95% confidence interval: 0.26–1.36). The dataset included mainly chronic coronary syndromes (85%), with most stent diameters ≤3 mm (66%), and imaging guidance performed in at least 97.5% of cases. There was no significant difference in TLF at 30-day follow-up or at the primary endpoint of 12 months.

Whilst complete follow-up and final results are still outstanding, these interim insights suggest that performing PCI under intracoronary imaging guidance may yield similar clinical outcomes for both BP-SES and DP-EES. ■



"Performing PCI under intracoronary imaging guidance may yield similar clinical outcomes for both BP-SES and DP-EES."

Comparing TAVI and Valve Replacement in Patients with Severe Aortic Stenosis

SCRUTINISING the results of the Evolut Low-Risk trial 2 years on has demonstrated that transcatheter aortic valve implantation (TAVI) may be an effective and less-invasive alternative to surgical aortic valve replacement.

For high-risk patients with severe aortic stenosis, TAVI has proven the superior treatment, but it remains to be seen how helpful it may be for groups with low-risk complications from surgery. The study is expected to change practice to encourage TAVI with a self-expanding supra-annular bioprosthesis, as a result of favourably interpreting the data for the primary outcome of death or disabling stroke.

"The study is expected to change practice to encourage TAVI with a self-expanding supra-annular bioprosthesis"

The trial was of randomised and non-inferiority design, comparing TAVI using self-expanding supra-annular bioprosthesis against surgical aortic valve replacement. Patients included in the study had severe aortic stenosis and a 30-day

surgical mortality risk <3%, for a cohort of 1,414. The endpoint outcomes were a composite of death or disabling stroke at 24 months.

The ratio of TAVI to surgery treatments was 730:684 and it was reported that TAVI exhibited superiority for valve haemodynamics and prosthesis-patient mismatch; however, surgery was the better alternative for pacemaker implantation and mild paravalvular leak. In a landmark analysis from 12–24 months, the primary outcome occurred in 1.9% of TAVI and 2.1% of the surgical groups, indicating no adverse catch-up phenomenon in the TAVI therapy group.

Limits exist in the present study: the data do not consider the contemporary cusp-overlay implantation technique used in TAVI that significantly reduces conduction disturbance and need for subsequent pacemaker. Future directives should focus on evaluating differences in impact upon patient outcomes, ideally tracking over a 10-year period.

This study was presented as part of a press release from EuroPCR on 18th May 2021, 'PCR STATEMENT on the 2-year clinical outcomes from the Evolut low-risk trial,' put forward by John Forrest. ■



A Virtual Live Case of Bi/Trifurcation Percutaneous Coronary Intervention of the Left Main

Louise Rogers
Editorial Assistant

Citation: EMJ Int Cardiol. 2021;9[1]:19-21.



On Day 2 of EuroPCR 2021, discussants from around the world took to their screens to join Jean Fajadet, PCR Vice-Chairman, and his panel, live from their studio in Paris, France. The aim was to understand how to adapt treatment strategy to the underlying anatomy in a case of left main bifurcation percutaneous coronary intervention.

THE CASE

The session began with a description of the case of a non-diabetic male patient with a history of a percutaneous coronary intervention to re-open a chronic total occlusion of the proximal mid-left anterior descending artery (LAD). In 2018, the patient presented with angina and a positive stress test at the Institute Cardiovasculaire Paris Sud, Massy, France. A coronary CT angiogram (CCTA) from 2018 displayed a lesion on the left main, a large circumflex artery, and obtuse marginal (OM) branch. The LAD was patent and there was an occlusion at the origin of the major septal branch. The team in Massy observed collateral flow from the dominant triconary artery with a distal LAD and second diagonal branch. The team performed the chronic total occlusion with two wires: one in the LAD and one in the diagonal branch. The operation was a success.

The patient recently presented again as symptomatic with recurrent angina and a positive stress test. On evaluation with a non-invasive CT an open, patent, dominant right coronary artery was visible, with no plaque present on the mid-segment and no critical stenosis. On the left, the OM branch appeared patent with slight black calcified plaque. The left main was severely diseased, with an eccentric lesion and an LAD with patent stent on the proximal mid-LAD. Immediately, it was noted that what they were viewing was a trifurcation of the left main and the lesion was distal, taking an origin from the LAD and circumflex artery. The most recent laboratory results came back normal and the patient is currently on dual antiplatelet therapy, β -blockers, calcium antagonists, and statin therapy. The most recent CCTA, presented to the EuroPCR audience, showed a short, discreet, distal left main lesion involving the large LAD, which was

"The aim was to understand how to adapt treatment strategy to the underlying anatomy in a case of left main bifurcation percutaneous coronary intervention."

totally patent, and a large circumflex artery. The fractional flow reserve, performed in the distal LAD, came back positive (0.78) and the patient's SYNTAX score was 21.

THE DISCUSSION

The task of the panellists was to discuss what their approach would be to such a case of a trifurcation. Fajadet began by addressing cardiac surgeon Thomas Modine, Centre Hospitalier Universitaire de Bordeaux, Bordeaux, France, to ask how he would handle this particular case at his centre. The case, in Modine's opinion, perfectly illustrated the need for communication between cardiologists and cardiac surgeons. Recurrence of angina is a potential outcome regardless of how effective the first treatment or surgery was,

given the evolutionary nature of the disease. Due to the success of the first surgery, the patient's good quality arteries, and the patient's age, he believed future surgery to be very possible. He concluded that the case was a good indication for both medical and surgical treatment and that at his centre, he would have most likely performed a memory graft to cover all the left branches.

The screens turned to the live surgical case at the Institut Cardiovasculaire Paris Sud, Massy, France, where the surgeons were operating on the case in discussion. The team used a 7 French guiding catheter for extra support and backup. Three wires were inserted: one into the circulation, one into the intermediate branch, and one into the LAD. Imaging guidance had already been performed and the pullback with optical coherence tomography had been completed.



An anatomical model of a heart, showing a cross-section of the left ventricle and the coronary arteries. A white, bifurcated stent is visible, positioned to treat a stenosis in the left anterior descending artery (LAD). The model is held by a hand wearing a blue glove. The background is a soft-focus clinical setting.

"The screens turned to the live surgical case at the Institut Cardiovasculaire Paris Sud, Massy, France, where the surgeons were operating on the case in discussion."

The team raised the question as to whether it technically was a trifurcation due to the gap between the ostium and the ostium circumference of the OM branch. The diameter of the LAD was approximately 3.5 mm and there was ostial stenosis of the LAD, which became visible to the audience on the CCTA. The surgeons attempted an optimal viewing angle, crucial for bi- and trifurcation cases.

After viewing the live case in Massy, the discussion turned to the hub in South Africa, where Farrel Hellig, Sunninghill Hospital, Johannesburg, and Mpiko Ntsekhe, Groote Schuur Hospital and University of Cape Town, Cape Town, and colleagues, were asked with regard to their particular strategy.

Based on the optical coherence tomography images from the live operation, the team in South Africa came to the consensus that they would go for a provisional single-stent strategy from the left main ostium into the proximal LAD, followed by a proximal optimisation technique, and thereafter assess those results to determine whether double or triple kissing inflation was required. They concluded that kissing inflation into the intermediate branch was not necessary; however, this would need to be assessed to determine whether additional stenting was required. The use of a single stent was regarded as the most likely outcome. In their final remarks for the case of bi- or trifurcation, most of the team members agreed that they would be comfortable with the use of a 7 French and that the use of three wires was optimal; even after having seen that it was not technically a true trifurcation, three wires was the safest option in order to protect all three branches. ■

Left Atrial Appendage Closure for Stroke Prevention

Evan Kimber

Editorial Assistant

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IMPLEMENTING an effective patient-selection approach, integrating device choice, procedural planning, and patient follow-up, have proven crucial to the success of left atrial appendage closure (LAAC) therapy for atrial fibrillation (AF). This was the focus of the EuroPCR 2021 'Structural Theatre' session, which compared LAAC and direct oral anticoagulant (DOAC) treatment avenues for stroke prevention.

In this session, Patrick Calvert, from Royal Papworth Hospital in Cambridge, UK, gave a presentation on patient selection, alongside Ole De Backer of Copenhagen University Hospital, Denmark, who discussed device selection and planning using CT imagery. Ivan Kuntjoro, from the National University Heart Centre of Singapore, briefly outlined left atria morphology, and Farell Hellig of Sunninghill Hospital, Johannesburg, South Africa, introduced procedural plans in a step-by-step approach while performing a live procedure. The session was concluded by Edgar Tay, UK Royal College of Physicians, who gave his insights on several of these topics and concluded the stream with how to optimise patient follow-up care.

HOW TO SELECT SUITABLE PATIENTS FOR LEFT ATRIAL APPENDAGE CLOSURE

Calvert started his presentation by clarifying that LAAC reduces embolic stroke risk in the absence of oral anticoagulation (OAC) therapy. Calvert highlighted DOAC as the first-choice treatment for AF patients and listed the criteria for selecting LAAC, emphasising that considering a balance of risks is crucial when weighing up these therapy options. He highlighted the importance of consulting a multidisciplinary team of professionals in order to incorporate a clear, open discussion with the patient about preferences and risks. In essence, LAAC is most

useful to patients who cannot tolerate DOAC and want to have the procedure, but should not be used in cases with rheumatic heart disease (RHD), Calvert emphasised.

The criteria for use of LAAC include clear evidence from ECG of documented AF, and an absence of mitral stenosis (MS), as well as stroke-risk scores less than 3 and 2 using CHA₂DS₂-VASc and HAS-BLED models, respectively. The invasive and complex nature of the procedure, with the possibility of no tangible symptomatic benefits, underpins risks of the procedure; however, when patients on DOAC continue to have embolic strokes, LAAC intervention is necessary. Considerations should include the robustness of a patient and the possibility of major complications during surgery.

"The invasive and complex nature of the procedure, with the possibility of no tangible symptomatic benefits, underpins risks of the procedure; however, when patients on DOAC continue to have embolic strokes, LAAC intervention is necessary"

Expanding upon these parameters, Tay stated data have shown that patients receiving warfarin can effectively be treated with LAAC and agreed there is value in an open patient-multidisciplinary team discussion.

DEVELOPING AN APPROACH WITH APPROPRIATE DEVICE SELECTION

De Backer outlined the key points for appropriate device selection and procedural planning, recommending CT-based sizing methods ahead of transoesophageal echocardiography (TEE). De Backer stated, "the accuracy of LAA sizing cannot be over-emphasised," and that "optimised pre-procedural planning for

percutaneous LAA closure based on CT analysis is the gold standard."

Building upon this, Guiseppe Tarantini from the University of Padua Medical School, Italy, commented: "One device cannot fit all LAAs". However, he added, "one device can fit more than one LAA morphology."

ADVANCEMENTS IN PROCEDURAL PLANNING

Tay complimented the shift towards CT imaging and its role in aiding a step-by-step approach. He suggested planning is swifter and more accurate when conducted in this fashion. To present this, Hellig described the case of a patient



“optimised pre-procedural planning for percutaneous LAA closure based on CT analysis is the gold standard.”

with paroxysmal AF and gastrointestinal tract bleeding where DOAC was halted. De Backer gave an example of how CT software can be used in this scenario to visually aid the decision-making process for selecting either a ‘Watchman FLX’ or ‘Amulet’ device. He stressed how “crucial” it is that cardiologists do the pre-procedure CT analysis themselves.

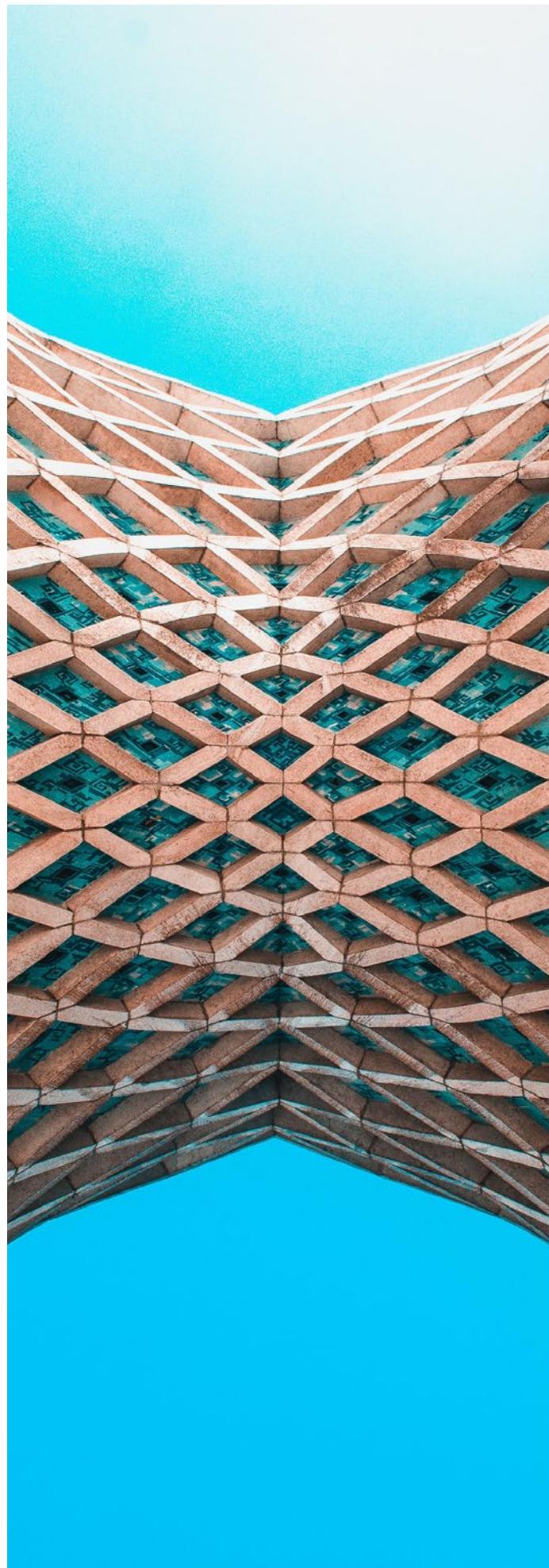
The value of this approach was observed in the live case from Sunninghill Hospital, Sandton, South Africa, which gave a demonstration of a complete seal in a complex situation. Pre-surgical analysis paid off when the device selected was repositioned multiple times successfully. Hellig alluded to the importance of selecting a device using both pre- and intra-procedural guidelines and confirming a stable position and seal before release.

OPTIMISING POST-PROCEDURE CARE

Last on the agenda was optimising post-procedure follow-up and care, and Tay stated, “the choice of post-procedure care is dependent on who the procedure is on.” He explained that OAC should be used for the first 45 days if it can be tolerated, TEE should then be employed to check for device-related thrombosis, and if clear the patient should then be de-escalated to antiplatelet therapy for 6 months. Tay confirmed there will be complications and 1 month of dual antiplatelet therapy followed by prescription of aspirin for those that cannot use OAC. In this way, post-procedural medication and follow-up is tailored according to a patient’s clinical picture.

FUTURE IMPLICATIONS

Looking ahead, the conversations in this EuroPCR event will help cardiologists to take personal responsibility when using CT imaging and to adopt a more open and diverse approach towards AF treatment. ■



Abstract Reviews

Read on for summaries of abstracts presented by leading experts in the field of interventional cardiology at the EuroPCR 2021 congress.

The Incidence and Short-Term Outcomes of Periprocedural Myocardial Infarction Following Cardiac Surgery Across Two International Definitions Using the High-Sensitivity Troponin Assay

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Disclosure: The high-sensitivity troponin assays used in this study were provided by Beckman Coulter (Beckman Coulter Inc., Brea, California, USA). The authors have declared no conflicts of interest.

Keywords: Cardiothoracic surgery, coronary artery bypass graft (CABG), high-sensitivity troponin (hs-cTn), myocardial infarction.

Citation: EMJ Int Cardiol. 2021;9[1]:25-27. Abstract Review No. AR1.

BACKGROUND AND AIMS

There are currently two guideline-recommended diagnostic criteria in use to define a periprocedural

myocardial infarction (PPMI) following coronary artery bypass grafting (CABG): the 4th Universal Definition of Myocardial Infarction (UDMI) and the Society of Cardiovascular Angiography and Interventions (SCAI).^{1,2} Understanding the merits of these definitions has become essential when interpreting the results of trials evaluating the outcomes of CABG. Despite the availability of modern biomarkers, there are as yet no studies comparing the frequency and outcomes of PPMI across these two definitions using high-sensitivity troponin (hs-cTn) assays. These criteria specifically state that a patient must have had CABG in order for a diagnosis of PPMI to be made but this leaves uncertainty as to the diagnosis in patients undergoing non-CABG cardiac surgery. The aim of this study was to describe the frequency, associations, and outcomes of PPMI when applying the SCAI and UDMI definitions using a hs-cTn assay to those

patients undergoing CABG and those undergoing other cardiac surgery.

MATERIALS AND METHODS

All patients admitted to cardiothoracic critical care following open cardiac surgery over a 6-month time frame were included, except for those who had a clinically diagnosed Type 1 myocardial infarction. Testing for hs-cTnI was performed on admission and every day for 48 hours, regardless of whether the supervising team felt there was a clinical indication for testing. The results were nested and not revealed to patients or clinicians unless they were requested as part of routine care. After the two PPMI definitions were applied to patients who had undergone CABG, they were also then applied to patients who did not undergo CABG.

