European Journal of Cardio-Thoracic Surgery 59 (2021) 522–531
doi:10.1093/ejcts/ezaa402 Advance Access publication 18 January 2021

POSITION STATEMENT

Cite this article as: Leonardi S, Capodanno D, Sousa-Uva M, Vrints C, Rex S, Guarracino F *et al*. Composition, structure, and function of heart teams: a joint position paper of the ACVC, EAPCI, EACTS, and EACTA focused on the management of patients with complex coronary artery disease requiring myocardial revascularization. Eur J Cardiothorac Surg 2021;59:522–31.

Composition, structure, and function of heart teams: a joint position paper of the ACVC, EAPCI, EACTS, and EACTA focused on the management of patients with complex coronary artery disease requiring myocardial revascularization

Sergio Leonardi [a,b,*], Davide Capodanno[c], Miguel Sousa-Uva[d,e], Christiaan Vrints[f], Steffen Rex [g,h], Fabio Guarracino[i], Héctor Bueno[j,l], Maddalena Lettino [m], Susanna Price[n], Marco Valgimigli[o], and Anders Jeppsson[p,q]

[a] Department of Molecular Medicine, Cardiology Unit, University of Pavia, Pavia, Italy
[b] Coronary Care Unit, Fondazione IRCCS Policlinico S. Matteo, Pavia, Italy
[c] Unità Operativa di Cardiologia, Dipartimento Cardio-Toraco-Vascolare e Trapianti, C.A.S.T., P.O. "G. Rodolico", A.O.U. "Policlinico-Vittorio Emanuele and Università di Catania, Catania, Italy
[d] Department of Cardiac Surgery, Hospital Santa Cruz, Avenue Prof Reynaldo dos Santos, Carnaxide, Portugal
[e] Cardiovascular Research Centre, Department of Surgery and Physiology, Faculty of Medicine-University of Porto, Alameda Prof Hernani Monteiro, Porto, Portugal
[f] Cardiovascular Diseases, University of Antwerp, Antwerp, Belgium
[g] Department of Anesthesiology, University Hospitals Leuven, Leuven, Belgium
[h] Department of Cardiovascular Sciences KU Leuven, Leuven, Belgium
[i] Department of Anesthesia and Critical Care Medicine, Azienda Ospedaliero Universitaria Pisana, Pisa, Italy
[j] Centro Nacional de Investigaciones Cardiovasculares (CNIC), Madrid, Spain
[k] Department of Cardiology, Hospital Universitario 12 de Octubre and Instituto de Investigación Sanitaria Hospital 12 de Octubre (imas12), Madrid, Spain
[l] Facultad de Medicina, Universidad Complutense de Madrid, Madrid, Spain
[m] Cardiology Division, San Gerardo Hospital, ASST-Monza, Monza, Italy
[n] Division of Adult Intensive Care and Cardiology, Royal Brompton and Harefield NHS Foundation Trust, London, UK
[o] Department of Cardiology, Inselspital, University Hospital of Bern, Bern, Switzerland
[p] Department of Cardiothoracic Surgery, Sahlgrenska University Hospital, Gothenburg, Sweden
[q] Department of Molecular and Clinical Medicine, Institute of Medicine, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden

* Corresponding author. Tel: +39 0382 501881, email: sergio.leonardi@unipv.it (S. Leonardi)

Received 26 June 2020; received in revised form 11 July 2020; accepted 19 August 2020

Abstract

Contemporary cardiovascular medicine is complex, dynamic, and interactive. Therefore, multidisciplinary dialogue between different specialists is required to deliver optimal and patient-centred care. This has led to the concept of explicit collaborations of different specialists caring for patients with complex cardiovascular diseases—that is 'heart teams'. These teams are particularly valuable to minimize referral bias and improve guideline adherence as so to be responsive to patient preferences, needs, and values but may be challenging to coordinate, especially in the acute setting. This position paper—jointly developed by four cardiovascular associations—is intended to provide conceptual and practical considerations for the composition, structure, and function of multidisciplinary teams. It focuses on patients with complex coronary artery diseases in both elective and urgent setting and provide guidance on how to implement the heart team both in chronic and in acute coronary syndromes patients, including cases with mechanical complications and haemodynamic instability; it also discusses strategies for clear and transparent patient communication and provision of a patient-centric approach. Finally, gaps in evidence and research perspectives in this context are discussed.

Keywords: Heart team • Multidisciplinary decision-making • Coronary artery disease

INTRODUCTION

There is an increasing emphasis on multidisciplinary decision-making within clinical practice guidelines in patient populations with diverse cardiovascular diseases [1]. Given the potential for individual clinician biases, team-based care has great potential merits. By bridging together specialists of different backgrounds, this approach acts to promote interdisciplinary dialogue with the principal goal of offering a balanced, complementary, evidence- and experience-based approach to patient care. However,

multidisciplinary decision-making has been criticized for its tendency to increase complexity in a number of ways, potentially resulting in diagnostic and treatment delays [2].

Despite proving to be beneficial in diverse patient populations and being consistently recommended as the favoured approach for decision-making by European and American guidelines, heart teams still remain poorly implemented [3]. The wide variation in coronary artery bypass grafting (CABG)-to-percutaneous coronary intervention (PCI) ratios across countries cannot only be explained by different geographical patterns of coronary artery disease (CAD). This is likely due to several reasons potentially including variability in scientific culture, resource availability, local experience, competing economic interests and reimbursement incentives, and/or referral (i.e. specialty) bias.

In 2019, a survey was sent to 1096 European cardiologists on the pattern of use, frequency, and composition of heart teams, mostly (68%) from hospitals with cardiac surgery available onsite (Supplementary material, *Figure*). Almost one out of five respondents (18%) answered that they did not have regularly planned heart team meetings. Typically, the interventional cardiologist, the cardiac surgeon, and the patient's clinical cardiologist were involved while other members, such as the anaesthetist (20%), participated more rarely.

For these reasons, four cardiovascular associations—the Association for Acute CardioVascular Care (ACVC), the European Association of Percutaneous Cardiovascular Interventions (EAPCI), the European Association for Cardio-Thoracic Surgery (EACTS), and the European Association of Cardiothoracic Anaesthesiology (EACTA)—have jointly developed the present collaborative position paper on the composition, structure, and function of heart teams. This article is intended to provide conceptual and practical considerations for multidisciplinary decision-making in patients with complex cardiovascular disease. It discusses strategies for professional and patient communication and promotion of a patient-centric approach; it also provides guidance on optimal implementation of the heart team concept in patients requiring complex myocardial revascularization, from stable angina to acute coronary syndrome including patients with mechanical complications and haemodynamic instability. Finally, gaps in evidence and research perspectives are discussed as so to complement clinical guidelines and bridge the gap between scientific evidence and clinical practice.

