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REVIEW

Clinical update

The rationale for Heart Team decision-making for patients with stable, complex coronary artery disease

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Stable complex coronary artery disease can be treated with coronary artery bypass grafting (CABG), percutaneous coronary intervention (PCI), or medical therapy. Multidisciplinary decision-making has gained more emphasis over the recent years to select the most optimal treatment strategy for individual patients with stable complex coronary artery disease. However, the so-called 'Heart Team' concept has not been widely implemented. Yet, decision-making has shown to remain suboptimal; there is large variability in PCI-to-CABG ratios, which may predominantly be the consequence of physician-related factors that have raised concerns regarding overuse, underuse, and inappropriate selection of revascularization. In this review, we summarize these and additional data to support the statement that a multidisciplinary Heart Team consisting of at least a clinical/non-invasive cardiologist, interventional cardiologist, and cardiac surgeon, can together better analyse and interpret the available diagnostic evidence, put into context the clinical condition of the patient as well as consider individual preference and local expertise, and through shared decision-making with the patient can arrive at a most optimal joint treatment strategy recommendation for patients with stable complex coronary artery disease. In addition, other aspects of Heart Team decision-making are discussed: the organization and logistics, involvement of physicians, patients, and assisting personnel, the need for validation, and its limitations.

Keywords Heart Team • Multidisciplinary • Shared decision-making • Revascularization • Coronary artery bypass grafting • Percutaneous coronary intervention • Appropriateness • Underuse • Guidelines

Introduction

There is precedence in the field of medicine that the level of care can be improved and made more consistent with the use of multidisciplinary teams to recommend the most optimal treatment. An example of this is the introduction of the tumour board in the 1960s, which has shown to significantly improve the quality of care.[1–3] A pre-treatment multidisciplinary discussion was associated with improved survival as well as reduced hospital-variations in survival rates[1] and has been identified as an independent predictor of treatment recommendations' conformity to clinical practice guidelines.[3]

The area of cardiovascular diseases has seen the development of Heart Teams early on for treatment of heart failure, pediatric and adult cases of congenital heart disease, and more recently for aortic and mitral valve interventions. In the context of myocardial revascularization, multidisciplinary Heart Teams have been introduced through randomized trials. While decision-making for patients with acute indications or less complex coronary disease may be straightforward, for patients with stable complex (e.g. left main and/or multivessel) coronary artery disease (CAD), a Heart Team consisting of a clinical/non-invasive cardiologist, interventional cardiologist, and cardiac surgeon is considered optimal to best assess the advantages and disadvantages of the various treatment strategies. The Heart Team has recently become a class 1C recommendation in European and American guidelines on myocardial revascularization.[4,5] However, while in oncology 63% of centres in

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the western countries have embraced multidisciplinary teams,[6] this approach has not yet been widely implemented for coronary indications for a myriad of reasons including the novelty of the concept, lack of experience, lack of proven benefit, logistical issues, as well as turf protection.[7,8] Yet, clearly there is a need for improved decision-making. A recent study suggests that non-compliance to guidelines can result in inappropriate or underuse of revascularization.[9] In patients with an indication for coronary artery bypass grafting (CABG), only 53% received such treatment, 34% underwent percutaneous coronary intervention (PCI), 12% received medical management, and 1% did not receive any treatment.

The purpose of the current manuscript is to explore the rationale behind Heart Team evaluation and to advocate for wider, regular use of Heart Teams in an orderly fashion, thereby enhancing the value of care for patients with stable complex CAD.

Revascularization: what the Heart Team could improve

Since CABG was demonstrated in the 1980s to be superior to medical therapy in patients with three-vessel or left main (LM) disease, many patients have undergone surgical revascularization. The introduction of PCI with balloon angioplasty and subsequently stents resulted in a consideration of both therapies as treatment options. The different treatment strategies should ideally be considered complementary. However, evidence suggests that the current decision-making process and treatment selection is questionable, thereby potentially resulting in suboptimal care and increased health care expenditures.

Variability

Owing to technical and therapeutic advancements and reduced invasiveness, PCI has been utilized increasingly since its introduction over three decades ago. Evidence from Europe, the United States, and Canada suggests that the PCI-to-CABG ratio has shifted significantly towards more PCI procedures.[10–12] This is in some degree caused by expanding indications for PCI. However, the Organization of Economic Cooperation and Development (OECD) reported a mean PCI-to-CABG ratio of 3.29 in 2007 in those countries affiliated with the organization, ranging from a low of 0.67 in Mexico to a high of 8.63 in Spain (*Figure 1*).[13] Even within the same health care system, a large difference in PCI-to-CABG ratios has been reported across different regions (*Figure 2*).[13] This wide variability in the type of revascularization utilization might be driven by economic and reimbursement considerations,[14] but other factors may also be contributory. Consistency and generality of recommendations might be best approached by Heart-Team-based care.