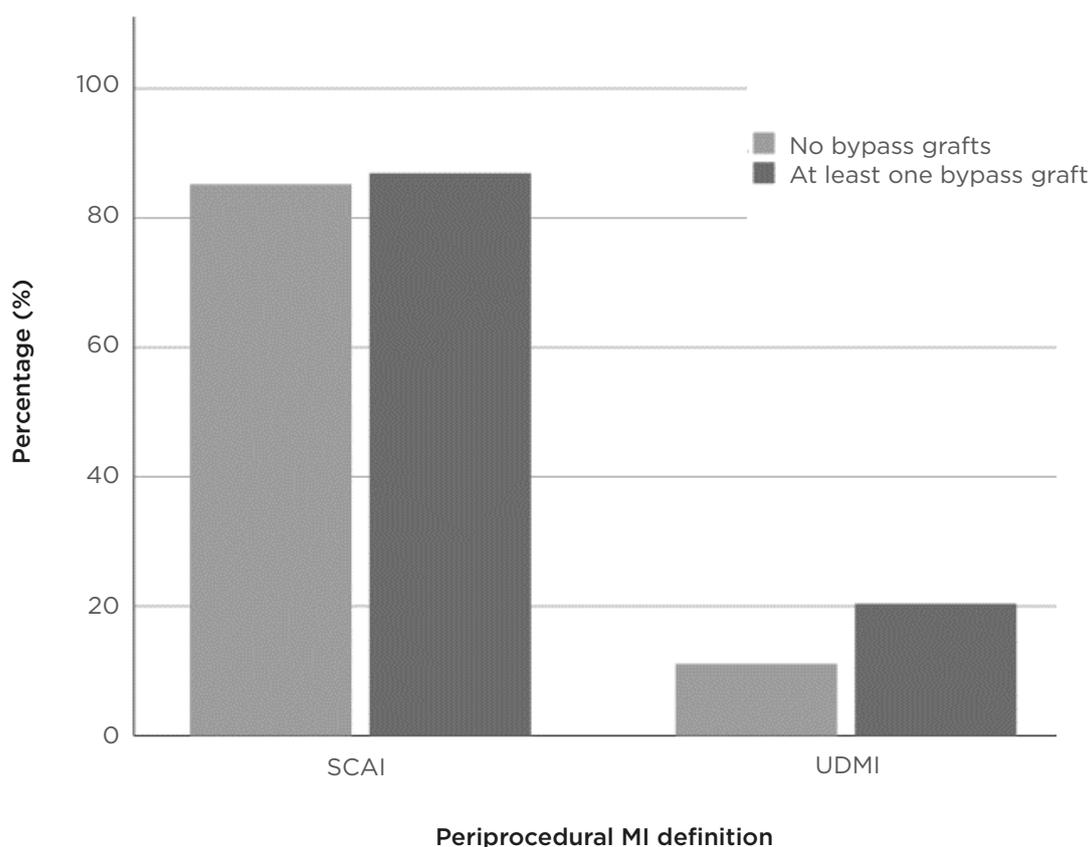


Figure 1: The frequency of periprocedural myocardial infarction depending on the definition used and whether the patient had coronary artery bypass grafts or not.

MI: myocardial infarction; SCAI: Society of Cardiovascular Angiography and Interventions; UDMI: 4th Universal Definition of Myocardial Infarction.

RESULTS

The study included 245 patients with at least one CABG, of whom 20.4% met criteria for UDMI PPMI and 87.6% for SCAI PPMI (Figure 1). There was no association between PPMI and length of stay or death in critical care regardless of the definition used. There were 243 patients included who did not have CABG in the study, of whom 11.1% met the criteria for UDMI PPMI and 85.2% for SCAI criteria. Again, there was no association between PPMI (regardless of definition) and length of stay or death in critical care.

CONCLUSION

The high frequency of PPMI using the SCAI criteria raises concerns about the validity of this definition in the era of hs-cTn assays. Longer term data are required to assess the relevance of a diagnosis of PPMI made using hs-cTn assays. The data suggest that separate PPMI criteria should be considered for patients that do not undergo CABG in future iterations of guidelines. ■

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Diagnostic Performance of Quantitative Flow Ratio Compared to Fractional Flow Reserve and Instantaneous Wave-Free Ratio for Physiology Evaluation of Intermediate Coronary Artery Stenosis

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Keywords: Coronary artery disease, fractional flow reserve (FFR), instantaneous wave-free ratio (iFR), intermediate coronary artery stenosis, physiology assessment method, quantitative flow ratio (QFR).

Citation: *EMJ Int Cardiol*. 2021;9[1]:27-28. Abstract Review No. AR2.

BACKGROUND AND AIMS

European and American experts recommend physiology-guided myocardial revascularisation.^{1,2,3} Nevertheless, physiology-guided revascularisation does not exceed 10% in the best scenario, worldwide.⁴ The most widely used pressure wire-based methods are associated with rare but potentially threatening complication;⁵ therefore, a novel minimally invasive fractional flow reserve (FFR) value computation method known as quantitative flow

ratio (QFR) has been developed.^{6,7,8} This study was aimed to investigate the agreement between QFR, FFR, and instantaneous wave-free ratio (iFR), in addition to evaluating the difference between QFR and both FFR and iFR on making a treatment decision.

MATERIALS AND METHODS

Two-hundred and thirteen patients, who had undergone a coronary angiography that revealed intermediate stenosis (lumen stenosis of 35–75%) by visual evaluation and for whom FFR or iFR measurements were performed between 1st January 2019 and 31st December 2020, were prospectively included into the study. FFR and iFR values were averaged from three independent measurements during the same procedure and FFR and iFR results were blinded online. QFR analyses were performed three times. Average QFR values were compared to average FFR or iFR values. FFR measurements were divided according to the diseased coronary artery (CA). The selected level of significance was $p < 0.01$.

RESULTS

In total, 240 lesions, including 146 left anterior descending (LAD), 25 left circumflex (LCX), and 69 right CA (RCA), were analysed. In total, 25 were iFRs. In the analyses of all lesions, a strong significant correlation coefficient between QFR and both FFR and iFR was found: $r=0.782$ and 0.871 , respectively; $p < 0.001$. After dividing lesions according to CA, the following results have been found: LAD: $r=0.749$, $p < 0.001$; LCX: $r=0.757$, $p < 0.001$; and RCA: $r=0.839$, $p < 0.001$. The secondary outcome was the agreement of clinical decision-making between contrast QFR and both FFR and iFR. In the analyses of all lesions, a strong, significant correlation between QFR and FFR have been found ($r=0.948$; $p < 0.001$). A weaker correlation between QFR and iFR was reported ($r=0.600$; $p=0.002$). Detailed analysis of separate CA has shown the following results: LAD: $r=0.941$, $p < 0.001$; LCX: $r=1.00$, $p < 0.001$; and RCA: $r=0.954$, $p < 0.001$. Compared to FFR as a reference, QFR had a sensitivity of 100%, specificity of 97.63%, and accuracy of 98.14%, and when compared to iFR the values were 100%, 95%, and 88%, respectively.

CONCLUSION

The variety of methods that are currently available encourages the search for the most economical, most convenient, and most reliable method. Repeatedly proved excellent agreement between FFR and QFR supports the wider acceptance into clinical practice, while at the same time encourages further research. Excellent QFR agreement to both FFR and iFR, especially in regard to clinical decision making, makes the method more acceptable to everyday clinical practice. QFR is a safe, cheap, and convenient method, with an excellent correlation to both FFR and iFR in CA stenosis functional significance assessment and clinical decision making, with a great sensitivity, specificity, and accuracy. ■

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Feasibility of Slender CTO PCI Transradially with Limited Use of Hardware

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Disclosure: The authors have declared no conflicts of interest.

Keywords: Chronic total occlusion (CTO), percutaneous coronary intervention (PCI), slender PCI, transradial.

Citation: EMJ Int Cardiol. 2021;9[1]:29-30. Abstract Review No. AR3.

BACKGROUND AND AIMS

Treating chronic total occlusions (CTO) by the antegrade approach requires appropriate devices and skill in resource-limited settings. Good guide-catheter support is crucial.^{1,2} Patients with diabetes and narrower radial arteries are prone to spasm with larger guiding catheters, and may benefit from a slender approach to percutaneous coronary intervention (PCI).^{2,3} However, in resource-constrained environments, restricted finances and accessibility limit the use of regular hardware necessary for successful CTO intervention, especially via the transradial approach (TRA). The authors investigated whether a slender technique by TRA using 5 French (Fr) guide and a smaller profile balloon is a feasible option for successful CTO intervention by antegrade approach in diabetics with narrower radial arteries.

MATERIALS AND METHODS

This was a single-centre, single-operator, retrospective observational study conducted at the authors' high-volume radial centre from July 2018 to June 2020. Data were derived from hospital records and the cardiac catheterisation

laboratory database. Statistical analysis was performed using SPSS version 16 (IBM, Armonk, New York, USA) and variables were compared using the Student's t-test and the chi-squared test. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 249 CTO PCI were attempted transradially. Given limited access to hardware, all procedures were performed using the antegrade wire escalation (AWE) technique, with 166 (67.2%) performed by 5 Fr guide and 81 (33.8%) by 6 Fr guide catheter. Nearly 75% of cases were of J-CTO score ≥ 2 , almost equally observed between 5 Fr (71.6%) and 6 Fr (74.1%) groups. In total, 53.1% were CTO of the right coronary artery. Furthermore, 41.3% and 5.6% were CTO of the left anterior descending artery and left circumflex artery, respectively.

Biradial injection was performed in most cases wherever applicable, in both groups. A small-profile balloon, usually a 1.25x5 mm semi-compliant balloon (76.7% versus 72.8% for 5 Fr and 6 Fr, respectively) or microcatheter (28.3% versus 27.1% for 5 Fr and 6 Fr, respectively), was used for support. Procedural success rates were 72.7% versus 74.1% for 5 Fr and 6 Fr, respectively ($p=0.82$). Crossover to larger backup guides was 3.2% versus 2.9% for 5 Fr and 6 Fr, respectively ($p=0.62$), with a single 6 Fr case switched to femoral access. Active support was achieved by deep intubation of guide and making α , γ , or ϵ loops in the majority of cases of the 5 Fr group, where extra support was necessary. Successful crossing by workhorse CTO guidewires was achieved by Gaia First (Asahi Intecc, Aichi, Japan; 68.6%), Gaia Second (12.3%), and thin intermediate support hydrophilic PT² wire (Boston Scientific, Marlborough, Massachusetts, USA; 19.1%).

A single coronary perforation occurred in the 6 Fr group, requiring emergency surgical intervention. No access site complications were noted in either group. Contrast volume was numerically lower in the 5 Fr group (152 versus 165 mL; $p=0.26$). Fluoroscopy time and procedural times (5 Fr: 34.31 min; standard deviation [SD]: ± 17.2 min; 6 Fr: 33.4 min; SD: ± 14.2 ; $p=0.67$) were comparable between the two groups.

CONCLUSIONS

5 Fr guide is a feasible approach for CTO PCI by AWE, with success rates comparable to other studies.³ Advantages include reduced contrast volumes and radial spasm in narrow arteries. Slender approach allows for better active support by TRA, complemented by the use of a low-profile balloon, instead of routine use of a microcatheter in resource-tailored situations. This slender approach is supported by techniques of deep intubation, as well as α , γ , and ϵ loops.¹ Despite certain limitations in cases of complex bifurcation lesions, and the use of adjunctive devices such as atherectomy,⁴ slender TRA by 5 Fr guide catheter offers a feasible approach to

CTO PCI by AWE, especially among patients with diabetes and narrow radial arteries. ■

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Full Bioresorbable Jacket with Magmaris™ Magnesium Scaffold: A Case Series

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Keywords: Bioresorbable scaffolds, Magmaris, percutaneous coronary intervention (PCI).

Citation: *EMJ Int Cardiol*. 2021;9[1]:30-31. Abstract Review No. AR4.

BACKGROUND AND AIMS

Bioresorbable vascular scaffolds (BRS) are a new and promising technology. BRS have been developed to provide the same advantages as drug-eluting stents, including radial strength,

prevention of vessel recoil, and release of an antiproliferative drug.¹ In addition, their complete degradation could offer restoration of vessel vasomotion and endothelial function, reduction of neoatherosclerosis,^{2,3} and the possibility of future revascularisation with bypass graft if needed. The aim of the present study is to assess the acute and mid-term outcomes of percutaneous coronary intervention (PCI) with magnesium-based BRS in patients with long, diffuse, and complex coronary lesions.

METHODS AND RESULTS

The authors present a 10-case series and included patients presenting with stable coronary artery disease or acute coronary syndrome with complex coronary lesions who needed to undergo PCI. All patients consented to participate in this study.

Exclusion criteria included the presence of distal left main lesions, saphenous vein graft lesions, unsuccessful pre-dilatation, and a reference vessel diameter <2.8 mm or >4.1 mm by quantitative coronary analysis. All magnesium-based BRS were implanted according to the 4P protocol (patient selection, proper sizing, pre-dilatation, and post-dilatation) and intravascular ultrasound guidance was used in all PCI cases.

The primary outcomes were cardiac death, target vessel myocardial infarction, target lesion revascularisation, and scaffold thrombosis at any time during the follow-up period.

Table 1: Occurrence of primary endpoints in patients treated with magnesium-based bioresorbable vascular scaffolds.

Endpoints	n (%)
TVR	1 (2.7)
TLR	2 (5.4)
Cardiac death	0 (0.0)
Stent thrombosis	1 (2.7)

TLR: target lesion revascularisation; TVR: target vessel revascularisation.

Clinical follow-up was scheduled at 3, 6, and 12 months post-PCI. All patients underwent angiographic follow-up at 12 months.

The authors included 37 patients and implanted 57 magnesium-based BRS from February 2017 to September 2018. Mean age was 61 years (standard deviation [SD]: ± 10.2 years) and 16.2% of the study cohort presented with myocardial infarction. Mean lesion length was 18.6 mm (SD: ± 4.8 mm), 16 lesions (28.0%) were longer than 20 mm, and most lesions were classified as American College of Cardiology/American Heart Association (ACC/AHA) classification B2/C (85.7%). Table 1 shows the incidence of primary outcomes.

All patients received dual antiplatelet treatment with aspirin and clopidogrel during the 12-month follow-up and were instructed to continue dual antiplatelet therapy for 3 years.

CONCLUSIONS

Magnesium-based BRS implantation is feasible and applicable in complex lesions with good acute and mid-term clinical outcomes. Further investigation is needed with a larger number of patients and longer follow-up. ■

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Coronary Flow Reserve May Be Used to Evaluate the Haemodynamic Significance of a Coronary Stenosis with Normal Fractional Flow Reserve Values: A Computational Fluid Dynamic Study

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Disclosure: The authors have declared no conflicts of interest.

Keywords: Computational fluid dynamic (CFD), coronary flow reserve (CFR), coronary physiology, fractional flow reserve (FFR).

Citation: EMJ Int Cardiol. 2021;9[1]:32-33. Abstract Review No. AR5.

BACKGROUND AND AIMS

Coronary physiology plays a major role in everyday clinical practice in catheterisation laboratories worldwide.¹ Today, coronary flow reserve (CFR) is used to evaluate the microcirculation, but not the haemodynamic significance, of coronary stenosis.² Fractional flow reserve (FFR) is the gold standard for this purpose, with a cut-off value of 0.8 for intervention.³ Its simplicity, however, limits its predictive value.² In order to establish the usefulness of CFR in evaluating a coronary stenosis independent of the geometry of each stenosis, a computational fluid dynamic (CFD) study is needed. The aim of this CFD study, therefore, is to estimate the significance of CFR in the evaluation of coronary stenosis, independent of the FFR.

MATERIALS AND METHODS

The authors used a right coronary artery (RCA) from a normal coronary CT angiography in order to build a 3D model of a RCA. A CFD study was performed using ANSYS software for stenosis of 0, 35, 60, and 80%, for both the resting and hyperaemic flows (stimulating the adenosine hyperaemia) (Figure 1). An input coronary flow of 0.5-1 mL/min/g was used. In order to calculate the myocardial mass corresponding to this particular RCA, the total length of all three coronary arteries was calculated and matched to the corresponding myocardium.⁴ Using a 3D slicer and a myocardial density of 1.08 g/mL,⁵ the input flow of the specific RCA was calculated. The FFR and CFR were then measured for each case at 6 and 8 cm distal to the stenosis. The stenosis was of concentric morphology in order to stimulate the settings of chronic coronary syndromes. The stenosis location was in the mid RCA and proximal to the right ventricular branch.

RESULTS

Unstable flow was proven only for severe stenosis and only with a more than 2-fold increase of the resting flow due to hyperaemia. The FFR was 1.00 for 0% stenosis, 1.01 for 35% stenosis, 0.99 for 60% stenosis, and 0.91 for 80% stenosis, where CFR was 4.02, 4.02, 3.89, and 1.90, respectively. In all cases with a stable flow, FFR was within normal range, but CFR was under 2.0 only for severe stenosis (80%). CFR could, therefore, potentially prove the haemodynamic significance of coronary stenosis even when FFR is above 0.80. FFR values were independent of the point of measure; however, CFR showed minor dependence, without major discrepancies between the measurements at 6 and 8 cm.

CONCLUSION

CFR could be used to prove the haemodynamic significance of coronary stenosis even when FFR is above 0.80. ■

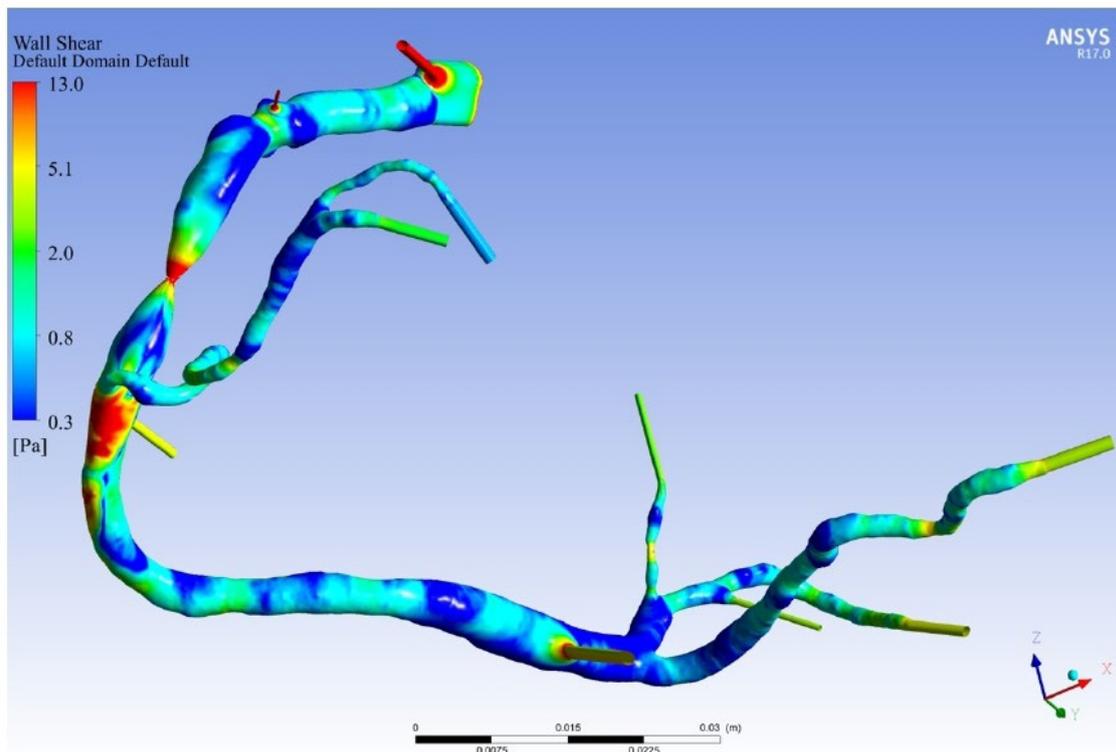


Figure 1: A computational fluid dynamic study of the right coronary artery model with an 80% stenosis and hyperaemic flow.

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Fractional Flow Reserve, Quantitative Flow Ratio, and Instantaneous Wave-Free Ratio: Comparison of Ionising Radiation Dose

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Keywords: Coronary artery disease, fractional flow reserve (FFR), instantaneous wave-free ratio (iFR), ionising radiation, physiology assessment method, quantitative flow ratio (QFR).