Methodology for task force composition and document development

The proposal of a joint, collaborative position paper on the composition, structure, and function of heart teams, has been formulated by the Acute Cardiovascular Care Association to three cardiovascular associations: the EAPCI, EACTS, and EACTA. As collaborative position paper, the document underwent revision and approval from relevant representative each association, typically from the scientific document groups. The manuscript was jointly developed to identify (i) a shared vision for the heart team concept, (ii) practical examples that could facilitate implementation of the heart team in clinical practice in patients with complex CAD, and (iii) research gaps and perspectives. All authors, as well as representatives of each association leadership, approved the content of the manuscript.

PART 1. GENERAL CONSIDERATIONS ON HEART TEAMS

The introduction of multidisciplinary teams for shared decision-making have been successful in oncology where they now represent the standard of care in the management of patients with complex cancers: they provide effective, high-value and safe treatments as well as end-of-life care consistent with individual needs, values, and preferences [4]. This success illustrates some of the potential opportunities of team-based care that could be translated to patients with complex cardiovascular disease. These include mitigation of decision-making biases, enhanced adherence to guidelines and evidence-based treatments toward the common goal of shared decision-making, the 'pinnacle' of patient-centred care. By patient-centred care, we mean a 'care that is respectful of and responsive to individual patient preferences, needs, and values' and that ensures 'that patient values guide all clinical decisions' [5].

Definition and composition

The heart team is defined as a group of different specialists who optimally interact to provide a balanced, unbiased, timely, and—where possible—evidence-based decision-making to patients with complex cardiovascular diseases (*Take Home Figure*). The type of specialists involved primarily depends on the disease of interest: anaesthetists, cardiac surgeons, and interventional cardiologists for patients with complex CAD and/or heart valve disease [1]; infectious disease specialists, microbiologists, imaging specialists, neurologists, and neurosurgeons (in addition to cardiologists and cardiac surgeons) for patients with complicated endocarditis; interventional cardiologists, cardiac surgeons, advanced heart failure, and critical care specialists for patients with cardiogenic shock [6]. Clinical (i.e. non-invasive) cardiologists (typically the treating physicians) are generally responsible to summarize the discussion and communicate with the patient. Other specialists with specific competences within (critical care cardiologists, heart failure, and imaging specialists) or outside the cardiovascular area (geriatricians, nephrologists) may be needed depending on specific concomitant diseases or patients' comorbidities as well as nurses to facilitate seamless care between doctors and patients.

Function

Indications. A heart team is usually indicated when important decisions that intersect multiples specialties have to be undertaken, such as the choice of the mode of myocardial revascularization (surgical or percutaneous) in patients with complex CAD [1]. As timing may be crucial in acute settings, it is essential that urgent/emergency diagnostic or therapeutic algorithms as well as involved professional members to be contacted are agreed upon in advance (e.g. 1-call 'shock line') with predefined and clear communication channels to minimize delays [6]. In these settings, it is helpful to define, in a written institutional heart team protocol, simple decisional pathways based on actionable steps as well as local feasibility and expertise considerations to streamline the process of care. These should include common scenarios and criteria to distinguish between unplanned (urgent/emergency) meeting versus planned decision-making in stable patients.

Considerations for optimal interaction. Interaction between members and interaction of the team with the patient are essential for the heart team success. It is therefore relevant to discuss requirements for balanced relationships between members, detail its structure, and reflect on guiding principle of their governance.

First, each hospital should always produce a written institutional protocol on heart team implementation [*Class I recommendation, level of evidence* (*LoE*) *C*]* [1]. This fundamental document should translate locally relevant guidelines recommendations and considerations based on feasibility and local expertise and address both clinical and operational aspects of the heart team. The institutional protocol should be agreed upon designated representatives of each component and include (i) clear clinical decision pathways (especially for urgent or emergency situations) based whenever possible on scientific evidence and appropriate guidelines; (ii) instructions indicating criteria for selecting patients who should be presented on heart team meetings; and (iii) feasibility considerations and local expertise. The protocol should be regularly revised as new evidence emerges or local facilities/expertise evolve. It should also indicate how often planned meeting should be convened and suggest modality of the unplanned meeting (in person or remote) when rapid decision-making is required. Importantly, institutional protocols must also be established in institutions without onsite cardiac surgery, where interventional cardiology departments should team up with a referral cardiac surgery unit (*Class I, LoE C*) [1]. In this setting, care delivery should be highly coordinated using technology and communications system, such as video or telemedicine consultations, that allow a rapid, accurate, and comprehensive remote assessment. This is especially important when rapid decision-making is required to prevent unnecessary transfers and ultimately optimize resource utilization and patient outcome.

Second, responsibilities, roles, and area of expertise of each component should be clearly outlined in the local protocol, including overlapping areas of expertise (such as assessment of the complexity of coronary anatomy for interventional cardiologist and cardiac surgeons) or areas where other specialists may be needed. This includes team-based considerations on patient ownership and who will be responsible and accountable for implementing the decisions and timelines.

Third, explicit reporting and decision-making tools may be considered to facilitate interactions. While team-based decisions should be informed by and not rely solely on scores [1], the use of validated risk scores, such as the Synergy Between Percutaneous Coronary Intervention With Taxus and Cardiac Surgery (SYNTAX) scores, the actionable SYNTAX II score (that complement the angiographic assessment of the SYNTAX score with clinical variables), the STS score, and the EuroSCORE II, has potential advantages and might therefore be considered to delineate an explicit risk assessment [7]. In general, actionable (i.e. which provide risk/benefit stratification algorithm to inform the decision-making on the preferable therapeutic option) scores should be favoured. If there are other relevant non-cardiovascular comorbidities (such as advanced dementia, advanced hepatic dysfunction or frailty) that are not included in scores calculation, these should be reported in writing and considered for final decision-making. A structured report may be helpful in non-urgent settings (see Supplementary material, *Appendix*).

Last, management of disagreements between members should be addressed. In general, different opinions should be viewed as an opportunity, not as a barrier for decision-making. Concerns and observations by any component should be adequately discussed, analysed, and documented. While there is no monopoly on expertise and any effort should be made to reach a consensus, there may be instances in which a complete consensus may not be achieved. As a guiding principle, the team component with the presumed highest expertise in the area of disagreement should contribute relatively more for the final decision. For example, in case of disagreement on the assessment of the surgical risk, such as low predicted risk based on the score but perceived higher based on other comorbidities, the opinion of the cardiac anaesthetist and surgeon should weigh relatively more than that of the clinical cardiologist or interventional cardiologist. If, after extensive discussion, major disagreements on patient management persist, all information should be transparently and jointly communicated to the patient by the whole team, particularly the treating physician, with the ultimate goal to help patient's decisions and thus avoiding distrust and confusion. In fact in these situations, it is even more important to discuss together as a group and illustrate different points of view, potential advantages, and disadvantages of each discussed option. Providing separate opinions has the potential to generate biased perception, confusion (especially in challenging case or when conflicting evidence is present), and may compromise patient trust.