Differences in baseline patient characteristics might explain part of the variance in the PCI-to-CABG ratio. However, physician-related factors dominate treatment decisions. Surgeons and cardiologists significantly differ in the information they provide the patient regarding the choice between PCI and CABG, thereby creating a bias towards a specific treatment.[15] Studies have shown that in 68% of patients who underwent PCI and 59% who underwent

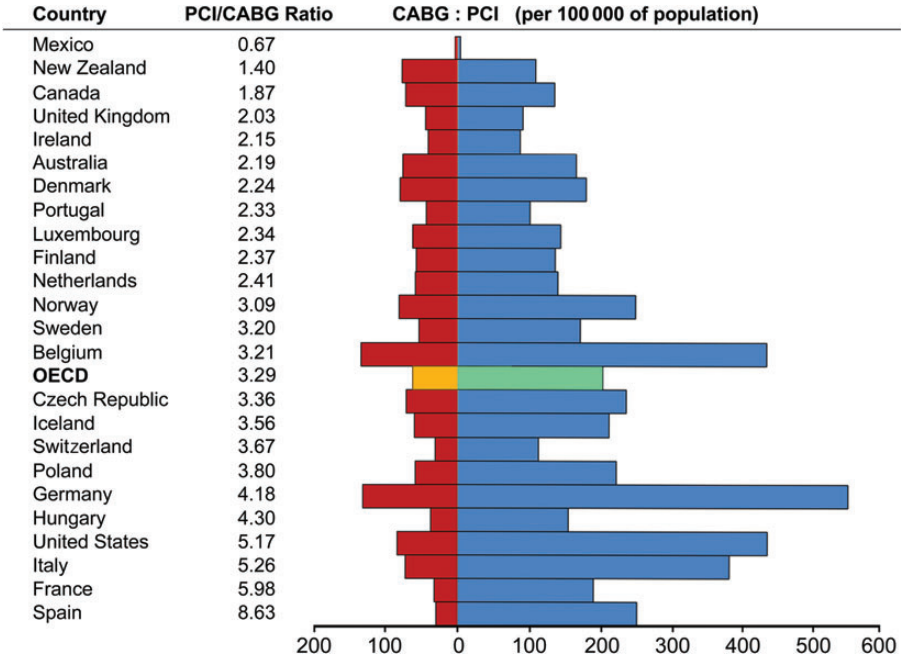

Figure 1 Revascularization procedures performed in countries throughout the Western world. Data from the Organisation for Economic Cooperation and Development (OECD) shows a great variety in the number of revascularization procedures per 100 000 inhabitants.[13] CABG, coronary artery bypass grafting; PCI, percutaneous coronary intervention.