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wave-free ratio (iFR), and a novel minimally invasive FFR value computation method, quantitative flow ratio (QFR).

MATERIALS AND METHODS

In total, 134 patients who have undergone coronary angiography revealing intermediate lumen stenosis of 35–75% by visual estimation and for whom FFR, QFR, or iFR measurements were performed within 2020 have been prospectively included in this single-centre study. Dose area product (DAP) and fluoroscopy time (FT) were the parameters chosen for ionising radiation dose evaluation and comparison. Additionally, patient BMI was collected for unification. Statistical analysis was performed using software package SPSS 20.0® (IBM, Armonk, New York, USA). The chosen level of significance was $p < 0.05$. Of all included functional assessment analyses, 48 were FFRs, 28 were QFRs, and 58 were iFRs. Mean BMI did not differ among groups: FFRs: 30.07, standard deviation (SD) ± 6.26 ; QFRs: 27.14, SD ± 4.61 ; and iFRs 29.75, SD ± 5.05 ; $p = 0.08$. BMI was moderately correlated to DAP ($r = 0.36$; $p < 0.001$). Mean FT and DAP for FFRs were 7.13 (SD ± 5.82) min and 1928.63 (SD ± 2137.21) cGy·cm², respectively; for QFRs they were 2.44 (SD ± 1.12) min and 923.12 (SD ± 768.47) cGy·cm², respectively; and for iFRs they were 6.50 (SD ± 3.90) min and 1605.39 (SD ± 1152.59) cGy·cm², respectively. FT was almost double in FFRs and iFRs compared to QFR ($p < 0.001$). Compared to FFR as a reference, DAP was half in QFR ($p = 0.012$).

BACKGROUND AND AIMS

The development of interventional cardiology is inevitably associated with increased dose of ionising radiation for the physician.¹ Additionally, physiology-guided myocardial revascularisation is supported by both European and American experts,^{2,3} but these procedures may increase the total procedure time in addition to increased dose of ionising radiation for the physician.⁴ Therefore, the authors aimed this study to investigate the differences in dose of ionising radiation among fractional flow reserve (FFR), instantaneous

CONCLUSION

Since all currently available physiology assessment methods are equally accurate, reliable, and convenient on treatment decision-making, radiation safety aspects are one of the most important issues for further studies. QFR repeatedly shows promising results in significant ionising radiation dose reduction, resulting in shorter FT and DAP, irrespective of BMI; therefore it could become the method of choice in many clinical decision-making situations. ■

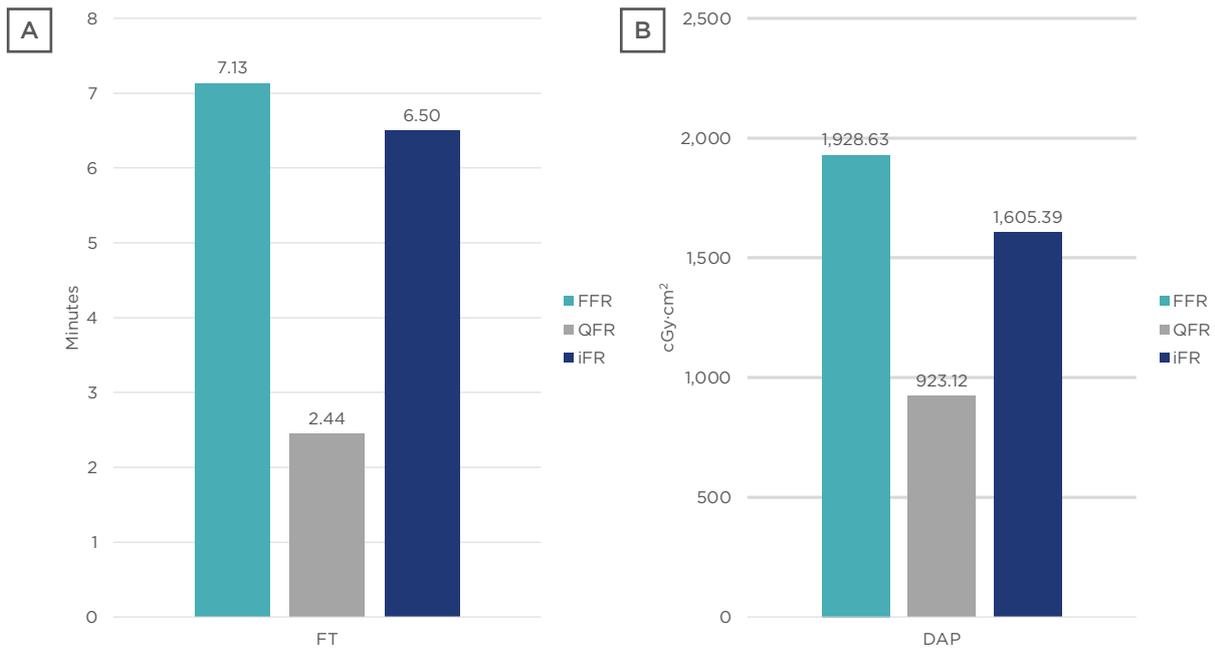


Figure 1: A) FT and B) DAP in FFR, QFR, and iFR procedure groups.

DAP: dose area product; FFR: fractional flow reserve; FT: fluoroscopy time; iFR: instantaneous wave-free ratio; QFR: quantitative flow ratio.

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Congress Interviews

Professor William Wijns, PCR Chairman, and Professor Bernard Prendergast, Course Director of PCR London Valves, spoke to EMJ about their respective roles within the society, their research interests and recent publications, and what the future of interventional cardiology holds.



Prof William Wijns

PCR Chairman;
SFI Professor of Interventional Cardiology, National University of Ireland Galway, Galway, Ireland

Q1 With over 35 years of clinical experience in interventional cardiology, what initially attracted you to specialise in this field?

Forty-two years actually... I was primarily interested in intensive care and also post-operative care after cardiac surgery and it was the beginning of the coronary care. Then cardiology, which used to be somewhat of a contemplative discipline, started to transform very quickly: direct-current shock, pulmonary artery pressure monitoring, early angiography after myocardial infarction, thrombolysis, etc. Then in 1979, I moved to the Thorax Centre, Erasmus University Medical Center in Rotterdam, Netherlands because of their early adoption of balloon angioplasty. I remember it as if it were yesterday when Andreas Grüntzig came over to review the first 50 cases treated with the Schneider balloon, and we all know the rest of the story.

Q2 What does your role as Chairman of PCR entail, and what have you achieved so far in this position?

PCR is a wonderful worldwide community of healthcare professionals who are passionate about advancing less-invasive care of patients suffering from various cardiovascular disorders, using a wide array of different devices yet all with one common feature, which is to reach the target treatment site through the endovascular route, using patient-friendly vascular access. The Chairman's role is to constantly stimulate PCR companions to search for excellence in adult education, following in the steps of Jean Marco and in line with a mission that has not changed over the past 35 years. PCR equals people, and the role of the Chairman is to help everyone get the best out of themselves.

Q3 Similarly, what long-term goals do you hope to accomplish during your term as PCR Chairman and what sort of legacy would you like to leave for those following you?

Certainly, we did not anticipate the challenges and transformative emergency that the coronavirus disease (COVID-19) pandemic imposed on us. Moving from face-to-face interactions to digital learning remains a challenge but also an immense opportunity. Together with my Co-Chairman, Jean Fajadet, from the Clinique Pasteur in Toulouse, France, a core group of 80 plus ultra-committed colleagues, and the enthusiastic support of the team at Europa Organisation, the backbone of PCR, we hope to draw the contours of the interventional course of the future. Without a doubt, we want to be able to again enjoy the rejuvenating boost that stems from personal sharing and exchange during physical meetings throughout the year, on all continents. There is more: we foresee the opportunity to reach out through digital channels to the many in need of education who are not able to attend, even those unable before the pandemic. Creating a model and learning the tools that will maximise

"Moving from face-to-face interactions to digital learning remains a challenge but also an immense opportunity"

the educational outreach to those who need it the most represents the challenge in front of us. With the support of our partners in the MedTech industry, the recent 2021 EuroPCR course has successfully delivered a proof of concept experiment that needs to be further refined but is already shaping the contours of future educational events: a revolutionary model that seems like a very sensible legacy for the next generation to build upon.¹

Q4 The mission of the PCR is: 'To serve the needs of each individual patient by helping the cardiovascular community to share knowledge, experience, and practice'. In your opinion, what areas of interventional cardiology need the most support to achieve this?

All areas of interventional science and care are in constant flux and sharing between peers is



the fundamental act of generosity, bringing valued content to the process of adult learning. Of course, the cycle of innovation alternates moments of rapid progress and moments of slow motion when the road gets bumpy, but in general, I cannot see that one area is left behind. Across borders, the fundamental principles of effective education are the same. Patient-centric education is driven by patient-oriented needs and should be practical, impactful, trustworthy, self-directed, respectful of local culture and circumstances, and long-lasting. To this end, hundreds of colleagues have been trained to become more effective teachers and facilitators, applying the principles of Visionary Transformative Adult Learning (VITAL). And now, we are all learning how to deliver effective education through various digital media.

Q5 Since the start of the COVID-19 pandemic, patients have been consistently deprived of timely cardiovascular treatment. What actions is the We CARE initiative (a collaboration between PCR and Stent - Save a Life!) taking to promote timely care for patients with heart disease during the pandemic?

We CARE aims to re-establish patient confidence in accessing cardiac healthcare services in the wake of the pandemic. The programme will reach out to patients, their families, and patient organisations, but also to primary care providers and national champions from the PCR community. Secondly, We CARE will reach out on a national and international political level to ensure that healthcare providers are adequately prepared to deal with any future major crises that could impact the provision or access to care. The project relies on the track record of Christoph Naber (Wilhelmshaven Hospital, Wilhelmshaven, Germany) and the international team who have successfully managed the Stent - Save a Life project with amazing impact on the delivery

of primary percutaneous coronary intervention for acute coronary syndromes.²

Q6 The recently formed PCR Tricuspid Focus Group is committed to fostering the establishment of tricuspid therapies, improving outcomes, and delivering sustainable clinical solutions for complex patients. What research is the focus group currently undertaking to support innovation in the treatment of tricuspid valve disease?

Your question describes exactly the 'raison d'être' of the PCR Tricuspid Focus group that was recently launched and is facilitated by Fabian Praz (Bern University Hospital, Bern, Switzerland)

and Francesco Maisano (San Raffaele University Hospital Milano, Milano, Italy).

Outstanding colleagues committed to advancing this field have clustered in several working parties addressing all aspects of the problem in a holistic fashion, namely anatomy and imaging, patient care pathways, interventions, outcomes, and innovation. Specific deliverables will be communicated to the larger community through various means: the website and PCROnline, webinars, publications, progress reports at PCR

Courses, and social media. I anticipate that this very talented group will come up with new standards of care that will benefit patients who are difficult to treat within the next few years.

Q7 Are there any current challenges in interventional cardiology, and how can they be potentially overcome?

Too many challenges and opportunities to name them all. Perhaps the fundamental challenge is the difficult integration of different medical cultures, which hampers the achievement of optimal individualised patient outcome. The vertical structure of undergraduate and specialty medical training and the resulting

"All areas of interventional science and care are in constant flux and sharing between peers is the fundamental act of generosity, bringing valued content to the process of adult learning."



cultural barriers are standing in the way of the needed integrated approach to patient care. Counterproductive territorial tension between medical treatment, interventional approaches, or surgery is difficult to overcome by postgraduate training only. The organisation of hospitals, divisions, and care pathways per medical discipline is no longer an adequate model. Solving severe disease conditions, often complicated by multiple comorbidities, is better achieved by teams mastering all the necessary expertise and organised as a functional structure equipped to address cardiovascular problems and associated renal and metabolic disorders. Major changes are needed in the way doctors and specialists are trained at medical school, as well as in the hospital structure and funding, aiming to eventually transform healthcare systems downstream.

What would your advice be to the younger generation that are following the same path and just beginning their career in this discipline. Where do you hope they will take the field of interventional cardiology over the coming decades?

Quite frankly, the next generation is amazing; their skills, creativity, wisdom, and broad knowledge are way above my own at their age. For them, embracing digital tools and telemedicine is natural. A growing number of female colleagues are joining a profession that has so far been largely dominated by males; gender parity is progressing. Programmes designed 'by and for' the next generation at PCR and the European Association of Percutaneous Cardiovascular Interventions (EAPCI) are often the most inventive and effective ones. Watch for instance the series of 'CathFlix' episodes on coronary interventions that were presented by Gabor Toth (Medical University of Graz, Graz, Austria) and colleagues before and during EuroPCR 2021. It is a demonstration of just how effective interactive teaching and learning can be! It is a gift to work with that community. There is no reason to be afraid or worried about the future. ■

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Prof Bernard Prendergast

Course Director of PCR London Valves and Co-ordinator for Valves and Structural Activities at PCR; Professor of Interventional Cardiology and Valvular Heart Disease, Guy's and St Thomas' NHS Foundation Trust, London, UK

Q1 What fascinates you the most about interventional cardiology, and why did you decide to pursue a career in this discipline?

There have been three defining moments in my medical career. The first was when I assisted in a renal transplant as a medical student and was stunned when restoration of blood flow to the icy, grey donor kidney produced a pink healthy organ and immediate production of urine. The second was my first primary angioplasty procedure as an independent interventional cardiologist, when restoration of perfusion in an occluded right coronary artery reversed complete heart block and associated haemodynamic compromise in a previously fit young man. And finally, my first transcatheter aortic valve implantation (TAVI) procedure in 2008, when a calcified rigid aortic valve was replaced with thin, mobile leaflets in a 45-minute procedure via the femoral artery. Progress in medicine, particularly in interventional cardiology, has been extraordinary over the past 30 years and it has been a privilege to work in such a stimulating and rapidly moving field.

Q2 How did you become involved with the PCR board and what was the goal you set out to achieve when you joined? What has been your proudest achievement within the board?

I was fortunate to undertake an Interventional Fellowship in Paris, France, with Alec Vahanian (at the end of the last century!) and EuroPCR was the 'go to' meeting where I learnt a huge amount about the emerging discipline of coronary intervention. Opportunities came my way to present cases and research data, and the early uptake of TAVI in the UK provided the platform for my greater involvement as a member of the PCR Board. The successful growth of PCR

London Valves over the past 5 years has been hugely rewarding and the entire team were thrilled by the success of the virtual meeting in 2020 that generated many of the virtual formats and concepts that have now been refined and adopted for EuroPCR 2021.

Q3 You are currently the Course Director of PCR London Valves and Co-ordinator for Valves and Structural Activities at PCR. Please could you tell us about your duties in both roles, and any key projects that are associated?

The field of valve and structural intervention has expanded exponentially in the past decade, transforming the clinical landscape to the benefit of patients and creating widespread demand for education in these new techniques. PCR London Valves was established 10 years ago and is now the largest meeting worldwide dedicated to the field of valvular heart disease, with >3,000 participants at the last face-to-face meeting in 2019, and >6,000 participants at the virtual meeting in 2020. Sister meetings in China (PCR-CIT Chengdu China Valves) and Japan (PCR Tokyo Valves) have enjoyed similar success and we are now working in partnership with Cardiovascular Research Foundation/Transcatheter Cardiovascular Therapeutics (CRF/TCT) to create a further educational workshop in Latin America as part of our growing 'Partners in Learning' collaboration.

Q4 It has been decided to move EuroPCR 2021 into an online meeting this year. What do you believe to be the advantages and disadvantages of a virtual congress?

Of course, we are all missing the buzz of large congresses, with packed halls, busy corridors,



"The successful growth of PCR London Valves over the past 5 years has been hugely rewarding and the entire team were thrilled by the success of the virtual meeting in 2020 that generated many of the virtual formats and concepts that have now been refined and adopted for EuroPCR 2021."

and dynamic exhibitions providing opportunities for networking, planning future projects, and catch-up with old friends and colleagues. On the other hand, the restrictions associated with the pandemic have perhaps made us re-examine the need for frequent international travel (with large carbon footprint), regular absence from home and the hospital, and the genuine benefits of repetitive slide presentations. Virtual congresses have forced us to re-invent medical education in new and attractive formats, focus on exactly what we are aiming to achieve, and make our programmes accessible to a larger worldwide community: in essence, the founding goals of PCR over 30 years ago. If we can ultimately capture the best of both formats, then COVID-19 will have allowed us the opportunity to make considerable progress.

Q5 How much of an impact do you believe the EuroPCR congress has, both directly on interventional cardiologists and indirectly on patients?

Over 8,000 interventional cardiologists visit Paris each May to attend the EuroPCR Course, drawn by the prospect of the highest-calibre postgraduate medical education combined with up-to-the-minute late-breaking data, practical demonstrations, opportunities for interactions with friends and colleagues, and the attractions of one of the world's great cities. The fact that the programme content is firmly rooted in everyday clinical practice means that educational take-home messages are translated immediately and directly to patient care.

"The field of valve and structural intervention has expanded exponentially in the past decade, transforming the clinical landscape to the benefit of patients and creating widespread demand for education in these new techniques."

Of course, travel to Paris is not possible in 2021, but the ready accessibility of the virtual programme means that even more participants will be able to benefit from everything on offer, with even greater benefits for patients worldwide.

Q6 Which sessions are you most looking forward to at EuroPCR 2021? Why?

The EuroPCR 2021 programme is packed with educational material covering the entire spectrum of cardiovascular intervention. The main sessions, encompassing live transmissions from leading cardiac centres, are always a major draw and their incorporation into the virtual broadcast sessions will be a particular highlight. We have a total of 68 Hotline presentations, including major Late-Breaking Trials, specific channels dedicated to 'classroom style' simulated learning, and a prestigious innovation award from the Jon DeHaan Foundation for novel breakthrough technologies. Importantly, all of the course content will remain available on demand via the PCR platform¹ until 26th August; so even if you missed it the first time round, there is still plenty of time to benefit from the comprehensive range of educational material.

Q7 What have been your personal clinical experiences during the COVID-19 pandemic, and what lasting impacts do you predict the pandemic will have on the field of interventional cardiology?

The COVID-19 pandemic has taken us all way outside our comfort zone, caring for patients in difficult circumstances whilst dealing with the anxiety of protecting our families and ourselves. At the same time, we have missed the opportunities for regular face-to-face interaction with friends and colleagues at home and abroad. In London, we have seen many young and sick patients; not only with cardiovascular complications of COVID, but also with serious

manifestations of everyday cardiac problems as a consequence of misdiagnosis or delayed presentation. The situation is now returning towards normality (at least temporarily) but we are faced with a new challenge of long waiting lists for diagnosis and treatment. I fear it will be at least 2-3 years until we truly emerge from the crisis.