PART 2. HEART TEAMS IN PATIENTS WITH COMPLEX CORONARY ARTERY DISEASE REQUIRING REVASCULARIZATION

The concept of heart team was first proposed by the task force of ESC/EACTS 2010 Myocardial Revascularization Guidelines and subsequently developed in patients with complex CAD to jointly decide the optimal mode of revascularization, i.e., surgical or percutaneous [8]. In this section, we provide guidance to implement the heart team in these patients and specifically discuss indications, patient communication strategies, and specific considerations on decision-making regarding optimal mode of revascularization.

Indications

Multidisciplinary decision-making is not required in all patients undergoing coronary revascularization but should be considered in patients with complex CAD, including patients with the chronic coronary syndrome (elective patients) or stabilized non-ST-elevation ACS (NSTEACS) [1, 9]. This latter group includes patients admitted for ACS but without evidence of recurrent myocardial ischaemia (symptoms or dynamic ST changes on the ECG) as well as haemodynamic (acute heart failure or cardiogenic shock) and/or electrical instability (cardiac arrest or sustained ventricular arrhythmias) [1, 10]. A separate setting (urgent or emergency indications) is represented by patients with complex CAD and unstable ACS (including STEACS) or patients experiencing mechanical complications.

*Class of recommendations and Level of Evidence provided are reported from the relevant guidelines

Definition of complex coronary artery disease

See Supplementary material, *Appendix*.

Non-urgent indications (patients with a chronic coronary syndrome or stabilized NSTEACS)

Heart team meetings should be regularly planned in elective patients. It would be desirable to plan at least one meeting per week, a situation that appear to be present in a limited number of centres according to our survey.

While heart teams should ideally meet to discuss all stable patients with complex CAD, there may be situations—advanced cancer with palliative care, very elderly, frail patients, reduced life expectancy, and advanced dementia—that indicate futility of and contraindicate an intervention (surgery and/or PCI), and may not require formal heart team meetings. These factors should be jointly and carefully discussed by heart team member representatives and explicitly listed in the written institutional protocol to minimize inappropriate heart team meetings and possible treatment delays. In case of uncertain (or partial) information, heart team should be instead convened to jointly decide optimal diagnostic and treatment strategy.

Urgent or emergency indications

In urgent or emergency settings such as patients with unstable NSTEACS or ACS with persistent ST-segment elevation and complex CAD, a culprit-lesion PCI is generally indicated (*Class I, LoE C*) [10]. In patients with residual multivessel CAD who may benefit from a surgical completion of revascularization (e.g. residual involvement of the proximal left anterior descending coronary artery or significant left main stenosis), heart team discussion may occur after clinical stabilization.

Uncommon but clinically important scenarios include mechanical complications of acute MI, such as papillary muscle rupture or ventricular septal defect. In these situations, CABG with concomitant surgical correction may be considered. A proposed flowchart addressing critical ACS patients is presented in Figure 1. Patients presenting with cardiogenic shock; relative hypotension or tachycardia without signs of end-organ perfusion (pre-shock); a new (or presumably new) loud systolic murmur; or flash pulmonary oedema should routinely undergo emergency echocardiography to diagnose a possible mechanical complication while waiting (and without delaying) coronary angiography (*Class I, LoE C*) [11, 12]. In patients with confirmed mechanical complications without persistent myocardial ischaemia, coronary angiography may be helpful to guide concomitant CABG during surgical correction [12]. In the unusual scenario of a patient with mechanical complications confirmed by echocardiography and suspected persistent transmural myocardial ischaemia (ST elevation or ongoing ischaemic symptoms) from occlusion of an epicardial coronary artery a balloon-only angioplasty may be considered if feasible with IV aspirin and a quickly reversible IV $P2Y_{12}$ inhibitors, such as cangrelor, as a bridge to surgery [13]. In these rare situations, heart team discussion may occur after angioplasty to optimize the timing for surgery. In some very high-risk patients with post-infarction ventricular septal defect, multidisciplinary discussion may include the option of haemodynamic stabilization by intra-aortic balloon pump or extracorporeal membrane oxygenation for a delayed repair as well as consideration for percutaneous ventricular septal defect closure. In urgent or emergency situations, patient communication should be kept as simple as possible and only verbal consent should be considered.

Highlights

- To streamline decision-making in urgent/emergency settings, it is advisable to include in the written institutional protocol predefined decisional steps as formal heart team meeting may delay life-saving care.
- Urgent *ad hoc* meeting restricted to few heart team members may be useful in this setting. A proposed flowchart addressing critical ACS patients is presented (Fig. 1).

Patient communication strategies

In elective patients, communication about the possibility—and mode—of myocardial revascularization should be performed when first consenting for coronary angiography and even earlier (i.e. at the time of indication to angiography) when possible and ideally targeted to patient's health literacy. This is the first important opportunity to illustrate and discuss together therapeutic options that include the cornerstone of optimal medical therapy and the possibility of myocardial revascularization with discussion of pros and cons of percutaneous and surgical revascularization. The treating physician (typically the clinical cardiologist) is generally involved at this stage. If the patient, after adequate consent, expresses a clear preference for one of the options, this

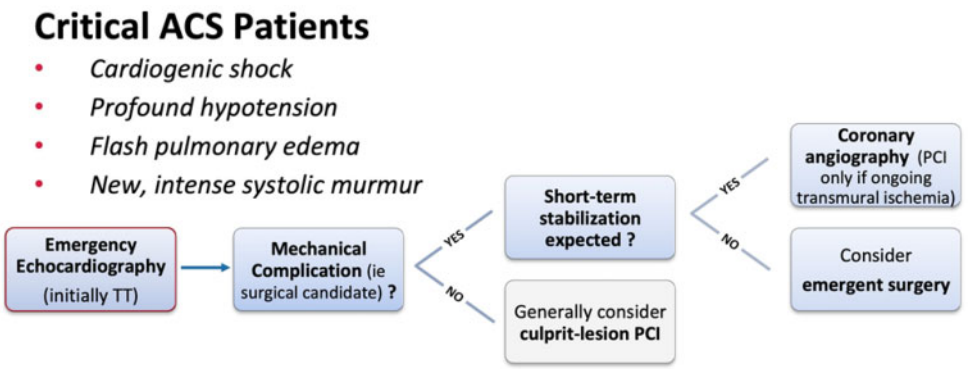


Figure 1. Proposed decision-making flowchart for critical ACS patients with suspected mechanical complications. ACS: acute coronary syndrome; TT: trans-thoracic.

should be preferably reported *in writing* in the clinical chart and considered for decision-making at the time of angiography. The proportion of patients who refuse one type of revascularization before diagnostic coronary angiography may be influenced by the way this is communicated. For this reason, patients who refuse CABG or PCI before coronary angiography could be monitored (Table 1). To allow a balanced, complete, and true multidisciplinary discussion, patient communication after coronary angiography should be ideally performed by all heart team members (surgeon, interventional cardiologist, anaesthetist, non-invasive cardiologist, nurses, and others as appropriate) together and at the same time, according to clinical status (i.e. urgent or not) and local feasibility.

Highlights

- Deciding the mode of coronary revascularization during coronary angiography in elective patients (i.e. stable CAD or stabilized NSTEACS) with complex CAD is discouraged. For the same reason, *ad hoc* PCI in these patients should be generally avoided.

Roles and responsibilities of team components

The primary responsibilities of the clinical (i.e. non-invasive) cardiologist are: to lead and coordinate patient communication (both when consenting for coronary angiography and subsequently during and after team decision-making); to ensure decisions are respectful of and responsive to individual patient preferences, needs, and values; to assess clinical indications for revascularization (ischaemic threshold and consequences of ischaemia on quality of life, presence of myocardial viability) and adequacy of medical therapy; to define clinical factors that may favour PCI or CABG in patients with an indication for revascularization (such as diabetes, coronary artery anatomy, high bleeding risk or contraindications to adequate dual antiplatelet therapy (DAPT) duration, concomitant indications for surgery) and relevant comorbidities, especially if not included in risk scores (such as advanced dementia). The primary responsibilities of the interventional cardiologist are: to quantify anatomical complexity and functional severity of CAD; to anticipate completeness and complexity of percutaneous revascularization (including anticipated contrast-medium volume); to describe general procedural aspects (including number and type of stents, anticipated DAPT duration, other aspects, such as indications of mechanical circulatory support in patients undergoing high-risk PCI). The primary responsibilities of the cardiac surgeon are: to provide an opinion on feasibility; to anticipate completeness and complexity of surgical revascularization; to describe general procedural aspects; to mention specific surgical risks and potential complications. The primary responsibility of the anaesthetist is to assess surgical risk together with the cardiac surgeon and potential measures to reduce this risk.

Notably, there are relevant areas of competence overlap, such as the assessment of the severity of coronary anatomy for interventional cardiologists and cardiac surgeons. In these overlapping areas, the use of objective evidence [i.e. quantitative angiography or fractional flow reserve (FFR)] may limit disagreement on subjective data (i.e. visual degree of coronary stenosis) (*Take Home Figure* and Supplementary material, *Appendix*, Q&A, Case 3).

Table 1: Proposed tools for heart team implementation in patients with complex coronary artery disease (CAD) and stable CAD or stabilized NSTEACS

Indicator	Description	Reporting method	Comments
1. Written Institutional protocol	Presence of a written institutional protocol	Presence: YES/NO	This should be agreed by the representative of each component locally and include explicit eligibility criteria to identify patients; feasibility considerations (e.g. remote video conferencing, timing of planned meeting and, in general, resource utilization), metrics to assess quality and outcome
2. Patients refusal before coronary angiography	Monitoring and reporting of patients who refuse CABG or PCI at the time of consent (and thus before) first coronary angiography among all eligible patients	Proportion	Metric that may capture unbiased communication
3. *Ad hoc* PCI in non-urgent indications without heart team discussion	Monitoring and reporting of patients who receive *ad hoc* PCI with no heart team discussion among all eligible patients	Proportion	Patients who refused CABG while consenting for angiography (to be documented in writing) or patients who were 'waived' as defined by the institutional protocol should not be counted as part of the denominator
4. Anatomical assessment of coronary severity	Monitoring and reporting of patients who had the SYNTAX score calculated and reported in the patient chart among all eligible patients	Proportion	If feasible, this should be calculated by both the interventional cardiologist and the cardiac surgeon
5. Heart Team performed	Monitoring and reporting of patients who underwent local heart team assessment among all eligible patients	Proportion	This should be documented *in writing* in the patients chart and include at a minimum, the clinical cardiologist, the interventional cardiologist, and the cardiac surgeon

Considerations on decision-making and optimal mode of revascularization

The rational for revascularization is provided not only by the presence of severe coronary lesions producing ischaemia but also by an underlying viable myocardium. In patients with normal systolic function, it can be generally assumed that the ischaemic myocardium is viable and should be revascularized. Patients with systolic dysfunction, especially if severe, may need further testing. It is now established that markedly depressed left ventricular function in the patients with ischaemic cardiomyopathy can be reversed with revascularization, particularly surgical [14]. In this setting, advanced imaging, such as cardiac magnetic resonance imaging may be helpful. Based on local availability and expertise, stress echocardiography with low dose dobutamine could also be considered to assess myocardial viability.

Finally, while coronary angiography is still the gold standard worldwide to assess anatomical severity of coronary lesion, the SYNTAX investigators have reported that, in 223 patients with left main or three-vessel CAD, a heart team treatment decision-making based on coronary computed tomography angiography showed high agreement with the decision derived from conventional coronary angiography suggesting the potential feasibility of a treatment decision-making and planning based solely on this non-invasive imaging modality and clinical information [15].

Optimal use (and potential limitations) of scores of coronary anatomical complexity. The SYNTAX score, currently recommended in patients with complex CAD (*Class I, LoE B*) [1] is intended to quantify anatomical complexity of CAD. In brief, each coronary lesion with ≥50% luminal stenosis in vessels ≥1.5 mm is independently scored considering the presence of bifurcations, trifurcations, or aortic ostial localization; chronic occlusion; vessel tortuosity, calcification, length, and thrombus formation. The score of each lesion is added to obtain the patient's final SYNTAX Score, with higher scores indicative of increasingly complex coronary disease. After being derived from the SYNTAX trial, the score has been validated in different patient populations. There are however several independent observations of substantial inter-individual variability in calculating the SYNTAX score [16]. This may have implications for adoption of SYNTAX score in clinical decision-making [16].

The residual SYNTAX score was developed to quantitatively assess the degree and complexity of residual stenoses, based on recalculating the SYNTAX score after PCI [17]. High residual SYNTAX scores have been associated with worse outcome in patients undergoing angiography-guided PCI [18, 19]. Therefore the anticipated completeness of revascularization by PCI or CABG should be considered and prioritized for decision-making (*Class IIa, LoE B*).