Q8 Could you highlight the principal findings and wider relevance of the recently published review you co-authored, entitled 'Incidence and Outcomes of Infective Endocarditis Following Transcatheter Aortic Valve Implantation'?

TAVI has revolutionised our approach to the management of aortic stenosis in the last 15 years, enabling treatment in patients previously considered high risk or unsuitable for surgery, and now offering a simple, minimally invasive procedure for younger, lower-risk patients. Infective endocarditis is a life-threatening complication of prosthetic valve replacement, which affects approximately 0.3-1.0% per person-year and is challenging to diagnose and treat. The impact of TAVI on the prevalence of the incidence and natural history of prosthetic valve endocarditis is incompletely understood. In this review article,² we highlighted how differences in patient age, comorbidities, valve design, implant technique, and requirement for frequent healthcare contact in the TAVI population have potential to influence the risk of endocarditis, its microbiological characteristics, clinical management, and outcome. ■

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Interviews

Ankur Kalra and Kendra Grubb spoke to EMJ about their personal research interests and landmark publications, the impact of the coronavirus disease (COVID-19) pandemic on interventional cardiology, and what the future of the discipline holds.

Featuring: Ankur Kalra and Kendra Grubb.



Ankur Kalra

Medical Director of Clinical Research for Regional Cardiovascular Medicine at the Cleveland Clinic and Associate Professor of Medicine at the Cleveland Clinic Lerner College of Medicine, Cleveland, Ohio; Section Head of Cardiovascular Research at Cleveland Clinic Akron General, Akron, Ohio, USA

Q1 What challenges did you face in your path to Harvard Medical School and your medical career?

I was born and raised in Delhi, India, and always wanted to come to the USA for advanced training; however, when I came to America, I was told I was not going to be able to train at an Ivy League institution because I was a foreign graduate, I was on a visa, and it's fairly competitive. So, I think the biggest challenge was to get my résumé up to speed and make it competitive enough for me to compete with the applicant pool that applies for advanced fellowships at Harvard hospitals. Teaching myself to be a good researcher was also extremely challenging because back in India, at

least at the time I was training in medical school, the curriculum did not have research built-in as one of the tools that you should learn or master.

Q2 How has your position as an interventional cardiologist influenced the poems in your book 'Ibadah', and what role can poetry play in medicine generally?

Through the lived experiences of others, especially my patients, I've been able to capture the different emotions associated with loss. To be able to write poems on how they feel or how they feel after losing someone is cathartic for me. I am an emotional and sensitive person myself.



“As physicians taking care of patients who are either going through extremely vulnerable times or have lost loved ones, I think art fills that space of human emotion, which is very relevant.”

Interventional cardiology is considered very aggressive so maybe I'm not the usual interventionalist. I think poetry and arts in general have a role in medicine because they are very healing and cathartic. As physicians taking care of patients who are either going through extremely vulnerable times or have lost loved ones, I think art fills that space of human emotion, which is very relevant. Certainly, the Cleveland Clinic where I work has an Arts and Medicine Institute. Throughout the Cleveland Clinic Main Campus there is a lot of artwork, which is central to the theme of healing and the manifestation of emotions through art in the form of sculpture, painting, and poetry.

In your 'Parallax' podcast you have discussed the role of mentorship in medicine. What are your experiences as a mentor and what qualities do you look for in a mentee?

Mentorship is like parenthood; it's a labour of love, it's selfless love, and I think that a lot of feedback goes into it. It's something I enjoy because developing medical students, residents, and fellows to be good clinical investigators is one of my pathways for giving back. I continue to develop myself in developing them. If we are trying to design a project together and they have come up with a solution, it is up to me to make sure that the solution is scientifically and methodologically valid and that the analysis is well done. In doing that, I am also educating myself.

The only qualities that I look for in a mentee are their ability to learn and work hard. Importantly, intelligence is different than knowledge is different than wisdom. You could be extremely

intelligent but if you don't have the work ethic to garner the knowledge that you need to be a good clinical investigator, then that intelligence is of no use. Similarly, if you are intelligent and knowledgeable, you still need the wisdom to put things into clinical perspective.

In 2018 you founded the non-profit startup makeadent.org, which aims to “decrease resource utilisation, improve quality, and yet be frugal.” What initiatives have been implemented to achieve this goal and what future projects are in the pipeline?

The overarching mission is to have an exchange with India, my country of birth, and to see whether we can foster this scientific exchange between investigators in the West and investigators in India in an effort to develop investigation in India. The Parallax podcast is part of the non-profit and I want to interview and showcase guests whose journeys have been inspirational and who I look up to myself. This provides a platform for learning and will help others emulate them and follow their path. The makeadent.org project that's really close to my heart has established a new fund last year at Cleveland Clinic Akron General, through which we've done some seminal work and published several papers already. The idea is to study inequity and diversity in the healthcare workforce and amongst our patients, and conduct research that investigates variation in resource utilisation across the spectrum of society in the USA.

How will you utilise the skills learnt during your current Master of Science programme in Health Economics,

Outcomes, and Management at the London School of Economics and Political Science within your medical career and wider pursuits such as makeadent.org?

Healthcare economics has always enticed and interested me because resource utilisation is something I wish to focus on as a clinical researcher. I know there is a lot of healthcare waste in the USA, whereas India and other countries in Southeast Asia and Africa are resource-poor. How can we leverage wastage in America and constraints in the eastern part of the world to come up with solutions that would be good for all of us, sort of like a symbiotic relationship? This is an area of investigation I really want to tap into but I don't think I have thus far. I think this programme would allow me to do that. I think it ties well into what makeadent.org wants to accomplish, and what I want to accomplish as a researcher. You will see themes of altruism and resource utilisation throughout my work, and therefore getting the formal education, knowledge, and tools through this course at the London School of Economics will help me in accomplishing those goals.

Could you summarise the key research findings and wider relevance of your recently published paper 'Incidence of Stress Cardiomyopathy During the Coronavirus Disease 2019 Pandemic'?

At the time when we conducted this research, we did not know that it would be such an international hit. We started seeing a cluster of broken heart syndrome cases in the lab and wanted to systematically investigate if this was just a cluster or whether it was truly associated with the pandemic. We compared the incidence of stress cardiomyopathy during the pandemic with the pre-pandemic control and found that there was an increase in the incidence of stress cardiomyopathy, which is basically a barometer of stress in the community. Physical, emotional, and psychological stress can manifest as broken

"Mentorship is like parenthood; it's a labour of love, it's selfless love, and I think that a lot of feedback goes into it."

heart syndrome, which is where the heart conforms into the shape of an octopus trap and significantly decreases its pumping function. Fortunately, the condition is reversible in about several weeks; however, you do need to follow these patients long-term. If you compare the mortality in this population with the population that does not have stress cardiomyopathy, you will see that across the spectrum of a decade, mortality is about 10% or so. Clearly, this is not trivial but something you need to focus on.

You have over 200 scientific manuscripts to your name, including original research, review articles, and case reports. What do you believe to be the current gaps in literature in cardiology and what specific topics deserve greater attention?

There are three major areas that I feel need a significant amount of focus: resource utilisation within cardiovascular medicine, the burden of cardiovascular diseases in South Asians, and healthcare disparities and inequities. The burden of heart disease in South Asians is something I personally want to focus on in the coming years.

In your opinion, what have been the landmark interventional cardiology trials so far in 2021 and how could coronavirus disease (COVID-19) shape the course of subsequent research?

One particular randomised trial published in 2021 that was of value and interest to me looked at the effects of ivabradine in patients with postural orthostatic tachycardia syndrome and showed that there was a significant benefit. Although this was not a study within interventional cardiology, it stood out for me and changed my practice. COVID-19 has brought up significant challenges for the clinical trial space, which is not the area I work in because I am an observational, health services, and outcomes researcher. However, I think it'll be extremely difficult to adjudicate events based on interventions because the pandemic could have affected mortality independent of the trial. This is a completely different environment and milieu in which you are conducting studies because you may be losing patients to follow-up or patients are dying prematurely.



Kendra Grubb

Surgical Director of Structural Heart and Valve Center and Associate Professor of Cardiovascular Surgery at the Division of Cardiothoracic Surgery, Department of Surgery, Emory University School of Medicine, Atlanta, Georgia, USA

Q1 After graduating from the University of Southern California, what influenced your decision to specialise in cardiothoracic surgery and interventional cardiology?

I decided to be a surgeon when I was very young. I used to say that I was 5 years old when I first told people I was going to be a surgeon; my father has since corrected me and has said that it was actually at 3. I went to medical school to become a surgeon; it was just a matter of figuring out which specialty. Therefore, I chose the traditional general surgery pathway, which is a 5-year residency. During my second year of training, I was on my first cardiothoracic surgery rotation and immediately I knew that operating on the heart was how I wanted to spend my career. I enjoyed the fine suturing and found the anatomy and pathophysiology fascinating, but even more, I was drawn to the impact I could make on a person's life. With a successful operation, I could make people feel better and add 20 years to their life.

As for additionally specialising in interventional cardiology, that had to do with developing

a niche. Prior to medical school, I completed a Master of Health Administration, which is essentially a Master of Business Administration for healthcare. In addition to confirming that I did not want to be in business, I also learned the importance of developing a niche. Transcatheter therapies, specifically transcatheter aortic valve replacement (TAVR), were just coming into practice when I was in training. As soon as I saw my very first TAVR I knew that I wanted to take part in using the cutting-edge technology. At that time, TAVR was only for patients who were high-risk or inoperable, too old or too sick for open surgery. With the new transcatheter devices, we could help a population of patients who had no other options, which was extremely exciting. Now, of course, TAVR is approved for all risk groups and we have transitioned to optimising the techniques and to the lifetime management of patients who may require multiple valves throughout their life. We have also seen the evolution from TAVR to a structural heart and valve team, which treats all four heart valves and other anatomic lesions in the heart.

“Now, TAVR is a mature technology and we are focusing on optimisation and starting to develop techniques for valve failure.”



Interventional cardiology is a field of medicine that has significantly benefitted from technological developments; are there any new tools on the horizon that you are especially anticipating?

Interventional cardiology, more specifically structural heart and valve, is a really exciting field right now. Early in my career, the focus was on TAVR and then every 6 months we seemed to adopt a new technique or device; it was a really exciting time. Now, TAVR is a mature technology and we are focusing on optimisation and starting to develop techniques for valve failure. I work with two pioneers in cardiac electrosurgery; they are leading the way for being able to lacerate the leaflets of the failed valves or removing the diseased leaflets completely, and are creating innovative novel therapies for patients who have no other options.

On the industry side, a whole host of devices are going through trials, early feasibility and pivotal, for the mitral valve and tricuspid. I suspect it will take a lot longer for these devices to become available as the causes of disease are more diverse and the anatomy much more complex. Yet, we remain hopeful because there is a very large patient population who have no surgical options and medical therapy alone does not correct a heart anatomic problem. Beyond valves, there is also really exciting technology to treat advanced heart failure by remodelling the left ventricle. The trials are ongoing, but so far the results are promising.

In the USA, women account for only 4-5% of cardiac surgeons and interventional cardiologists. Why do you think this is the case, despite women making up around one-half of medical school students?

It is multifactorial. I am fortunate to have an interventional cardiologist who is a woman as my partner on the structural heart team, but it is really uncommon for a programme to have two women operators. There are many reasons why women choose not to enter the cardiovascular subspecialties: some of it is due to a perception of the demands of the job and the challenges of being the only woman on a programme, but also important is the need for mentorship and sponsorship. When we look at the distribution of

women who do TAVR in the USA, over 30% of the states do not have a woman implanter, surgeon, or interventional cardiologist. It would be very challenging as a medical student in those states to decide to enter the field.

This is compounded by the lengthy training required at a time in a woman's life when starting a family may be a priority. Cardiac surgery or interventional cardiology training is a minimum of 6 years and for many residents it will take even longer with the addition of advanced fellowships or designated research time. For me, after medical school, I was in training for an additional 8 years: general surgery for 5, cardiothoracic surgery for 2, and an advanced fellowship in interventional cardiology and transcatheter therapies for another 1 year. With the addition of a Master's, I was 36 years old when I started my first year as an attending. For many women in medical school, the path is too long and uninviting.

You have been described as a champion for female cardiovascular disease, which is the most common cause of death among women worldwide; how does this disease affect women differently to men?

Cardiovascular disease is the number one killer of women in the USA and worldwide. Although heart attack and stroke are common in both men and women, the bigger concern is that women tend to have worse outcomes. For example, the mortality for women after heart surgery is higher than for men and this is true for medical therapy for cardiovascular disease as well. Why the difference? There are many theories, but we really do not have a reason. There is often a delay in presentation as well as diagnosis for women with cardiovascular disease. Also, most of the early pharmaceutical trials enrolled predominantly men and the result may not be generalisable to women.

As a member of Women in Thoracic Surgery, could you tell our readers about the aims of this organisation?

Women in Thoracic Surgery is an organisation of women surgeons that promotes women in the field through mentorship and community. The goal of Women in Thoracic Surgery is to help women become leaders in the field and to eliminate gender disparities.

Q6 Could you share the key conclusions drawn from your recent paper: ‘Safety of same-day discharge after uncomplicated, minimalist transcatheter aortic valve replacement in the coronavirus disease (COVID-19) era’?

Due to the constraints of the coronavirus disease (COVID-19), we had to be creative in our approach to patient care. Patients were afraid to come to the hospital for procedures and we were not allowing family members to stay with them. This became a major obstacle for us when providing needed valve procedures and resulted in patients delaying their care and then presenting much further along in the disease process; they were much sicker. Our routine minimalist patient pathway, with conscious sedation and next day discharge, had been in place for a long time. We were able to leverage our experience and develop a protocol to send patients home the same day as the TAVR. The family would drop the patient off early in the morning and wait in the car for their loved ones to meet the discharge criteria. The paper mentioned in the question is the summary of our early patient experience and we found there was no difference between the patients who were sent home the same day and the patients who were on our traditional next day discharge pathway. The patients loved it, the families appreciated our commitment to protecting patients from exposure to COVID-19, and we were able to decrease our bed utilisation and conserve resources in order for the system to care for more patients with COVID-19, albeit in a separate part of the hospital.

Q7 How has COVID-19 affected your day-to-day practice and what lessons have you learnt since the start of the pandemic?

There are so many lessons from trying to care for heart patients during the COVID-19 era; it's an entire separate discussion and we could spend all day talking about it.

In short, COVID-19 forced us to be very thoughtful in our approach to patient care. We were forced to achieve the same level of care without the patient spending a tremendous amount of time at that hospital. For the initial patient visit, we transitioned to telehealth and had Zoom visits with the patients and their families. We instituted the same day discharge protocol that I mentioned in the previous question, and prioritised patients who were most in need of the procedure but were also the most likely to not require a stay in the intensive care unit or multiple days in the hospital. We focused on much-needed efficiencies to continue to deliver the highest level of care. Frankly, most of the changes were needed pre-COVID-19 and our programme, and patient care, will benefit from the changes we have made.

Q8 What do you hope that the future working in cardiothoracic surgery and interventional cardiology will bring, for both patients and clinicians, and in your career ahead?

As we discussed, cardiovascular disease (heart attack, congestive heart failure, and stroke) is the leading cause of death worldwide. Especially in the USA, we have the most cutting-edge technology and innovative procedures and techniques, but we don't focus enough on prevention or early recognition of disease. Often, we see patients so far along the disease process that there is little to offer, and this makes the procedure a much higher risk. My hope for the future is that we find ways for earlier detection of disease and opportunities for intervention, before the disease advances and the patient is at the end stage. Although this may sound like I am trying to put myself out of business, in fact I am not; prevention is key and early detection allows for early intervention and this is the best opportunity to improve a patient's quality of life and longevity.

“The goal of Women in Thoracic Surgery is to help women become leaders in the field and to eliminate gender disparities.”

Surgical Treatment of Greater Saphenous Vein Thrombosis Involving the Saphenofemoral Junction: An Albanian Experience



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Superficial vein thrombosis (SVT) is less well-studied than deep vein thrombosis (DVT) because it has been considered less serious and is easily diagnosed following clinical symptomatology, and therefore requires mainly conservative treatment.¹ The condition is common and is usually accompanied by clear inflammatory skin changes, and should be denoted as interchangeable with superficial vein thrombophlebitis.²

The saphenofemoral junction is an important anatomic marker when differentiating between SVT and DVT, the latter being a highly probable complication of the initial superficial thrombotic process. Authors diverge in the cut-off values of distance from the junction for the thrombotic process to be considered as a DVT with high probability of lethal consequences, such as a pulmonary embolism. Even in the absence of such a serious complication, DVT can still concur with SVT when thrombus presence is 1-3 cm from the junction.³⁻⁵

Authors still debate over the best treatment option for SVT. A diversity of methods and interventions are advised, including elastic stockings, anti-inflammatory drugs,

anticoagulants, and/or surgery.⁶ Even surgeons are not unanimous when offering such a solution: ligation of the saphenofemoral junction (SFJ), stripping of the varicose veins, and resection of the greater saphenous vein (GSV).^{7,8} The recurrence of varicosities is in fact not the only adversity challenging almost all surgical options; pulmonary embolism is another major event that requires appropriate prevention peri- and intra-operatively, since an extension of the thrombus into the deep venous system is still possible. Apart from concerns over these adversities, authors still debate the best option for treatment of SVT, as well as the best technique, if any.⁹

From January 2012 to December 2016, 120 patients presented at the Service of Vascular Surgery, Tirana, Albania, with truncal varicose veins complicated with thrombosis within 0-5 cm from the SFJ. The mean age of patients was 58 years (range: 34-82 years) with the majority of patients in their 50s. 82 patients were female (68%) and 38 were male (32%). All cases underwent a duplex scan pre-operatively, and the imaging data were associated with the intra-operative findings.

In 24 patients (20% of the cases), in whom the thrombus was 1 cm from the SFJ and with extension into the common femoral vein (CFV), a high ligation was performed after clamping the CFV above and below the junction. In the other group of patients (n=96; 80% of the cases), where the thrombus was 2–5 cm from the SFJ, the CFV was not clamped. The presence of the thrombus within 0–5 cm from the SFJ is likely to be an indication for surgical intervention, albeit other sources suggesting the efficacy of a 45-day anticoagulation therapy.¹⁰

The disconnection of the GSV from the CFV will prevent the extension of the thrombus into the femoral and iliac veins, thus avoiding potentially life-threatening complications such as DVT and pulmonary embolism. What is more, the clamping of the CFV should always be performed when the thrombus has penetrated the later, when it is within 1 cm from the junction, and when the surgeon is not sure whether the junction itself is free. On the other hand, when sonography data suggest a thrombus distance of 2–5 cm from the femoral vein, there is enough space for the operating surgeon to ligate the saphenous vein

without risking a thromboembolic event, and no need to clamp the CFV.