The functional significance of a lesion, based on FFR or instantaneous wave-free ratio, is a more important determinant of future adverse cardiac events in patients undergoing PCI than angiographic severity [20]. Percutaneous coronary intervention of lesions that are angiographically but not functionally significant can be deferred safely with good long-term outcomes in stable patients [21]. In patients with stable angina and NSTEACS undergoing FFR-guided PCI, residual angiographic disease as assessed by the residual SYNTAX score was not predictive of adverse outcome, supporting the concept of functionally complete revascularization [22].

Highlights

- The calculation of SYNTAX score should be performed by experienced operators and ideally confirmed independently by both the interventional cardiologist and the cardiac surgeon.
- Functional assessment of coronary lesions (invasive or non-invasive) should be routinely considered to guide revascularization in stable patients in cases of lesions of intermediate-grade stenosis (i.e. 50–90% by visual assessment) or without documented ischaemia.
- If functional assessment was not (or cannot be) performed, the residual SYNTAX score is useful to verify if the revascularization was anatomically complete.

Percutaneous coronary intervention: anatomical and procedural considerations

In approaching complex CAD by means of PCI, the heart team has to factor several anatomical and procedural decision-making considerations.

Multivessel disease may present either with single, relatively short lesions, or with complex, long and calcified lesions located along the three main epicardial vessels. The SYNTAX score was originally conceived with the aim of standardizing the anatomical extension of coronary atherosclerosis. The information conveyed by the SYNTAX score calculation includes aspects that are relevant to PCI complexity, such as the extent of myocardium at jeopardy (e.g. a lesion in the proximal left anterior descending artery does not match the risk of a lesion located in the apical portion of the vessel) and a number of lesion characteristics that convey higher peri-procedural and long-term ischaemic risk in patients when treated with PCI (e.g. when the lesion is long, the vessel is tortuous, the disease is diffused, or when bifurcations or chronic total occlusions are present). Complex PCI procedures may also require higher contrast-medium volume, and thereby higher risk of acute kidney injury. In multivessel disease patients with high SYNTAX score, if surgery is deemed contraindicated by the heart team (e.g. due to comorbidities or poor quality of distal vessels for grafting purposes), PCI can be accomplished using standard of care techniques [23]. These now include intracoronary physiology assessment to avoid unnecessary stenting and use of current-generation drug-eluting stents featuring thin platforms, and biocompatible, biodegradable or no drug carriers. Calcified or resistant lesions can be successfully dilated by means of atherectomy, scoring, lithotripsy, or use of high-pressure non-compliant balloons. In case of complex procedures in patients at risk of haemodynamic instability or haemodynamically unstable, mechanical circulatory devices may provide useful. In heart team discussions, a key criterion for considering PCI as an alternative to surgery should be the ability to achieve the same level of complete functional revascularization [24].

Coronary artery bypass grafting: anatomical and procedural considerations

While the discussion about which revascularization method to choose (PCI or CABG) is more relevant for the heart team than the technical considerations of the respective method, there are

specific points relevant to CABG, including anticipated completeness of revascularization and conduit selection that deserve to be discussed by the whole team.

Completeness of revascularization. Two large meta-analyses including both randomized and observational studies, showed a significant reduction in long-term mortality, myocardial infarction, and repeat myocardial revascularization in patients with anatomically complete revascularization, independently if CABG or PCI was used [25, 26]. The 2018 ESC-EACTS myocardial revascularization guidelines recommend that completeness of revascularization should be prioritized when choosing between CABG and PCI in patients with multivessel disease (*Class IIa, LoE B*) [1]. In general, complete revascularization is more often achieved after CABG than after PCI. In the SYNTAX trial, 66.9% of patients allocated to the CABG arm and 52.8% in the PCI arm received complete anatomical revascularization. The FAME study showed that a more restrictive selection of target lesions based on functional guidance resulted in improved long-term outcomes after PCI compared with anatomically guided lesion selection [20]. Accordingly, complete revascularization based on the functional definition is the preferred strategy for PCI [1] while the role of functional guidance for CABG is still under investigation.

Conduit selection. Conduit availability and selection in CABG have a key role in ensuring completeness and durability of myocardial revascularization. In general, the anticipated conduit to be used should be factored in the multidisciplinary discussion on mode of revascularization. Indeed, if surgical complete revascularization cannot be achieved due to lack of conduits a hybrid approach may be an option.

Radial artery grafts is now recommended with a Class I indication over saphenous vein graft in patients with severe stenosis [1] particularly in younger patients (<75 years), female patients, and patients without renal insufficiency [27], but it is still used infrequently thus representing an opportunity to improve quality of care (*Class I, LoE B*). If the patient lacks sufficient graft material due to previous excision of the saphenous vein or poor vein quality, and/or have widespread peripheral atherosclerosis involving the radial or ulnar arteries, and/or the patient has contraindications for vein harvesting due to leg ulcers, conduits option selection may be limited. Reasons that may limit the use of radial artery grafting include poor function of the ulnar artery (positive Allen Test), lack of local expertise and patient characteristics such as age and life expectancy. Hybrid procedures, defined as consecutive or combined surgical and percutaneous revascularization, may be considered in specific patient subsets at experienced centres. For this type of revascularization, multidisciplinary decision-making is particularly advantageous.

Anaesthetic risk

For the assessment of perioperative risk, anaesthetists usually rely on the American Society of Anesthesiologists (ASA) classification of the patient's physical status (PS) (Supplementary material, Table). This was introduced in the 40s and is now used worldwide after regular updates [28]. Originally developed to describe the PS as only one component of the operative risk, the ASA PS classification has been repeatedly shown to be independently associated with postoperative morbidity and mortality in a wide variety of disciplines [28]. However, its predictive value in cardiac surgery is less well established with most cardiac surgical patients having an ASA PS of 3 ('a patient with severe systemic disease') or 4 ('a patient with severe systemic disease that is a constant threat to life'), probably limiting the discriminatory power. In a recent analysis of the National Anesthesia Clinical Outcomes Registry (NACOR) of the Anesthesia Quality Institute (AQI) encompassing 132 502 cases of CABG and valve surgeries, only the presence of ASA PS 5 ('a moribund patient who is not expected to survive without the operation') was identified as an independent risk factor for death, whereas the other PS classes were not associated with perioperative risk [29].

Final decision-making considerations

Utility and limitations of current risk scores to estimate surgical risk in patients undergoing coronary artery bypass grafting are described in the Appendix (Supplementary material, Appendix).