None of the patients suffered from a pulmonary embolism during the procedures. In the second subgroup (96 patients; operated without clamping the CFV) there was one case with DVT, with extension of the thrombotic process into the common femoral and external iliac veins. Another two patients from the same subgroup presented minor symptomatology of pulmonary embolism post-operatively. All three cases with minor complications were successfully treated with rivaroxaban and were discharged within 1 week following the operation. The other patients (117/120) were discharged 2–3 days following the surgery. No serious complications presented in either subgroup within a 3-month follow-up period.

Surgery of GSV involving SFJ is a safe and effective option, when comparing final outcomes with anticoagulation therapy alone; the occurrence of severe adverse complications when anticoagulating patients should also be kept in mind.¹¹

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A New Approach to Percutaneously Treat Chronic Coronary Total Occlusions: The 'Minimalistic Hybrid Approach' Algorithm

EDITOR'S

PICK

Percutaneous recanalisation of coronary chronic total occlusions has traditionally relied upon large-bore introducer sheaths and dual arterial access, with interventions frequently performed via the transfemoral approach. In what seems to be a paradigm shift to a new approach, the Editor's Pick article for this year's issue of *EMJ Interventional Cardiology* by Vescovo et al., describes the 'minimalistic hybrid algorithm' as an alternative procedure to the traditional methods. The authors discuss the choice of starting strategy, which takes into account the type of collaterals (ipsilateral or contralateral) and angiographical features of the lesion. Additionally, the review considers the efficacy and safety of this novel approach, recently assessed in one retrospective and one prospective single-centre study.

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Abstract

Vascular access-related complications are one of the most frequent issues following percutaneous interventions of chronic total occlusions (CTO) because of the traditional use of large introducer sheaths for more back-up catheter support, and the need for multiple access sites, often including femoral access. In current practice, many operators still approach the revascularisation of CTO through femoral access despite the demonstrated advantage of radial procedures, mostly in terms of incidence of bleeding complications. Recently, an alternative strategy to deal with CTO, with the aim to minimise the number of access-related complications without affecting the successful revascularisation rate, has been proposed: the 'minimalistic hybrid approach' algorithm. This approach consists of the use of classic 'hybrid algorithm' techniques, but also aims to minimise the number of access sites, the size of the catheters used, and the adoption of the femoral access.

INTRODUCTION

Percutaneous treatment of chronic total occlusion (CTO) is considered one of the most challenging procedures due to the high incidence of complications and the relatively low success rate compared with non-CTO percutaneous coronary interventions (PCI).¹⁻³ However, the technical advances of the last two decades, the greater knowledge and experience shared by expert CTO operators, and the introduction of specific algorithms for treatment standardisation have led to higher procedural success, especially in high-volume CTO-PCI centres.⁴⁻⁷ Special attention was also given to the unsolved problem of vascular access-related complications because of the routine use of large-bore catheters and the insertion of multiple sheaths, often at the level of the femoral artery. Recently, a modified version of the classic 'hybrid algorithm', called the 'minimalistic hybrid approach (MHA) algorithm', was proposed with the aim to limit vascular complications without affecting the rate of successful revascularisation.⁸ This strategy consists of the use of classic hybrid algorithm techniques, but aims to minimise the number of access sites, the size of the catheters used, and the adoption of the femoral approach.

CHRONIC TOTAL OCCLUSION REVASCULARISATION TECHNIQUES

Four main techniques are commonly used during CTO revascularisation. These are defined as 'antegrade' or 'retrograde' strategies, according to the direction the lesion is crossed (from the proximal to the distal part and from the distal to the proximal part, respectively), and as 'wire escalation' or 'dissection and re-entry' techniques, according to guidewire location during CTO crossing (intraluminal or subintimal, respectively).⁹ Thus, it is possible to distinguish the strategies as follows: antegrade wire escalation (AWE); retrograde wire escalation (RWE); antegrade dissection and re-entry (ADR); and retrograde dissection and re-entry (RDR).

During wire escalation, the operator attempts to cross the CTO while remaining in the true lumen of the vessel. During the attempt, guidewires with higher tip stiffness and more penetration force are used progressively. In the dissection and re-entry techniques, the guidewire is advanced

through the subintimal space and redirected into the true lumen of the vessel once beyond the CTO lesion.

Finally, retrograde techniques are adopted in case of failure of antegrade options or when complex anatomy and a well-developed collateral circulation is present.¹⁰ Collateral circulation consists of a communication between two vessels (contralateral collaterals) or between two segments of the same vessel (ipsilateral collaterals) and represents an alternative source of blood flow for the myocardial area perfused by the CTO target vessel.¹¹ These collaterals are traditionally used by interventional cardiologists during the procedure for obtaining an appropriate view of the coronary anatomy and to reach the distal cap of the occlusion. Guidewires and microcatheters are advanced through collaterals to gain access to the distal lumen of the occluded vessel.¹²

THE 'HYBRID ALGORITHM'

The percutaneous treatment of CTO is associated with a substantial rate of complications. A recent prospective study in CTO-PCI suggested that the percentage of periprocedural complications is considerably greater compared to non-CTO-PCI, with an overall rate of in-hospital major adverse cardiac and cerebrovascular events of 7%.¹³ In particular, clinically relevant coronary perforation was found to be the most common event (4.8%), followed by periprocedural myocardial infarction (2.6%), death (0.9%), and urgent surgery (0.7%). Interestingly, no strokes were recorded among the 1,000 patients included in the registry. However, access site haematoma was seen in 4.3% of the patients, confirming a high rate of vascular-related complications in today's practice. Despite the fact that these rates are still high in the current era, significant improvements have been made over the past years. In particular, the development of PCI-CTO algorithms has contributed to a decrease in the number of complications as well as an increase in the rate of successful revascularisation.⁶

One of the most commonly adopted algorithms, mainly across North America and Europe, is the so-called 'hybrid algorithm', which was proposed by a group of expert CTO operators in 2011.⁵ One of the key elements of this algorithm is the use of the dual injection technique that consists of

the simultaneous engagement and injection of the coronary arteries to improve visualisation of the entire coronary anatomy.¹⁴ More specifically, a first injection is performed at the level of the vessel that provides collaterals (donor vessel), followed 2–3 seconds later by a contralateral injection in the target CTO vessel. Doing so, the contrast reaches the proximal and distal segment of the CTO at the same time and allows visualisation of the entire course of the occluded coronary artery.

One of the main advantages of this technique is that it allows understanding of the exact location of the guidewire, particularly once the body of the CTO is passed. In fact, without the injection from the donor vessel, in many cases it would not be possible to identify the segment beyond the CTO and therefore to discern if the guidewire is inside or outside the lumen of the vessel, with subsequent potential increased risk of complications such as perforation. The dual injection represents the first step of the procedure, allowing the evaluation of the following four anatomical characteristics: the ambiguity of the proximal cap; disease on the distal target (diffuse or not diffuse); the presence of favourable collaterals; and lesion length (<20 mm). Subsequently, the operator can choose the starting strategy among the four aforementioned techniques, but with the possibility during the procedure to quickly switch from one strategy to another because of the presence of a guiding catheter in each coronary artery.

However, despite several advantages provided by the hybrid algorithm, a potential drawback may be represented by the systematic use of the simultaneous double injection. In fact, this requires two sites of access, with an increased chance of vascular-related complications. For this reason, a modified version of the classic hybrid algorithm, the MHA algorithm, has been proposed.^{8,15}

THE 'MINIMALISTIC HYBRID APPROACH' ALGORITHM

The MHA algorithm has been developed with the aim to minimise the number of access sites as well as the size of the introducer sheath. Moreover, the use of forearm (radial/ulnar/distal radial) access is strongly recommended

over the femoral. In fact, despite the lower risk of vascular access-related complications with trans-radial approach, femoral access remains common in CTO-PCI practice;¹⁶ the reason being the complexity of CTO-PCI, which often requires large catheters (7–8 French [Fr]). The main difference between the two algorithms is the use of simultaneous double injection. In the hybrid algorithm, dual injection is mandatory and considered a cornerstone because allowing an optimal visualisation of the entire target vessel (even the distal segment beyond the CTO) seems to make the procedure safer and increase the chance of successful revascularisation. The simultaneous visualisation of the entire vessel acknowledges the relationship between the proximal and the distal cap of the lesion, allowing the operator to point the guidewire towards the proper direction. This is particularly useful when wire escalation techniques with high-penetration-force guidewires are used.

As mentioned, the aim of the MHA is to reduce the number of access sites and to minimise the size of the sheaths, in order to decrease the rate of vascular complications. To do so, the authors suggest choosing the access according to five different scenarios the operator may deal with. The initial set-up in all cases is represented by a single 6 or 7 Fr sheath (trans-wrist). Thus, simultaneous double injection is not considered unavoidable in this algorithm.

The MHA recommends a careful evaluation of the anatomy in order to plan the procedure and to choose the best technique for each specific scenario. Performing a good coronary angiography in the procedural planning using the MHA is even more important than in the classic hybrid algorithm due to the lack of simultaneous dual injection during the procedure. Very long films performed by a single catheter allow analysis of the collateral circulation and the characteristics of the CTO. When in doubt, a 'stepwise double injection' is strongly recommended before starting the PCI, with sequential assessment of the donor artery first and the CTO artery afterwards using one single arterial access site.

Using the angiographical features, the type of collaterals, and the technical preference of the operator, it is possible to choose between five different approaches (Figure 1).

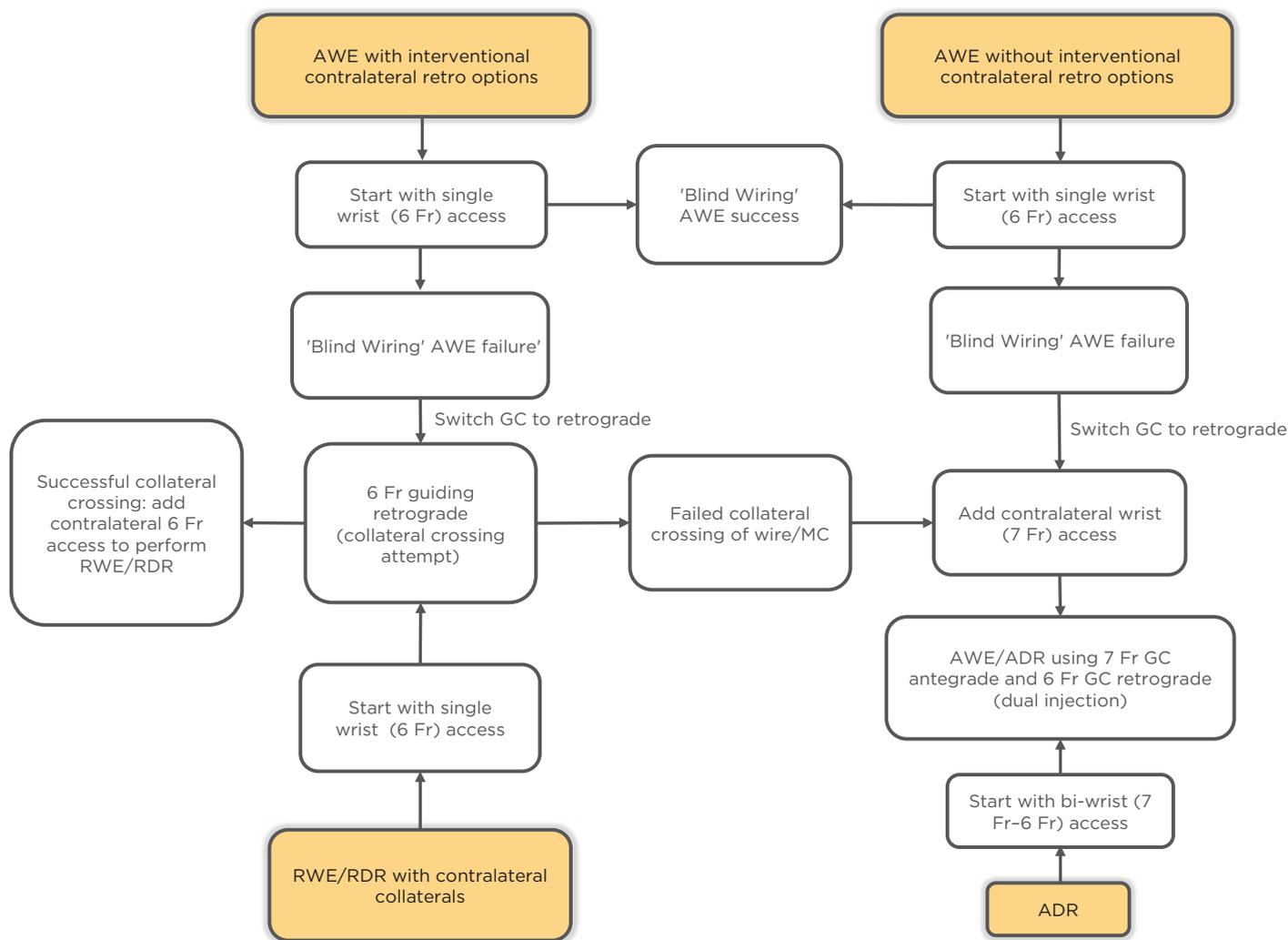


Figure 1: ‘Minimalistic hybrid approach’ algorithm flowchart.

Choice of set-up according to the starting strategy.

ADR: antegrade dissection and re-entry; AWE: antegrade wire escalation; Fr: French; GC: guiding catheter; MC: microcatheter; RDR: retrograde dissection and re-entry; RWE: retrograde wire escalation.

1. Antegrade Wire Escalation as First Choice, Contralateral Interventional Collaterals Available for Retrograde Options in Case of Antegrade Wire Escalation Failure

In this case, the operator decides to start the procedure with the AWE technique using a single 6 Fr sheath in the forearm. The operator starts by using hydrophilic guidewires with low penetration power (e.g., Fielder XT-R; Asahi Intecc Co., Seto, Japan) to pass through the lesion while remaining inside the lumen of the vessel. Sometimes, an appropriate visualisation of the distal vessel is

not possible with only a single injection due to the presence of competitive flow between the target and the main vessel. This specific scenario in which the lesion crossing is performed without seeing the distal segment beyond the CTO has been defined as ‘blind wiring escalation’. Therefore, the operator should be guided by tactile feedback more than visual feedback.

For this reason, in this specific procedure step, the use of hydrophilic guidewires with intermediate- or high-penetration-force that present a scarce tactile feedback is not recommended and should be avoided because of a higher risk of perforation. In case of failure of the blind wiring

escalation attempt, the operator should switch to a retrograde attempt; in doing so, the operator proceeds to remove the catheter from the CTO vessel and switches it with another guiding catheter to cannulate the contralateral vessel (using the same access as before, thus remaining 'single access'). Afterwards, the donor vessel is engaged in order to cross the collaterals, reach the distal cap of the CTO, and try to face the lesion in a retrograde fashion. If the operator is able to cross the collaterals with the guidewire and the microcatheter, a second 6 Fr sheath is placed in the contralateral wrist and a 6 Fr guiding catheter is used to cannulate the CTO vessel followed by RWE or RDR. If, however, it is not possible to cross the collaterals, a second 7 Fr sheath is placed in the contralateral wrist in order to engage the CTO vessel with a 7 Fr guiding catheter and cross the lesion by means of AWE technique, using guidewires with greater penetrative powers and the double injection, or with ADR.

2. Antegrade Wire Escalation as First Choice with a Lack of Contralateral Interventional Collaterals for Retrograde Options

When the operator decides to start the procedure using the AWE technique but no contralateral interventional collaterals for the retrograde approach are available, a single 6 Fr sheath trans-wrist is used. First, an antegrade attempt with low-penetration-power guidewires is completed in a 'blind wiring' fashion. In case of failure, the operator switches to more advanced antegrade techniques such as the AWE with guidewires with greater penetrative force or ADR. To do so, the 6 Fr guiding is changed for a guiding that fits the donor artery and a second 7 Fr sheath is placed in the contralateral wrist to engage the CTO vessel with a 7 Fr guiding catheter. The original 6 Fr access is used to place a 6 Fr guiding catheter in the donor vessel in order to perform the contralateral injection and obtain a better visualisation of the distal target vessel anatomy (double injection), which is mandatory to make the procedure safer.

3. Retrograde Wire Escalation/ Retrograde Dissection and Re-entry When Contralateral Collaterals

Represent the Main Source of Interventional Collaterals

In this approach a single wrist access with 6 Fr sheath is recommended as the initial set-up to cross the contralateral collaterals. If the operator is able to reach the distal segment of the target vessel via collaterals with a guidewire and microcatheter, a second 6 Fr sheath is placed in the contralateral wrist to finalise the retrograde strategy (RWE/RDR). If it is not possible to cross the collaterals, antegrade advanced techniques remain the last options (AWE with intermediate- or high-penetrative-force guidewires or ADR) and a guiding catheter with more internal space is needed. Thus, a second 7 Fr sheath should be inserted into the contralateral forearm in order to place a 7 Fr guiding catheter in the CTO vessel.

4. Antegrade Wire Escalation Without Interventional Collaterals

The set-up in the case of ADR consists of double trans-wrist access (7 Fr and 6 Fr introducer sheath) because of the need for simultaneous double injection for clear visualisation of the target vessel course. A 7 Fr guiding catheter is placed in the CTO vessel, while a 6 Fr guiding catheter is inserted in the donor vessel for contralateral injection. All of the different techniques (AWE, RWE, RDR) are possible in case of ADR failure.

5. Any Antegrade or Retrograde Approach in Case of Ipsilateral Collaterals

When ipsilateral collaterals are the main source of collateral visualisation, the insertion of a single 7 Fr introducer sheath (trans-wrist) is suggested. This set-up allows the use of all four techniques. However, when the operator fails to cross the lesion with a single catheter, a second 6 Fr sheath can be placed in the other wrist to add a second catheter in the same coronary vessel and allow 'ping-pong' techniques.

STRENGTHS AND WEAKNESSES OF THE 'MINIMALISTIC HYBRID APPROACH' ALGORITHM

The advantage of the modified hybrid algorithm is represented by the minimisation of

double access, sheath size, and trans-femoral approaches, potentially reducing the number of vascular-related complications as well as the discomfort for the patient. However, some critical issues have been raised.

The Use of Blind Wiring Technique

Blind wiring has been considered the main weakness of the algorithm because it does not follow one of the 'commandments' of CTO operators: the simultaneous double injection. According to some expert opinions, the lack of dual injection could make the procedure less safe due to poor angiographic visualisation and consequent increased risk of perforation and tamponade. However, by using soft guidewires in this particular setting, it is possible to tackle the lesion without increasing this risk of perforation. A recent publication showed the safety of a single-catheter approach in a small group of patients with CTO undergoing percutaneous revascularisation.¹⁷

Obtaining Second Access in the Middle of the Intervention

The need to obtain second access during the procedure, after the patient has already received a full dose of heparin, could impose a higher risk of access site bleeding. However, a strategy to minimise this risk is to use forearm approach or use ultrasound guidance when femoral access is needed.

The Use of Small-Bore Catheters

In some scenarios a 6–7 Fr catheter could be inappropriate because of the lack of enough support. To overcome this drawback, the authors recommend the use of supportive catheters such as the Amplatz left catheter for the right coronary artery or an oversized extra back-up catheter for the left coronary artery. Additional tools such as guide extension devices should be used with low threshold in case of inadequate support.

It must be noted that the use of single-access and small catheters make the CTO procedure, which is already challenging when approached with standard techniques, even more complex.

Because of this, the MHA is aimed for expert CTO interventional cardiologists, with deep knowledge of material properties, awareness of the potential drawbacks, and long experience in the use of the classic hybrid algorithm as well as forearm access.

EFFICACY AND SAFETY OF THE 'MINIMALISTIC HYBRID APPROACH' ALGORITHM

The efficacy and safety of this new approach have been recently evaluated in one retrospective and one prospective single-centre study. In the former, a group of 91 patients were treated with the MHA algorithm. The authors observed a success rate of 89.0%, a perforation rate of 2.2%, and no vascular complications. Interestingly, in 52 (64.2%) cases there was no need for a second access to achieve procedural success. Finally, when compared with the conventional treatment, despite the small number of patients in the classic hybrid approach group, no differences were found between the two approaches with respect to successful revascularisation.¹⁸ These results have been confirmed in a consecutive series of 56 CTO-PCI, showing a success rate of approximately 91%, achieved with single trans-wrist access in 33 out of 56 patients (58.9%). Periprocedural complications occurred in three (5.5%) cases, with only one perforation and one vascular complication (pseudoaneurysm of distal radial artery).¹⁹ These studies confirm a low rate of complications comparable with previous large registries.

CONCLUSION

The MHA algorithm shows encouraging results and may represent a valid alternative to the classic hybrid algorithm, with the advantage of reducing the risk of vascular-related complications without increasing the rate of perforation or affecting the frequency of successful revascularisation. However, further large, multicentre studies are needed to confirm these preliminary results and to evaluate the reproducibility of the algorithm by other CTO operators.

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A Rare Finding: A Left Atrial Cavernous Haemangioma

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Abstract

Background: Cardiac haemangiomas are extremely rare, benign tumours that can arise from any heart structures. Although patients may present with a range of symptoms, the majority are asymptomatic and picked up incidentally on imaging or at autopsy. Echocardiography, cardiac MRI, and coronary angiography are the main imaging modalities for diagnostic work-up. Surgical resection is the recommended treatment, with good post-operative outcomes.

Case Presentation: The authors present a case of a 69-year-old female with a subacute history of dyspnoea and weight loss. A CT scan to screen for malignancy revealed a possible filling defect within a prominent left atrial appendage. Further cardiac imaging with transoesophageal echocardiography and cardiac MRI confirmed a mass in the left atrium, which was initially thought to be an atrial myxoma. Following successful surgical resection, histology demonstrated characteristic features of a benign cavernous haemangioma.

Conclusion: The authors present a rare finding of a cardiac cavernous haemangioma. Although cardiac haemangiomas are more often found on the right side of the heart, this case demonstrates a left atrial appendage haemangioma, which is very unusual. The importance of multimodality imaging is also demonstrated. Definitive treatment is surgery, with follow-up often involving surveillance transthoracic echocardiography to ensure no recurrence.

BACKGROUND

While cardiac tumours have been documented since the 1500s, first featuring in Italian anatomist and surgeon Colombo's 'De re anatomica' ('On Things Anatomical')^{1,2}, it was not until 1952 that Banhsen and Newman performed the first successful open surgical excision of a primary cardiac tumour, followed by Crafoord et al. in 1954 using a cardiopulmonary bypass.^{3,4}

The incidence of primary cardiac tumours discovered at autopsy is around 0.02%, with 75% of these being histologically benign.⁵ Cardiac haemangiomas are extremely rare, accounting for approximately 1-2% of all primary cardiac tumours. They are benign vascular tumours that can occur in any chamber of the heart, predominantly on the right side, with only 7% of cases arising from the left atrium, which was seen in this case.^{6,7} They may occur in any of the three cardiac layers: the

endocardium, myocardium, and pericardium. They are rarely found in the intra-atrial septum, intraventricular septum, or on the valves.

Cardiac haemangiomas are characterised microscopically by benign proliferative endothelial cells lining blood vessels, with increased vascularisation.⁶ They are classified into three subgroups, according to histological appearances: cavernous (composed of vessels with wide lumens), capillary, and arteriovenous malformations (angiodyplasias).^{8,9}

As patients are commonly asymptomatic, cardiac haemangiomas are often discovered incidentally on imaging or revealed during autopsy. However, depending on the anatomical location of the tumour, patients can present with breathlessness, congestive heart failure, chest pain, syncope, pericardial effusion, and valve stenosis. Although benign histologically, if left untreated, cardiac haemangiomas can rupture or give rise to conductive and haemodynamic abnormalities, resulting in significant morbidity and mortality.¹⁰ Therefore, surgical resection is the treatment of choice. There are case reports of conservative management approaches without obvious major complications in adults where resection was deemed too high-risk.^{11,12}

CASE PRESENTATION

A 69-year-old female was referred by her general practitioner to an elderly care clinic with worsening exertional dyspnoea and fatigue for 3 months. She also reported an unexplained 3 kg weight loss in the same period, with no change in her lifestyle to account for this. Her exercise tolerance was unlimited on flat ground; however, she could only complete a flight of stairs at a slow pace, being limited by fatigue and breathlessness.

Her past medical history included chronic obstructive pulmonary disease, breast fibroadenoma, kidney stones, solitary lipoma removal, and a recent diagnosis of paroxysmal atrial fibrillation. She was an ex-smoker (20 pack-years) and had a family history of diabetes and stroke. Her medication history included lansoprazole, inhaled tiotropium, inhaled budesonide and formoterol fumarate, inhaled salbutamol, and flecainide. Physical examination was normal, with a blood pressure

of 137/80 mmHg and a regular heart rate of 67 beats per minute.

INVESTIGATIONS

Baseline investigations demonstrated normal renal function, full blood count, C-reactive protein, plasma viscosity, bone profile, CA125, liver function, thyroid function, vitamin B12, and folate. Her ferritin was only mildly raised at 167 µg/L. Chest X-ray showed emphysematous changes.

A CT scan of the chest, abdomen, and pelvis to screen for malignancy demonstrated a prominent atrial appendage, with a possible filling defect (Figure 1A). There was no evidence of lymphadenopathy. Given the recent diagnosis of atrial fibrillation, the mass was initially considered to be a thrombus. Transoesophageal echocardiography (Figure 1C) did not clearly show the left atrial appendage (LAA) as it appeared either compressed externally or largely replaced/full of a mass. The mass appeared heterogeneous and larger than her CT at 39x60 mm. There was no obvious invasion into surrounding structures and one view showed flow within. There were no other structural abnormalities.

She went on to have a cardiac MRI (cMRI; Figure 1D). This showed a mass originating from within the LAA and measuring approximately 50x35 mm, with no invasion beyond this. There was homogeneous signal on T1-weighted sequences, some heterogeneity on T2-weighted sequences, and hyperintensity on T2 short tau inversion recovery (fat saturation) sequences (Figure 2). Real-time imaging during gadolinium administration suggested some perfusion but not extremely brisk. In the early phase following gadolinium there was heterogeneity, with some uptake and other areas which appeared avascular. There was no significant compression of other cardiac or vascular structures. The mass most likely represented a LAA myxoma with possible thrombus.

Given her progressive dyspnoea and the potential risk of life-threatening complications such as embolism and arrhythmia, she was referred for surgical excision of the LAA mass.

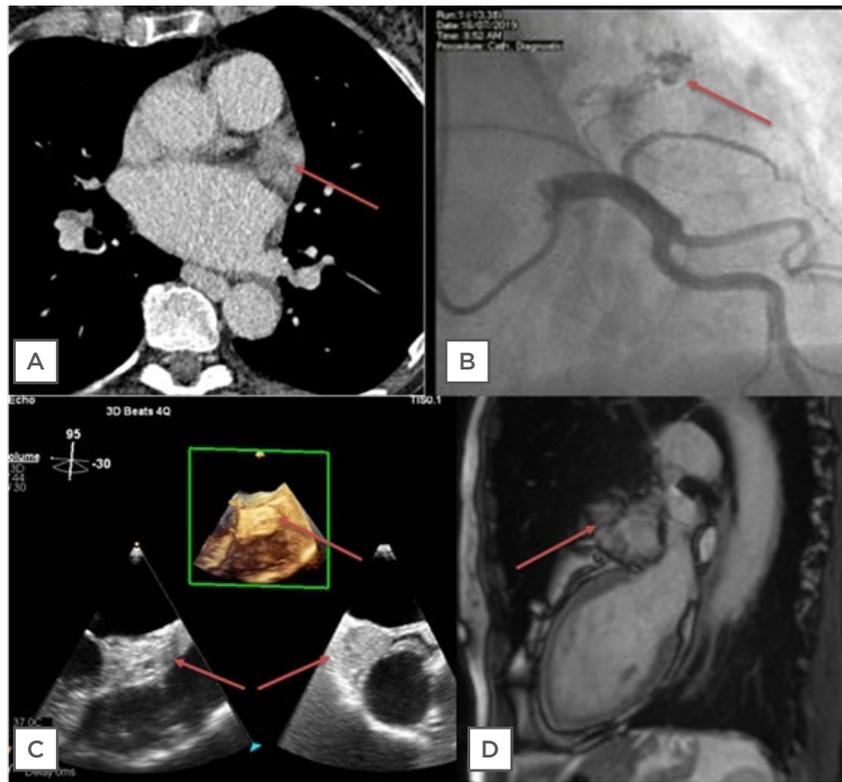


Figure 1: Imaging modalities, with cardiac mass highlighted by red arrow. A) Transverse section on CT; **B)** right anterior oblique cranial view on angiography showing neovascular formation supplying haemangioma; **C)** transoesophageal echocardiography with 3D imaging showing a left atrium mass; **D)** sagittal section on cardiac MRI.

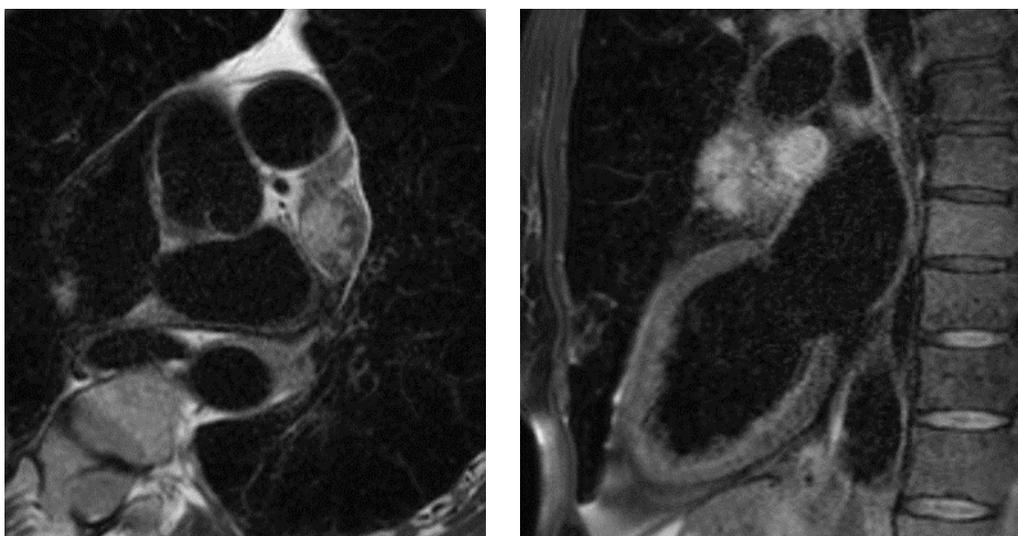


Figure 2: T2 STIR MRI images with fat suppression. A) Transverse section; **B)** sagittal section. STIR: short tau inversion recovery.

She subsequently underwent coronary angiography as a work-up for surgery. This demonstrated normal coronary arteries and a vascular blush through the tumour (Figure 1B).

TREATMENT

She underwent surgical resection, and histology demonstrated sections of atrium containing a well-circumscribed lesion, comprising multiple thick- and thin-walled blood-filled vascular channels, with foci of papillary endothelial hyperplasia. There was no evidence of atypia or necrosis. The histological findings were characteristic of a benign cavernous haemangioma.

Following surgery, she was repatriated to the local district general hospital for post-operative rehabilitation, which was complicated by hospital-acquired pneumonia requiring intravenous antibiotics and pulmonary oedema requiring treatment with intravenous administration of furosemide.

In a 3-month follow-up clinic she reported a reduction in peripheral limb oedema but ongoing breathlessness and chest tightness. This was attributed to resolving pleural effusions and chronic obstructive pulmonary disease. Unfortunately, the patient developed recurrent chest infections and is under the respiratory team for further follow-up. A 1-year follow-up transthoracic echocardiogram demonstrated no recurrence of the haemangioma.

DISCUSSION

Cardiac haemangiomas are rare benign cardiac tumours that are histologically like that of their extracardiac counterparts. They develop from proliferation of endothelial cells and pericytes. As mentioned previously, they can be divided into three subgroups: cavernous, capillary, and arteriovenous malformations. The histological appearances of the capillary subgroup demonstrate a myxoid matrix with capillary-sized vessels, endothelial cells, pericytes, and fibroblasts. The cavernous pattern consists of large, dilated vascular spaces with either thick or thin walls. Lastly, the arteriovenous pattern is characterised by

heterogeneous dysplastic vessel types with muscularised vessels or irregular, thickened wall diameter and, on occasion, containing fibrous and fat tissue. However, cardiac haemangiomas may be a combination of the three patterns. Immunohistochemistry can reveal expression of typical endothelial markers including CD31, CD34, and factor VIII.

Cardiac haemangiomas, including cavernous haemangiomas, are generally sporadic in nature and can be found in all areas of the heart but rarely in the epicardium or valves.^{9,13} The authors' case demonstrated a cardiac haemangioma in the LAA, which is very rare. Han Y et al.¹⁴ reviewed 56 cases and found that most cardiac haemangiomas were found on the right side of the heart, with 7% seen in the left atrium. Cardiac cavernous haemangiomas are slightly more commonly seen in females and can occur at any age.¹⁰

There are several cardiac imaging modalities available for the work-up of a suspected cardiac tumour, each with varying benefits and limitations (Table 1). Transthoracic echocardiography is an effective, non-invasive investigation with a sensitivity of 93% and is particularly useful in diagnosing tumours within the ventricles. Transoesophageal echocardiography provides a slightly more effective diagnostic modality, particularly for tumours within the atria (97% sensitivity).¹³ Echocardiography in general can be utilised to assess size, morphology, attachments to adjacent structures, extension, and haemodynamic effects and can improve intracavity definition, assess vascularity, and exclude thrombus. CT is established in its use to assess chest and lung tissue and corresponding vascular structures, assess masses involving the coronaries, and exclude coronary artery disease and calcified masses. PET can be useful for differentiating between benign and malignant lesions, staging malignancies, optimising biopsy location, and planning radiotherapy in certain circumstances. cMRI is considered the gold standard imaging modality for assessing possible cardiac tumours. It is non-invasive and produces high-resolution images without using ionising radiation.¹⁵

Table 1: Advantages and disadvantages of different imaging modalities for assessment of a suspected cardiac tumour.

Imaging Modality	Advantages	Disadvantages
TTE	<ul style="list-style-type: none"> Non-invasive 93% sensitivity More effective for the evaluation of ventricle-based tumours Real-time observation Does not require contrast material or radiation exposure Low cost and portable 	<ul style="list-style-type: none"> Less specific than MRI in soft tissue characterisation, including differentiation between tumour and thrombus Image quality affected by body habitus and lung pathology (e.g., emphysema) Tumour size may be difficult to quantify Tumour origin, such as from the superior vena cava or branch pulmonary vessels, may not be identifiable Limited assessment of extracardiac structures
TOE	<ul style="list-style-type: none"> 97% sensitivity Good views of the atria and LAA Real-time observation Does not require contrast material or radiation exposure Effective in differentiating structural features, such as site of attachment 	<ul style="list-style-type: none"> Invasive procedure Less specific than MRI in soft tissue characterisation May require sedation or general anaesthetic Limited assessment of extracardiac structures
CT	<ul style="list-style-type: none"> Non-invasive Allows assessment of nearby structures Exclusion of coronary artery disease and calcified masses Fast acquisition times Cancer staging 	<ul style="list-style-type: none"> Radiation exposure Risk of contrast-induced nephropathy Less effective than MRI at evaluating soft tissue structures
PET	<ul style="list-style-type: none"> Non-invasive Differentiating benign and malignant lesions, especially when combined with MRI Biopsy location and radiotherapy planning 	<ul style="list-style-type: none"> Can lack anatomical information Small tumours may not be detectable Involves a radioactive element Limited availability in some centres Affected by blood sugar levels and oral intake timings
cMRI	<ul style="list-style-type: none"> Non-invasive High-resolution images Does not use ionising radiation Gold standard for evaluation for possible cardiac tumours Evaluating tumour vascularity 	<ul style="list-style-type: none"> Requires contrast material Long acquisition times Limited availability Contraindications include claustrophobia and older generation cardiac devices
Coronary angiography	<ul style="list-style-type: none"> Assessment of coronary artery disease prior to surgical intervention Can demonstrate tumour blood flow 	<ul style="list-style-type: none"> Invasive with risk of complications Limited assessment of tumour size, structure, and extension

cMRI: cardiac MRI; LAA: left atrial appendage; PET: positron emission tomography; TOE: transoesophageal echocardiography; TTE: transthoracic echocardiography.

cMRI can effectively assess morphology, dimensions, location, extension, and infiltration into adjacent tissue, and characterise histopathology.¹⁶ Coronary angiography is useful pre-operatively to assess for coronary artery disease as coronary artery bypass grafting can be undertaken at the same time as resecting the tumour. It can also demonstrate the blood supply to the tumour and reveal the characteristic vascular blush, which is associated with many cardiac tumours. Interestingly, the vascular blush seen with most cardiac tumours, including haemangiomas, is not typically associated with the cavernous subtype because of the large vascular spaces that promote very slow flow.¹¹ However, coronary angiography did reveal this finding in the authors' case.