Current guidelines delineate specific aspects to consider in decision-making that favour CABG or PCI (Figure 2) [1]. While the definition of acceptable surgical risk is indicated ('for example, absence of previous cardiac surgery, severe morbidities, frailty, or immobility precluding CABG'), no specific guidance on recommended risk scores is provided. In general, a 30-day mortality risk <2-3%, preferably assessed using the STS score, may be considered as guidance to define low risk in conjunction with other relevant patient-related comorbidities not included in the risk scores. However, the terms 'acceptable' and 'low' surgical risk have different meanings and implications. An 'acceptable' risk is related to the alternative treatment option (such as PCI or optimal medical therapy in patients considered for CABG) and include patient's preference while low risk is an absolute concept, mostly related to explicit risk assessment by score. If the expected risk and benefit alternatives are perceived as unfavourable, the acceptable risk could thus be higher than what we define as low risk.

Highlights

- Clinically, the presence of diabetes, left ventricular systolic dysfunction, high bleeding risk contraindicating appropriate DAPT duration, high anatomical CAD complexity, and concomitant indication for valve or other concomitant procedures favour CABG over PCI while the presence of severe comorbidities, especially if not included in risk scores, such as frailty, dementia, advanced cancer, or other factors that may affect the rehabilitation process, favour PCI (Figure 2).
- Heart teams are particularly valuable in complex decisions, such as when factors favouring both PCI and CABG are present. In these instances, it is important that the team comprehensively lists and optimally quantifies each factor that may affect decision-making in order to precisely assess the risk of mortality and morbidity and appropriately inform patients about the decision.

PART 3. RESEARCH PERSPECTIVES

The evidence supporting multidisciplinary decision-making and informing its use is very limited with most of the relevant recommendations provided by expert consensus, i.e., level of evidence C.

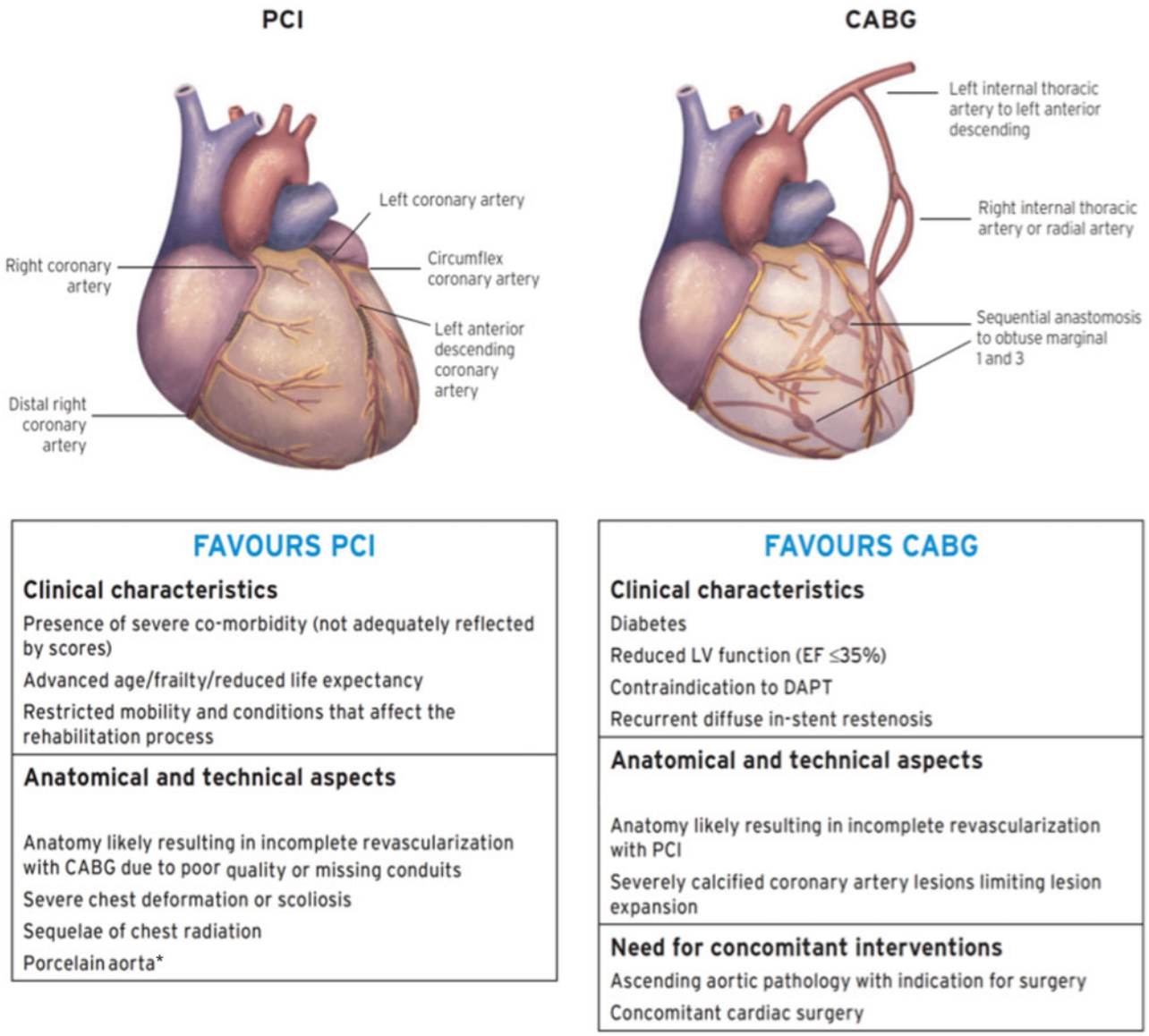
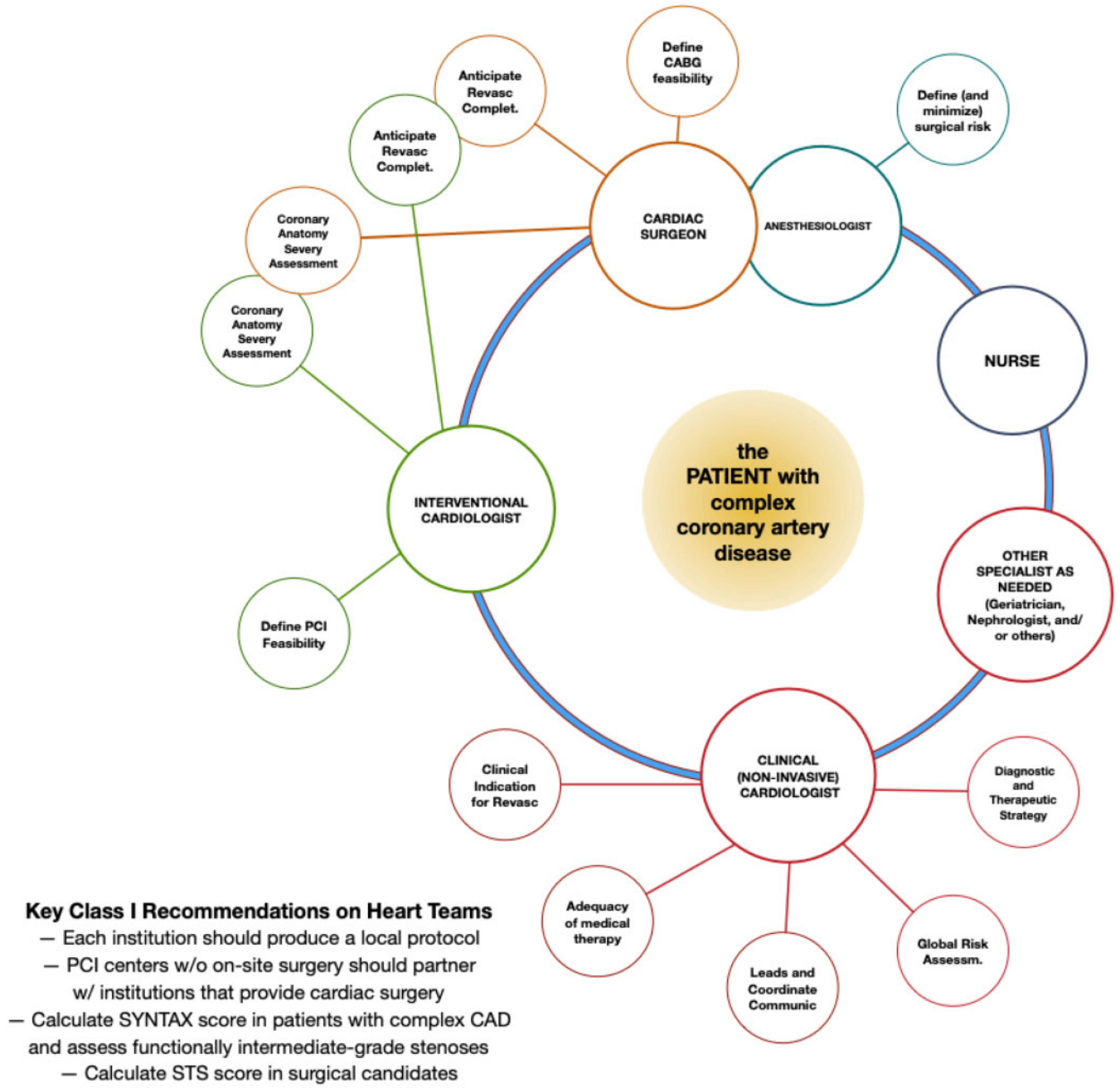