Tumour resection can occur under extracorporeal membrane oxygenation installed using aortic and bicaval venous cannulation, with concomitant valve surgery if required. Post-operative complications may include arrhythmia, major bleeding into the chest, renal dysfunction, and wound

infection. As a consequence of the low incidence of haemangiomas, large cohort published studies are rare in regard to post-operative survival; however, one article reported survival following resection similar to a standard population but recommended close follow-up with annual echocardiography for the first 4 years minimally.¹⁷

LEARNING POINTS

Cardiac cavernous haemangiomas are rare benign tumours more commonly seen in the right heart; this case demonstrated a LAA cavernous haemangioma, which was unusual. Surgical resection is the recommended approach to management to relieve symptoms and reduce the risk of life-threatening complications, including tumour rupture, embolism, arrhythmia, and haemodynamic compromise. There are a number of imaging modalities to assess cardiac tumours. cMRI remains the gold standard for assessment because of its non-invasive nature and production of high-resolution images.

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Rare Right Ventricular Obstructing Myxoma: An Incidental Finding for a Common Symptom

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Abstract

Background: Palpitations are a common clinical manifestation within the general population and are often associated with conduction abnormalities within the heart. Structural causes account for only 3% of palpitations. As such, they are often investigated with cardiac event/Holter monitoring. Presented here is a case of palpitations secondary to intracardiac mass.

Case summary: A 58-year-old female patient presented with palpitations. The electrocardiogram was unremarkable. Transthoracic echocardiography revealed a large, mobile mass visualised in the right ventricular outflow tract. Further investigations, including cardiac CT and cardiac MRI, confirmed a right ventricular myxoma, which was successfully surgically excised. There has been no evidence of recurrence or long-term morbidity.

Discussion: Myxomas are extremely rare and most commonly present with signs of heart failure, thromboembolic events, or constitutional symptoms. Palpitations are a usual presentation of cardiac masses. Myxomas carry a high risk of sudden death through thromboembolic events or dysrhythmias, therefore immediate intervention is essential. From the findings, patients presenting with palpitations are recommended to undergo a transthoracic echocardiogram to identify the possibility of palpitations secondary to structural variants or abnormalities.

Learning Points: If there are no haematological or biochemistry abnormalities, and no risk factors for palpitations were ascertained, patients presenting with palpitations should ideally have a transthoracic echocardiogram, in addition to Holter monitoring, to rule out a structural cause for their clinical manifestation. Structural abnormalities noticed on echocardiography are better characterised with cardiac MRI as it provides both structural and possible tissue characterisation.

BACKGROUND

Primary intracardiac tumours are very rare, with an incidence of 0.02% of which myxomas are the most common.^{1,2} Commonly affecting the mid-aged female population, myxomas are typically located within the atrium (93%) and rarely within the ventricular systems (6–8%).^{1,3} The clinical phenomenology and adverse outcomes are dependent on several factors: size, location, and the extent to which they interfere with the cardiac conduction system.^{1,3,4} Myxomas classically present as a triad of symptoms: malaise, low-grade fever, and joint pain.^{1,5,6} These masses, despite being histologically benign, pose a high risk to patients, increasing the risk of dysrhythmias and thromboembolism, which result in the risk of sudden death.^{1,4}

Myxomas are typically investigated using a combination of transthoracic echocardiography (TTE) and transoesophageal echocardiography (TOE). Urgent surgical intervention is usually the definitive treatment. Recurrence is extremely unlikely in resected isolated tumours.^{1,5} Here, a case is presented of an incidental finding of right ventricular outflow tract (RVOT) myxoma obstructing the flow across the pulmonary valve in a patient with palpitations, which was successfully treated with surgical resection.

CASE REPORT

A 58-year-old female patient was referred to the cardiology clinic due to palpitations. Her main complaint was sporadic palpitations that had been ongoing for several months, worsening with exertion but with no resultant presyncope or syncope. There were no reported constitutional symptoms and no evidence/risk factors for thromboembolic disease. Her comorbidities included that of chronic kidney disease Stage 3B, hyperlipidaemia, rheumatoid arthritis, and Crohn's colitis.

Clinical examination confirmed haemodynamic stability and an ejection systolic murmur, heard loudest in the pulmonary area. The electrocardiogram showed sinus rhythm at 80 beats/min and no ischaemic changes. Her blood results were generally normal, with no evidence of electrolyte abnormalities, anaemia, or thyroid disease (haemoglobin: 129 g/L; mean

corpuscular volume: 95.8 fL; thyroid stimulating hormone: 1.54 mU/L). There was no history of consumption of excessive caffeine, alcohol, or carbonated drinks, and she denied use of illegal or recreational drugs.

A cardiac event monitor revealed mainly sinus tachycardia (maximum heart rate approximately 158 beats/min) with isolated atrial and ventricular premature beats. The TTE discovered a large, mobile mass visualised in the RVOT before the pulmonary valve, obstructing the flow across the RVOT/pulmonary valve with a peak gradient of 48 mmHg. The biventricular size and systolic function were normal. A cardiac CT showed low attenuation and a mildly enhancing, spherical mass in the right ventricular outflow tract, contiguous with the pulmonary valve (Figure 1). Further characterisation with a cardiac MRI (CMR) showed a hypointense, 41x19x23 mm polypoidal lesion attached by a narrow stalk to the anterior wall of the right ventricle outflow tract, 38 mm proximal to the pulmonary valve annulus. The lesion had a lobulated smooth surface and prolapsed across the pulmonary valve in systole, resulting in a transvalvular gradient of 47 mmHg (Figure 2). The T2-weighted MRI tissue characterisation was in keeping with a myxoma. CMR confirmed normal biventricular size and function and there was no extracardiac lesion on CT thorax, abdomen, or pelvis.

The patient underwent resection of the right ventricular outflow tumour following discussions with the cardiac surgeons (Figure 3). A post-procedural transoesophageal echocardiogram showed good left ventricle (LV) and right ventricle function with no valve lesion. Since the operation, the patient remained clinically asymptomatic. Their repeat TTEs at yearly intervals between 2017 and 2019 were all normal, with no evidence of tumour recurrence or intracardiac thrombus.

DISCUSSION

Although myxomas are the most common type of intracardiac masses, RVOT myxomas are extremely rare.⁷ The patient presented atypically with persistent tachycardia and complained of palpitations during exercise but showed no classical features. Although a common complaint within the general population, structural causes for palpitations only account for approximately

3% of all palpitations.⁸ Given that the patient's clinical account did not identify obvious risk factors, combined with grossly normal phlebotomy, electrocardiogram, and Holter monitoring results, an echocardiogram was performed, which identified the tumour in the RVOT. Previous case reports have referenced the 'tumour plop', relating to a characteristic

sound caused by atrial myxomas occurring in up to 15% of cases,¹⁶ which could have been the murmur heard on auscultation in the patient. The palpitations, especially during exertion, could be explained by the obstruction of the RVOT by the myxoma, resulting in reduced cardiac output, which can cause tachyarrhythmias.

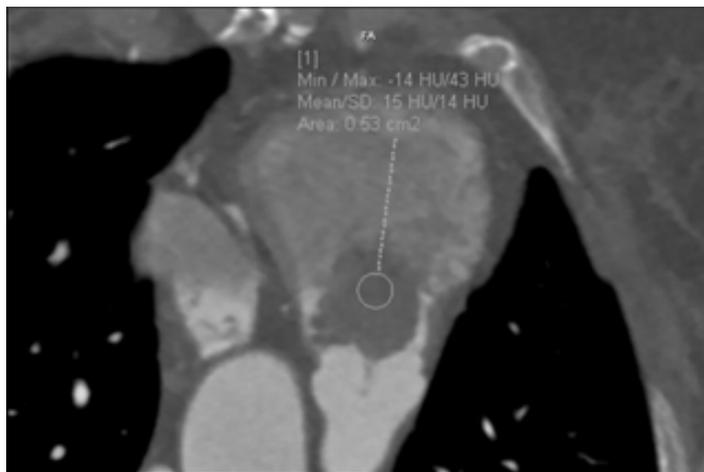


Figure 1: Prospective gated CT coronary angiogram.

Scan phase brought forward to opacify the right ventricular outflow tract, which showed a 1.8x2.5 cm, low-attenuation, mildly enhancing, spherical mass in the right outflow tract contiguous with the pulmonary valve.

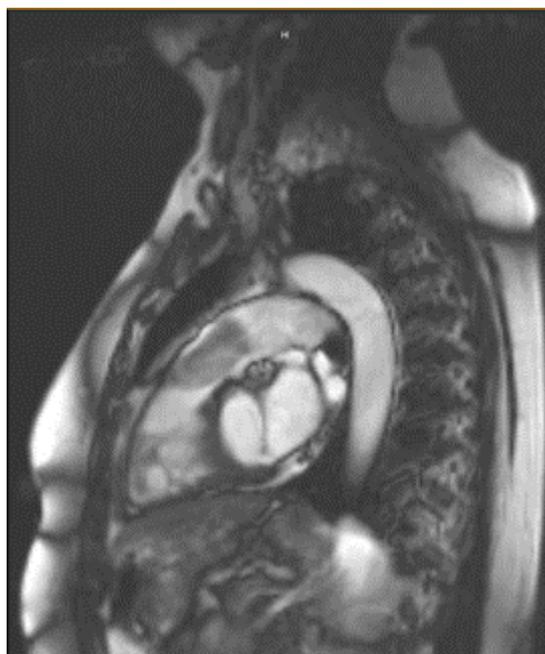


Figure 2: Cardiac MRI.

Hypointense, 41x19x23 mm polypoidal lesion attached by a narrow stalk to the anterior wall of the right ventricle outflow tract 38 mm proximal to the pulmonary valve annulus.



Figure 3: Image of the resected tumour.

The complications of large RVOT myxomas include RVOT obstruction, causing congestive heart failure, pulmonary embolism due to embolisation into the pulmonary arteries, vena cava syndrome, and restrictive cardiomyopathy.⁷ Given the high-risk nature of these tumours, in keeping with recommendations from previous cases,^{1,4,5,9} swift surgical intervention was undertaken, which was curative with no recurrence evidenced as of yet.

Early radiological evaluation of the tumour and immediate surgical intervention has led to a good prognosis in this patient. As such, the patient did not develop thromboembolic complications and maintained her normal right ventricular function throughout, which could have declined if there had been a delay in assessment and treatment. By acting as such, the risk of future catastrophic events and morbidity were reduced.

TTE plays an important and timely role in the evaluation of the patient with palpitations and can detect up to 95% of all myxomas.¹⁰ Detailed morphological analysis is best conducted using CMR given its potential to spin echo image intensities, which aid in differentiation between cardiac tumours. However, it is important to recognise that a cardiac CT in comparison to CMR scans are much faster, more accessible, have fewer contraindications, and can also offer important information that may be of greater clinical value in an emergency.

The post-procedure TOE confirmed normal left and right heart function without any evidence of procedural cardiac complications. It is understood that this is a common practice, as it aids a qualitative and visual estimation of the LV function¹¹ and assesses for any procedural cardiac complications. Given that studies^{11,12} have shown comparable results between TTE and TOE in determining LV function, and with the additional benefits of TTE being less invasive, easier to use, and more patient-friendly, the patient underwent serial TTEs post-operatively.

Existing case reports present cases with downstream clinical consequences of cardiac masses and have always recommended that early diagnosis and surgical resection could have been curative and thus, prevent complications.^{13,14} Taking these recommendations on board, this case illustrates one of the very few reports on the early identification of a cardiac myxoma using multimodal imaging and curative surgery. Immediate surgical intervention was of both symptomatic and prognostic benefit to this patient. Additionally, the case highlights that it is essential to keep an open mind to the possibility of rare findings to common symptoms, and illustrates the importance of non-invasive cardiac imaging modalities in the diagnosis of structural causes to a common clinical problem, such as palpitations.

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Fatal Cardiovascular Collapse During Trans-aortic Transcatheter Aortic Valve Replacement Following Intra-procedural Retrograde Transcatheter Heart Valve Migration into the Left Ventricular Outflow Tract

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Abstract

Transcatheter heart valve retrograde migration after transcatheter aortic valve implantation is unusual. It can occur during the implantation of the aortic transcatheter heart valve, i.e., intra-procedural, or in the first few days following the intervention. Transcatheter valve embolisation and migration soon after deployment typically results from the implantation of a prosthesis that was undersized for the annulus, an unreasonably low implantation, or the expulsion of the device following deployment by an excessive ventricular contraction. The presented case highlights the importance of the timing of the complication that has taken place, in this case, intra-procedural, which has become relevant to the research.

INTRODUCTION

Transcatheter valve embolisation and migration (TVEM) into the left ventricle (LV) is especially significant and requires conversion to an emergency surgical technique, with unusually high mortality reported.¹ TVEM may be responsible for extreme acute aortic regurgitation and cardiogenic shock. Although transcatheter

aortic valve replacement (TAVR) is less invasive than a surgical aortic valve replacement, periprocedural complications remain common. Among these is an uncommon but serious complication of prosthesis displacement into the LV, requiring emergency cardiac operation related to high mortality rates.²

The authors present a rare case of intra-procedural retrograde migration of the transcatheter heart

valve (THV), potentially linked to low implantation in a native aortic valve with extreme asymmetric calcification, which presented as a sudden-onset, electro-mechanical dissociation leading to fatal cardiovascular collapse.

CASE REPORT

A 77-year-old female was admitted with complaints of progressive breathlessness on exertion, New York Heart Association (NYHA) Class III. She had experienced an anterior wall myocardial infarction in 2008 and underwent percutaneous coronary intervention to the left anterior descending artery (LAD). Clinical and echocardiographic examination confirmed the presence of severe aortic stenosis and calculated a logistic Euro SCORE of 26. The patient was frail; her Society of Thoracic Surgeons (STS) risk score was 5.3%.

She was referred to the institutional heart team, who considered her for TAVR as a first option. Her echocardiogram showed fair LV function

(ejection fraction 55%) with hypokinesia of the distal interventricular septum and apical segments, severe calcified aortic stenosis with a valve area of 0.6 cm², and a peak/mean gradient of 88/55 mmHg.

Coronary angiography revealed a patent LAD stent with non-obstructive plaques in the LAD and right coronary artery. A multidetector CT scan revealed diffuse atherosclerotic changes in the ascending aorta particularly; there was dense calcium at the sino-tubular (ST) junction. The CT-derived measurements of the ascending aorta and aortic annulus measured a mean aortic annulus diameter of 21 mm, perimeter of 66.9 mm, and annulus area of 322.5 cm². The left coronary ostial height was 11.4 mm and the right coronary ostial height was 13.2 mm (Figures 1A, B). The size of both external iliac arteries was borderline for the balloon-expandable THV; the right external iliac artery was smaller than the left. Hence left femoral artery approach was preferred, particularly as the right femoral artery also had moderate tortuosity with mild stenosis (Figure 1C).

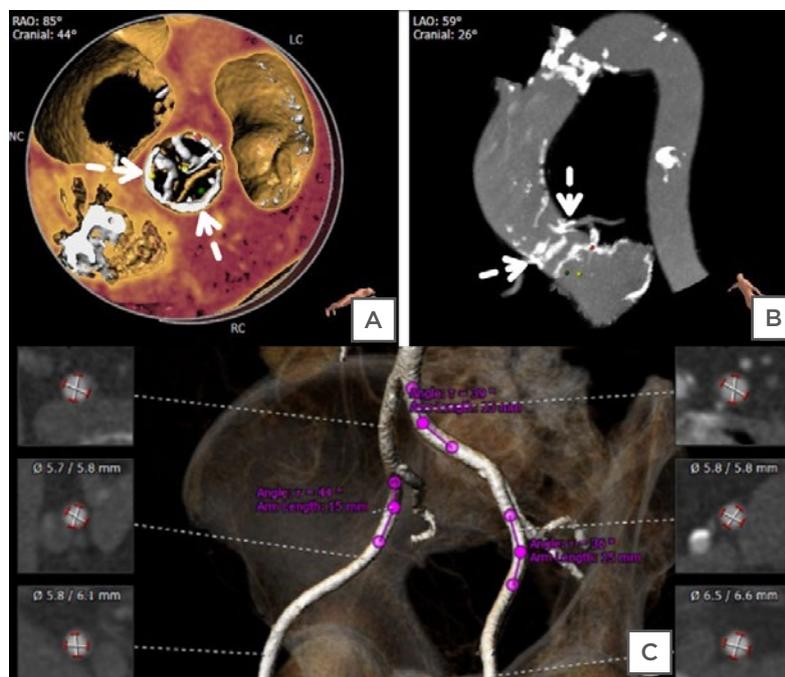


Figure 1: Computed tomography of the ascending aorta.

A, B) 3D reconstruction obtained with 3mensio software (Pie Medical Imaging, Maastricht, Netherlands) showed the presence of a thick, unequal calcified arc (>180°) at the sino-tubular junction (dashed arrows) and annular calcium extending to the left ventricular outflow tract. **C)** 3D reconstructed volume-rendered image of the iliofemoral arterial system revealed that the right common iliac artery had mild stenosis and was mildly tortuous. The left iliac artery had less tortuosity without major stenosis.

The trans-femoral TAVR under general anaesthesia via a left femoral artery approach proceeded under the fluoroscopic and transthoracic echocardiographic guidance (Figures 2A, B). A 14 French (Fr) expandable Python introducer sheath (Myval, Meril Lifesciences Pvt. Ltd, Vapi, India) could traverse without any resistance (Figure 2C). A balloon aortic valvuloplasty was performed using an 18x40 mm balloon under rapid right ventricular pacing at 180 beats/minute (Figures 2D, E). Balloon-expandable THV (Myval, Meril Lifesciences Pvt. Ltd, Vapi, India) could not cross the left femoral artery despite

hard push (Figure 2F). The authors then took the introducer sheath outside and attempted to dilate it with larger 16 Fr sheath dilators; they then tried balloon dilatation of the inline sheath to increase the internal diameter of the sheath and allow the balloon THV to pass through. Also considered was direct vascular access via arteriotomy for insertion, but this was ruled out due to the extensive surgical dissection. Before the closure with Proglide™ devices (Abbott Vascular, Redwood City, California, USA), a repeat angiography was performed to rule out any vascular complications.