Figure 2. Considerations for decision-making by the heart team between percutaneous coronary interventions and coronary artery bypass grafting.
(*) Consider no-touch off-pump CABG in case of porcelain aorta.
CABG: coronary artery bypass grafting; DAPT: dual antiplatelet therapy; EF: ejection fraction; LV: left ventricular; PCI: percutaneous coronary intervention

Traditional ways of hypothesis testing, such as randomized controlled trial, can be challenging to apply to multidisciplinary decision-making processes. In general, the rational for adopting heart team approach to decision-making is the assumption that this approach minimizes bias and thus incorrect decisions. Therefore, the heart team is not a value *per se* but only if it facilitates implementation and adherence to evidence-based care, an assumption that needs verification. To verify this assumption we urgently need to design and disseminate registries and quality improvement initiatives that explore not only the presence of local heart teams but—most importantly—their outcome. If a local heart team is routinely convened for patients with complex CAD, but then it systematically excludes (or inappropriately decides) one treatment option, it does not provide high-quality care. Therefore, observational studies and quality improvement initiatives collecting data on appropriate information and considerations of patient preference, concordant type of revascularization according to explicit decision-making tools as well as other metrics suggested in Table 1 are needed to promote high-quality heart teams. Heart team may also promote standardization and reduce variability in decision-making, but data on reproducibility are limited. Finally, the complexity of care is an obvious downside of complex and multidisciplinary decision-making. Therefore, along with data on implementation, it is important to collect data that capture this intrinsic limitation, such as prolonged hospitalization or increased costs, to comprehensively characterize the effect of heart teams.

CONCLUSIONS

In patients with complex cardiovascular disease, multidisciplinary decision-making may reduce specialty bias, promote evidence-based care, and help patients make informed decisions. We discuss strategies to implement 'heart teams' in patients with complex CAD,



Take Home Figure. The patient-centred heart team. The figure illustrates the concept of a team of different specialists, with complementary and at times overlapping expertise, caring for the patient with complex coronary artery disease. CABG: coronary artery bypass grafting; Communic: patient communication; PCI: percutaneous coronary intervention; Revasc: revascularization [1].

including patients with acute cardiovascular diseases, promote a patient-centric approach, and suggest future research directions that comprehensively assess the added value of heart teams in view of the increased complexity of care.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *EJCTS* online.

Conflict of interest: S.L. reports grants and personal fees from AstraZeneca, personal fees from Bayer, personal fees from BMS-Pfizer, personal fees from Chiesi, outside the submitted work. M.V. reports personal fees from AstraZeneca, grants and personal fees from Terumo, personal fees from Alvimedica/CID, personal fees from Abbott Vascular, personal fees from Daiichi Sankyo, personal fees from Opsens, personal fees from Bayer, personal fees from CoreFLOW, personal fees from Idorsia Pharmaceuticals Ltd personal fees from Universität Basel,| Dept. Klinische Forschung, personal fees from Vifor, personal fees from Bristol Myers Squib SA, personal fees from iVascular, personal fees from Medscape, outside the submitted work. A.J. reports personal fees from AstraZeneca, personal fees from Boehringer-

Ingelheim, personal fees from LFB SA, personal fees from Octapharma, personal fees from Xvivo Perfusion, outside the submitted work. Other authors declare no conflicts of interest.

References

[1] Sousa-Uva M, Neumann F-J, Ahlsson A, Alfonso F, Banning AP, Benedetto U *et al.* 2018 ESC/EACTS Guidelines on myocardial revascularization. Eur J Cardiothorac Surg 2019;55:4–90.

[2] Rosenschein U, Nagler RM, Rofe A. The heart team approach to coronary revascularization—have we crossed the lines of evidence-based medicine?. Am J Cardiol 2013;112:1516–9.

[3] Leonardi S, Marino M, Crimi G, Maiorana F, Rizzotti D, Lettieri C *et al.* Appropriateness of percutaneous coronary interventions in patients with ischaemic HEart disease in Italy: the APACHE pilot study. BMJ Open 2017;7:e016909.

[4] Bomhof-Roordink H, Fischer MJ, Van Duijn-Bakker N, Baas-Thijssen MC, Van Der Weijden T, Stiggelbout AM *et al.* Shared decision making in oncology: a model based on patients', health care professionals', and researchers' views. Psycho-Oncology 2019;28:139–46.

[5] National Research Council. Crossing the quality chasm: a new health system for the 21st century. Washington, DC: National. Academies Press, 2001.

[6] Tehrani BN, Truesdell AG, Sherwood MW, Desai S, Tran HA, Epps KC *et al.* Standardized team-based care for cardiogenic shock. J Am Coll Cardiol 2019;73:1659–69.

[7] Farooq V, Van Klaveren D, Steyerberg EW, Meliga E, Vergouwe Y, Chieffo A *et al.* Anatomical and clinical characteristics to guide decision making between coronary artery bypass surgery and percutaneous coronary intervention for individual patients: development and validation of SYNTAX score II. Lancet 2013;381:639–50.

[8] Task Force on Myocardial Revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS); European Association for Percutaneous Cardiovascular Interventions (EAPCI), Kolh P, Wijns W, Danchin N, Di Mario C, Falk V, Folliguet T *et al.* Guidelines on myocardial revascularization. Eur J Cardiothorac Surg 2010;38(Suppl):S1–52.

[9] Chang M, Lee CW, Ahn J-M, Cavalcante R, Sotomi Y, Onuma Y *et al.* Comparison of outcome of coronary artery bypass grafting versus drug-eluting stent implantation for non–ST-elevation acute coronary syndrome. Am J Cardiol 2017;120:380–6.

[10] Roffi M, Patrono C, Collet J-P, Mueller C, Valgimigli M, Andreotti F *et al.* 2015 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation. Eur Heart J 2016;37:267–315.

[11] Neskovic A N, Hagendorff A, Lancellotti P, Guarracino F, Varga A, Cosyns B *et al.* Emergency echocardiography: the European Association of Cardiovascular Imaging recommendations. Eur Heart J Cardiovasc Imaging 2013;14:1–11.

[12] Ibanez B, James S, Agewall S, Antunes MJ, Bucciarelli-Ducci C, Bueno H *et al.* 2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation. Eur Heart J 2018;39:119–77.

[13] Leonardi S, Bhatt DL. Practical considerations for cangrelor use in patients with acute coronary syndromes. Eur Heart J Acute Cardiovasc Care 2019;8:39–44.

[14] Anavekar NS, Chareonthaitawee P, Narula J, Gersh BJ. Revascularization in patients with severe left ventricular dysfunction. J Am Coll Cardiol 2016;67:2874–87.

[15] Collet C, Onuma Y, Andreini D, Sonck J, Pompilio G, Mushtaq S *et al.* Coronary computed tomography angiography for heart team decision-making in multivessel coronary artery disease. Eur Heart J 2018; 39:3689.

[16] Généreux P, Palmerini T, Caixeta A, Cristea E, Mehran R, Sanchez R *et al.* SYNTAX score reproducibility and variability between interventional cardiologists, core laboratory technicians, and quantitative coronary measurements. Circ Cardiovasc Interv 2011;4:553–61.

[17] Généreux P, Palmerini T, Caixeta A, Rosner G, Green P, Dressler O *et al.* Quantification and impact of untreated coronary artery disease after percutaneous coronary intervention. J Am Coll Cardiol 2012;59: 2165–74.

[18] Malkin CJ, George V, Ghobrial MS, Krishnan A, Siotia A, Raina T *et al.* Residual SYNTAX score after PCI for triple vessel coronary artery disease: quantifying the adverse effect of incomplete revascularisation. EuroIntervention 2013;8:1286–95.

[19] Park KW, Kang J, Kang S-H, Ahn H-S, Kang H-J, Koo B-K *et al.* The impact of residual coronary lesions on clinical outcomes after percutaneous coronary intervention: Residual SYNTAX score after percutaneous coronary intervention in patients from the Efficacy of Xience/Promus versus Cypher in rEducing Late Loss after stENTing (EXCELLENT) registry. Am Heart J 2014;167:384–92.e5.

[20] De Bruyne B, Pijls NH, Kalesan B, Barbato E, Tonino PA, Piroth Z *et al.* Fractional flow reserve–guided PCI versus medical therapy in stable coronary disease. N Engl J Med2012;367:991–1001.

[21] Pijls NH, Van Schaardenburgh P, Manoharan G, Boersma E, Bech J-W, Van't Veer M *et al.* Percutaneous coronary intervention of functionally nonsignificant stenosis. J Am Coll Cardiol 2007;49:2105–11.

[22] Kobayashi Y, Lønborg J, Jong A, Nishi T, De Bruyne B, Høfsten DE *et al.* Prognostic value of the residual SYNTAX score after functionally complete revascularization in ACS. J Am Coll Cardiol 2018;72:1321–9.

[23] Escaned J, Collet C, Ryan N, Luigi De Maria G, Walsh S, Sabate M *et al.* Clinical outcomes of state-of-the-art percutaneous coronary revascularization in patients with de novo three vessel disease: 1-year results of the SYNTAX II study. Eur Heart J 2017;38:3124–34.

[24] Marino M, Leonardi S, Crimi G, Ferrario M, Musumeci G, Tarantini G *et al.* Lack of implementation of guidelines recommendations for coronary revascularization in stable patients with complex disease is associated with high rates of incomplete revascularization: analysis from the Apache study. Heart Vessels 2019;doi:10.1007/s00380-019-01459-1.

[25] Garcia S, Sandoval Y, Roukoz H, Adabag S, Canoniero M, Yannopoulos D *et al.* Outcomes after complete versus incomplete revascularization of patients with multivessel coronary artery disease. J Am Coll Cardiol 2013;62:1421–31.

[26] Zimarino M, Ricci F, Romanello M, Di Nicola M, Corazzini A, De Caterina R. Complete myocardial revascularization confers a larger clinical benefit when performed with state-of-the-art techniques in high-risk patients with multivessel coronary artery disease: a meta-analysis of randomized and observational studies. Catheter Cardiovasc Interv 2016;87:3–12.

[27] Gaudino M, Benedetto U, Fremes S, Biondi-Zoccai G, Sedrakyan A, Puskas JD *et al.* Radial-artery or saphenous-vein grafts in coronary-artery bypass surgery. N Engl J Med 2018;378:2069–77.

[28] Hackett NJ, De Oliveira GS, Jain UK, Kim JY. ASA class is a reliable independent predictor of medical complications and mortality following surgery. Int Surg J 2015;18:184–90.

[29] Brovman EY, Gabriel RA, Lekowski RW, Dutton RP, Urman RD. Rate of major anesthetic-related outcomes in the intraoperative and immediate postoperative period after cardiac surgery. J Cardiothorac Vasc Anesth 2016;30:338–44.