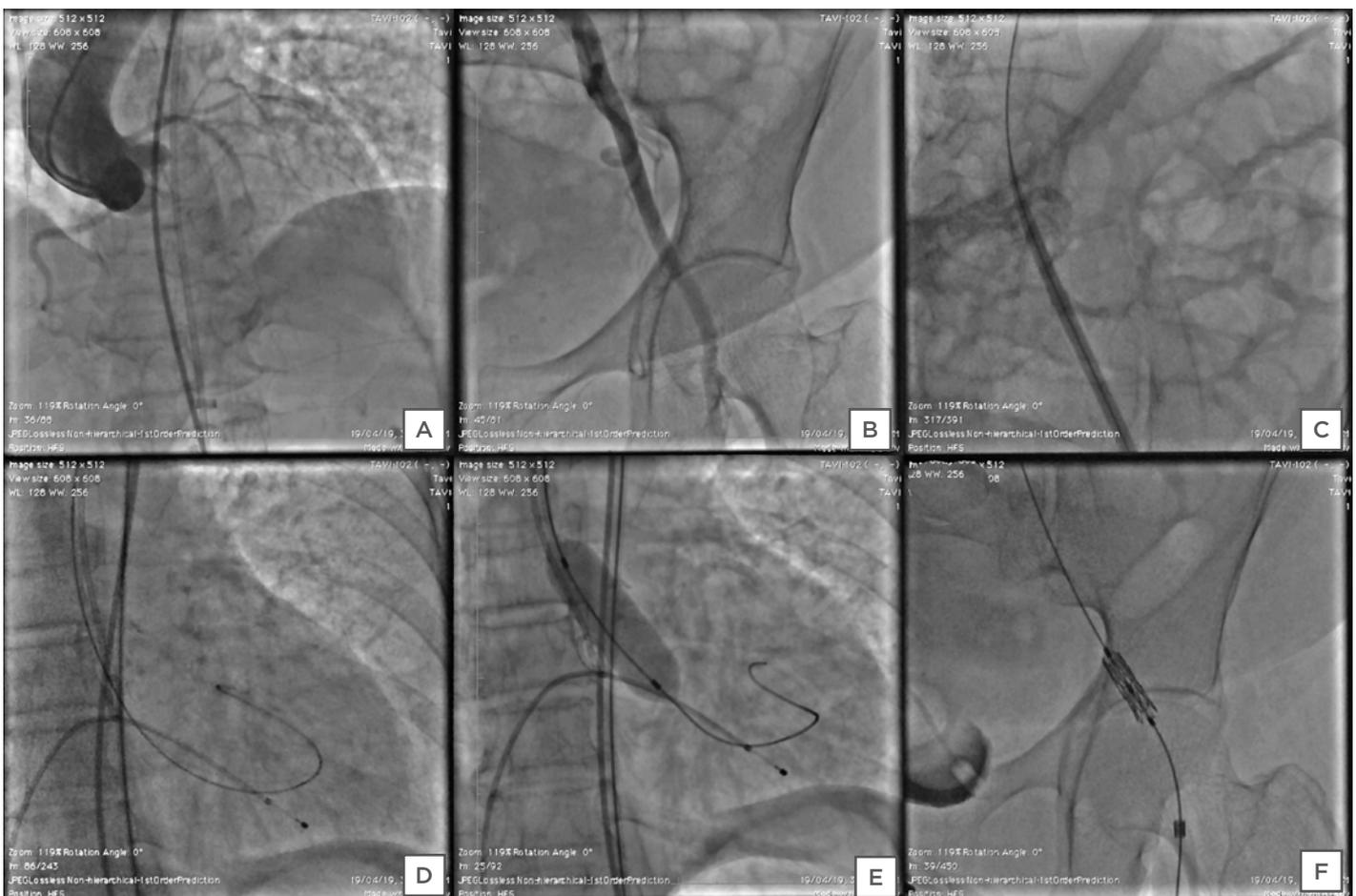


Figure 2: Stepwise procedure of the trans-femoral transcatheter aortic valve implantation.

A) Baseline aortic root angiography demonstrated a calcified aortic valve with mild aortic regurgitation, and visualisation of the ascending, arch, and descending thoracic aorta and coronary arteries. **B)** The pigtail was inserted into the common right femoral artery through a contralateral crossover, showing that the common femoral artery was considered appropriate for a trans-femoral approach due to the good calibre and lack of anterior calcifications. **C)** 14 French introducer sheath was inserted trans-femorally across the left iliac artery into the aorta without any resistance. **D)** After the crossing of the aortic valve with 0.035" straight-tip wire with the support of an Amplatz Left catheter, the pre-shaped Super Stiff™ Amplatz wire was exchanged into the left ventricle. **E)** Pre-dilatation of the aortic valve was performed using an 18x40 mm Z-Med™ balloon (NuMED, Inc., Hopkinton, New York, USA). **F)** The balloon-expandable aortic valve was unable to cross through the left common iliac artery.

The Heart Team decided to switch to a direct access, with a trans-aortic approach. Trans-aortic access was obtained through upper partial J-shaped sternotomy to the right third intercostal space. Two pledged purse-string sutures were placed at the designated spot, which was identified both by finding a calcific-free spot in the preoperative multidetector CT and by palpating the aorta directly at a minimum distance of 5 cm from the aortic annulus. The insertion of a soft wire and a 6 Fr catheter was performed with a direct needle puncture (Figure 3A). After the crossing of the aortic valve with the wire, a pre-shaped Super Stiff Amplatz guidewire (Boston Scientific, Marlborough, Massachusetts, USA) was placed in the LV, followed by insertion of the 14 Fr expandable insertion sheath into the ascending aorta (Figure 3B). After the

deployment, X-ray fluoroscopy demonstrated that the prosthesis had moved partially into the LV outflow tract (Figures 3C, D). The patient fell into cardiopulmonary arrest. After a few minutes of resuscitation with pharmacological agents and internal cardiac massage, her vital signs improved but remained imperfect with wide pulse pressure. The cardiothoracic surgical team performed open midline sternotomy and cardiopulmonary bypass and found a stressed, distended LV that may be attributed to acute aortic regurgitation. Due to heavy calcification of the ST junction, aortic root, the cardiothoracic surgeon could mount 17 mm of the aortic prosthetic valve. The patient was unable to be resuscitated and died due to persistent hypotension and electro-mechanical dissociation, notwithstanding attempts by the heart team.

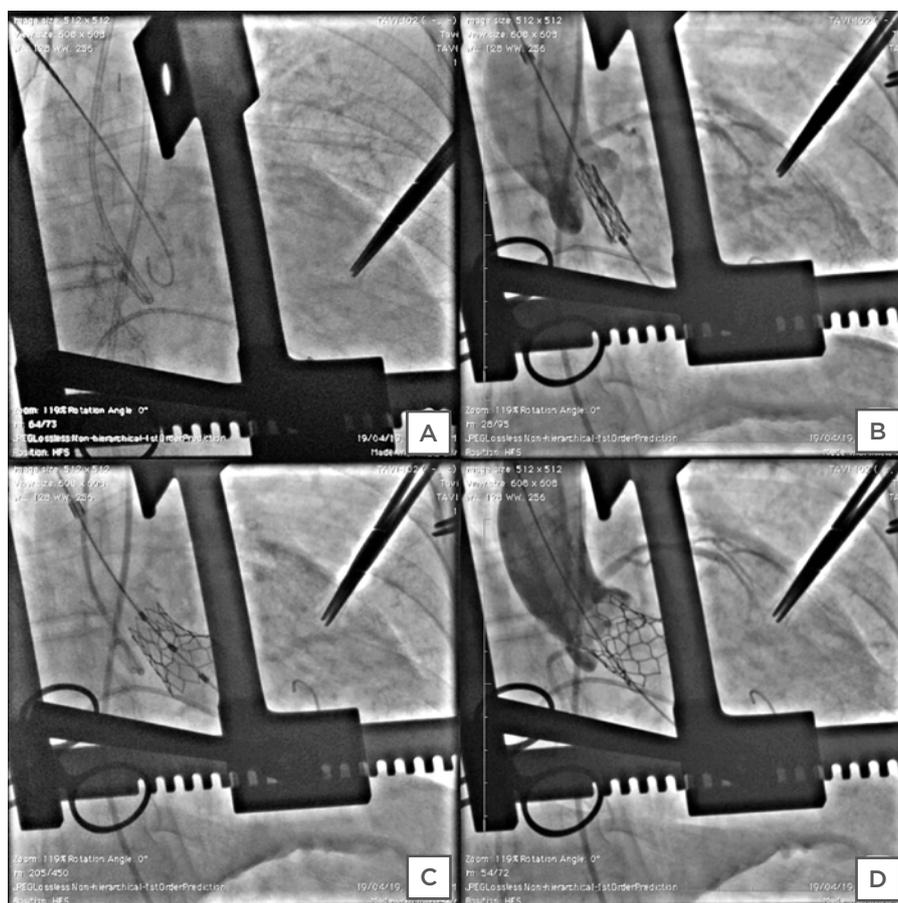


Figure 3: Stepwise procedure of the direct trans-aortic transcatheter aortic valve implantation.

A) The Super Stiff™ Amplatz wire was crossed across the aortic valve. **B)** The optimal positioning of the transcatheter heart valve before the deployment. **C)** Upon dilatation of the lead to uneven expansion of the balloon-expandable transcatheter heart valve, the proximal end of the valve remained unexpanded while the distal end of the valve expanded fully. **D)** Aortic root angiography revealed migration of the transcatheter heart valve to the left ventricular outflow tract with electromechanical dissociation, leading to cardiovascular collapse.

DISCUSSION

A valve that migrates to the ventricle unnecessarily can be associated with adverse effects such as mitral insufficiency, arrhythmia, or aortic injury. Prosthesis embolisation shortly after deployment is generally the result of a grave error in the placement or ejection of the system during deployment via an appropriate ventricular contraction.³

Malpositioning of the valve is often recognised as an important factor leading to the occurrence of paravalvular aortic regurgitation as well as weak haemodynamics of the THV, compromise of the mitral valve, and abnormalities in conduction.⁴ Precise balloon-expandable valve placement requires knowledge of the motion and shortening of the THV during implantation. Acute severe aortic insufficiency can cause hypotension and shock following TAVR. Hypotension and wide pulse pressure on the arterial trace may suggest the diagnosis, with failure to maintain good diastolic pressure after TAVR. Major transvalvular regurgitation after TAVR is rare and is typically associated with acute failure of the structural valve. This may include rupture of the prosthesis or malfunctioning leaflet ('frozen leaflet'), which is rare but a possible complication following TAVR. Alternatively, to solve the problem, prompt cardiopulmonary bypass and surgical valve replacement may be necessary.³ After its introduction, the trans-aortic procedure has been well adopted by heart teams and has become a viable choice for severe vascular disease that impedes trans-femoral transcatheter aortic valve implantation (TAVI), with 95% procedural success and 2.1% conversion rate to surgical aortic valve replacement as in the present case.⁵

Kim et al.⁶ studied periprocedural TVEM in their retrospective 'TRAVEL registry', which collected data from 26 international centres, finding that it occurred in 0.92% of cases. The use of first-generation prostheses and the existence of a bicuspid aortic valve were independent predictors of TVEM. Bail-out steps included manoeuvring of the THV using snares or various devices (41.0%), the valve in the valve or multiple implantations (83.2%), and transition to surgery (19.0%) as happened in the present case.⁶

The criteria recently established by the Valve Academic Research Consortium (VARC)-2

may further standardise definitions of post-operative complications.⁷ Causes of TVEM were recorded by each site after an in-depth review of procedural documentation and angiographic images, and were classified as procedural, structural, or anatomical, due to a sizing failure or unspecified. TVEM that occurred acutely during the intervention was listed as the most common intra-procedural type and 20.5% occurred in the LV, as in the present case. Further, thorough research found that the most common individual causes of TVEM were malpositioning (50.2%), interference (20.9%), post-dilation (5.9%), sizing error (5.1%), and rapid-pacing failure (4.8%), or unknown (5.5%).⁶

Conversion to surgery occurred in 19.0% of cases of TVEM and the rate was higher in ventricular TVEM than in aortic TVEM (41.1% versus 13.4%, respectively; $p < 0.001$); the surgical conversion rate was compulsory 12.8%, as in the present case. The overall majority of patients needing cardiopulmonary assistance was 21.6% and comprised cardiopulmonary bypass 17.2%, but the result was worse for all the attempts involving conversion to surgery.⁸

In a study by Makkar et al.,⁹ the mortality rate associated with TVEM was even higher (46.2%); that may have been attributed to the exclusive use of balloon-expandable systems, which, due to a higher probability of ventricular embolisation, involve a surgical procedure more frequently.⁹

Too-low positioning in the LV causes the leaflets to be exposed or creates a leaflet overhang, which leads to severe central aortic regurgitation. Although a small quantity of native leaflet overhang is not uncommon, particularly at the commissures of the aortic valve where the leaflet is attached to the ST junction, it may cause complications by leaving a significant amount of calcified, rigid leaflet above the THV. Various studies have enlisted few risk factors for implant embolisation/migration, such as improper sizing of the TAVI valve, limited or non-uniformly distributed calcification of the aortic annulus, inadequate location of the implant too high or too low in the annulus, or post-deployment native leaflet overhang exerting a downward force on the prosthesis.¹⁰

The cases of TVEM in the LV outflow tract were predominantly related to the use of the balloon-

expandable SAPIEN XT prosthesis (Edwards Lifesciences, Irvine, California, USA), similar to the present case. Free embolisation into the LV is almost impossible due to the use of self-expanding THVs. With repositionable prostheses, the risk of embolisation or migration can be reduced further.^{10,11}

Intra-procedural TVEM was associated with increased acute and mid-term mortality and morbidity. Notably, a large proportion of TVEM tended to be preventable. But there are few unpreventable causes secondary to technical issues or complex anatomy as in our case.⁶

The authors believe that the low implantation coincided with severe asymmetric calcification of the ST junction. Non-uniformly dispersed calcification may prevent adequate anchoring and full expansion of the prosthesis. Furthermore, it should be remembered that the retrograde force on a closed valve during diastole was shown to be approximately 10-fold the antegrade force during systole, which would have contributed to the dislocation towards the LV.¹²

KEY LEARNING POINTS

TVEM is an unlikely circumstance; prevention requires several considerations:

- Careful pre-procedural co-ordination, including precise assessment of the aortic annulus using multidetector CT as a benchmark.
- Choice of the most suitable prosthesis shape and size for the specific patient.
- Appropriate implantation strategies.
- Ensuring proper temporary pacing.
- Effective closed-loop communication between operators, assistants, and technicians.^{13,14}

The overwhelming majority (94.5%) of patients had a specific cause of TVEM, the majority

of which were procedure-related, such as malpositioning, manipulation, post-dilatation, and fast-rate pacing malfunction. The authors found three potential causes for this intraprocedural TVEM in the present case: 1) malpositioning, with low valve positioning due to rapid deployment in unstable trans-aortic positioning; 2) inadequate valve expansion; and 3) asymmetric heavy aortic valve calcification.

PERSPECTIVE

Knowledge in TVEM management ought to be a requirement for TAVI teams. Access to cardiothoracic surgery is needed, as is the availability of percutaneous material for THV extraction. Aside from proper TAVI preparation, education, and implementation techniques, advances in delivery systems can reduce the risk of TVEM even further. Later generations of self-expanding and mechanically expanding THVs should have retrieval choices that remain in effect until the prosthesis is implemented. However, due to the inherent presence of THV interference with the native valve system and the lack of suture-based fastening, TVEM will continue to be a challenge of the TAVI procedure.

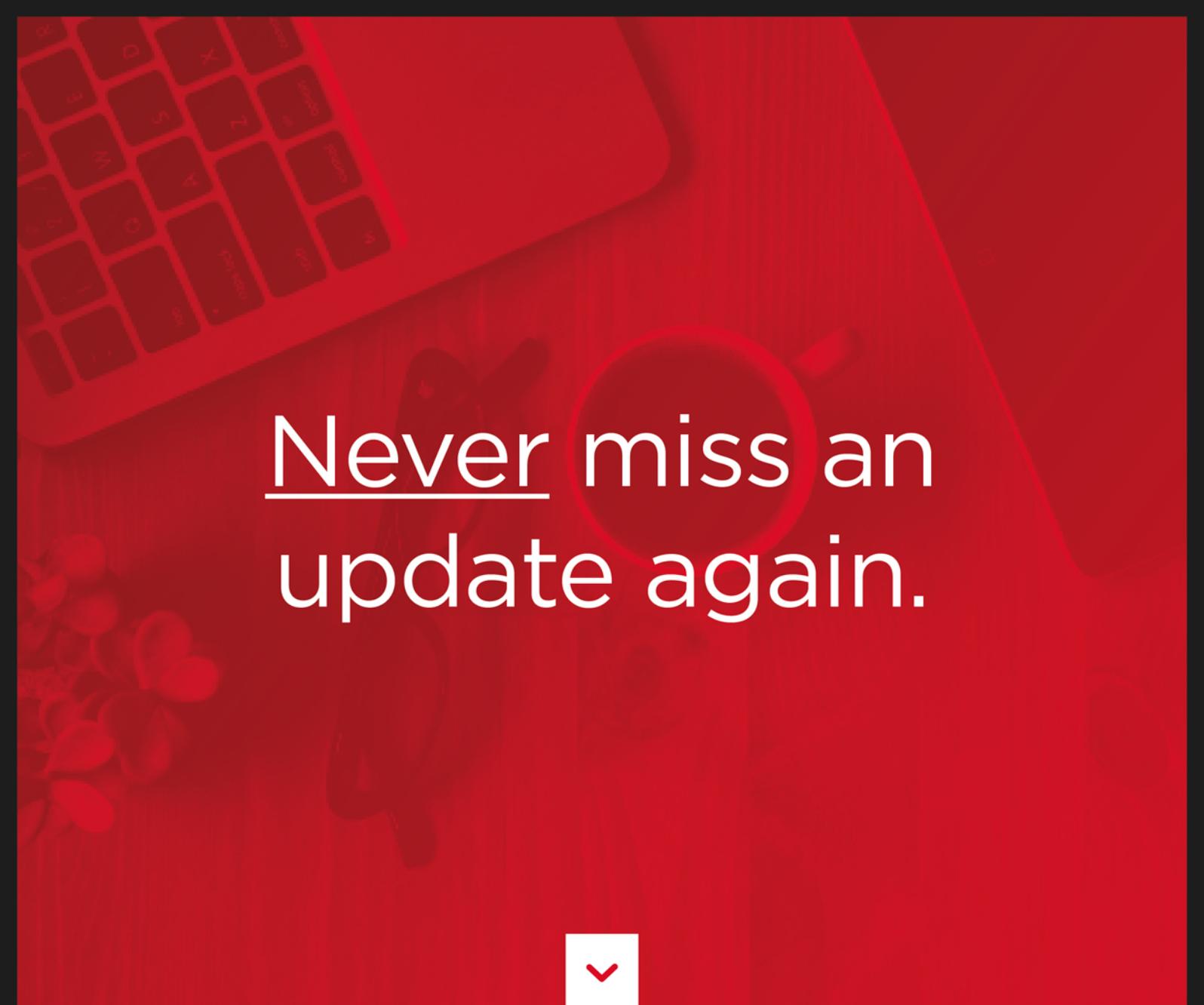
CONCLUSION

Intra-procedural retrograde migration of the THV is an unusual complication after TAVR. THV displacement into the outflow tract of the LV after deployment is associated with cardiovascular shock and the need for emergency cardiac surgery, and usually has poor outcomes. The gaps in knowledge concerning TVEM are connected not only with clinical outcomes but also with timing, causes, and strategies for bail-outs. Additionally, further research into the re-sheathable new-generation systems may be helpful to avoid such complications in the future.

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