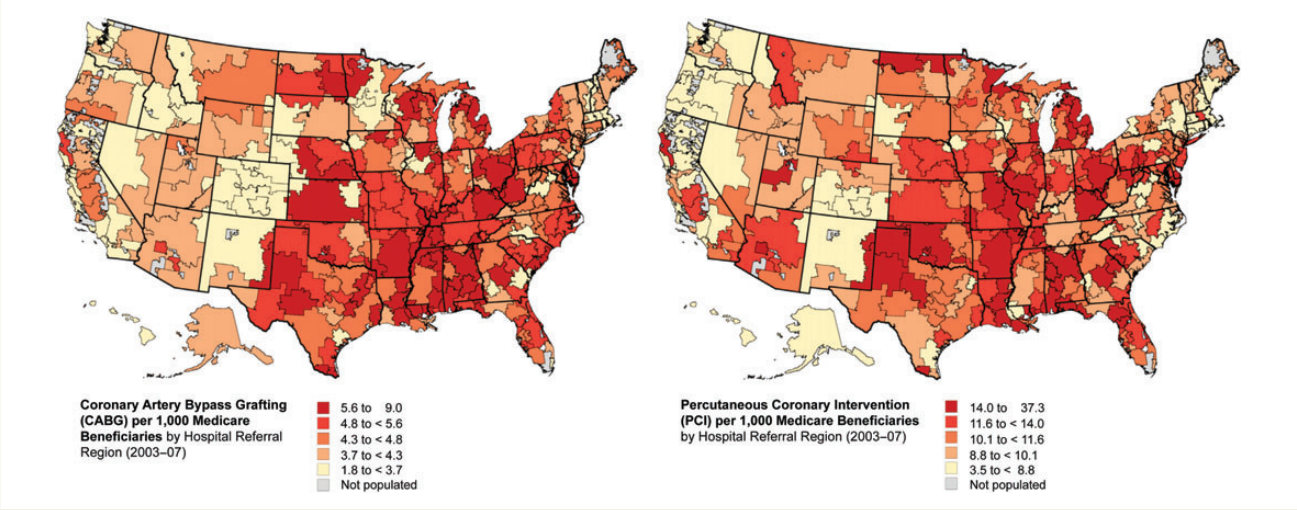

Figure 2 Rates of CABG and PCI in hospital referral regions within the United States. The mean rate of CABG was 5.2 per 1000 Medicare enrollees and 11.3 for PCI. Rates are adjusted for age, sex, and race. Copied from the Dartmouth Atlas of Health Care.[84] Abbreviations as previously.

Table 1 Overt and subconscious factors that influence whether comprehensive and well-balanced information of revascularization strategies is provided by physicians

'Building an empire' leading to (inter)national recognition
Conflict of interest with industry
Knowledge of patient's preferences
No appreciation of personal therapeutic limits
Not being up-to-date regarding PCI and/or CABG (technology, outcomes, indications, etc.)
Opportunity to include a patient in an enroling randomized trial
Personal conflict between interventional cardiologist and/or surgeon
Physician–patient bonding
Preservation of patient–referral pathways
The physician's centre is a centre of excellence in PCI or CABG
'Turf protection' (protection of patient access and salary)

CABG, coronary artery bypass grafting; PCI, percutaneous coronary intervention.

CABG, the alternative revascularization strategy was not discussed with the patient.[16] Several overt and subconscious physician-related factors may influence these treatment recommendations (*Table 1*). To overcome these issues, the Heart Team may increase agreement among surgeons and cardiologists with respect to the choice of the preferred treatment.[17]

Decision-making

Before the decision is made to perform revascularization, assessment of coronary lesions is essential. Typically, and according to the guidelines, revascularization is indicated if there is significant angiographic diameter stenosis (≥50–70%) with documented ischaemia or fractional flow reserve <0.80.[4]

Factors that should be taken into account prior to decision-making are patient co-morbidities, the patient's history, coronary lesion complexity, and operative risk, but also the anticipated goals of therapy and the life-expectancy or expected quality-of-life improvement. Several risk models have been developed to estimate the operative risk and long-term outcome,[18–22] which can provide guidance for the Heart Team regarding safe and efficient treatment recommendations. However, these risk models should inform, not replace, clinical judgement and local operator expertise in estimating the overall benefit–risk balance of treatment interventions.

The STS score[18] and logistic EuroSCORE[19] are the most commonly used models to assess the patient's operative mortality risk. Both models include patient characteristics, co-morbidities, previous events, and operative factors to calculate a risk of mortality. The EuroSCORE has a satisfactory inter-observer variance ($\kappa = 0.71$), but still the calculation is subject to many errors, ranging from simple encoding errors to re-calculation errors (e.g. creatinine plasmatic level to creatinine clearance).[23] It can be expected that errors are more likely to occur in complex models with more variables, such as the STS score or the new EuroSCORE II.[24] As a joint group the Heart Team enables an extra check with regard to the accuracy of the scores but cannot overcome the modest prognostic utility of scores. Simpler risk models with a limited number of variables, such as the ACEF score that includes only three factors,[25] may also provide satisfactory risk stratification and are likely to have fewer errors.[26]

The SYNTAX score, established in 2005, was developed to grade complexity of CAD.[27] Validated in the SYNTAX trial, the score was found to be a good predictor of adverse events in the PCI population, however, not in CABG patients.[28] Although it is vital to acknowledge the hypothesis-generating nature of the SYNTAX trial subgroup data, the score is a promising tool to

Table 2 Observer variability in assessment of the SYNTAX score

Author, year	Patients	Number of patients	Score evaluation	Intra-observer variability (κ)[a]	Inter-observer variability (κ)[a]
Serruys, 2009[38]	LM and/or 3VD	100	Two corelab technicians	0.59 for raw scores 0.61 for score tertiles	0.45 for raw scores 0.52 for score tertiles
Garg, 2010[35]	LM and/or 3VD	100	Three interventional cardiologists	0.54 for raw scores	—
Shiomi, 2011[39]	LM	101	Two interventional cardiologists	0.69 for score tertiles	0.58 for score tertiles
Tanboga, 2011[37]	—	76	Two interventional cardiologists	0.69 for score tertiles	0.56 for score tertiles
Généreux, 2011[36]	MVD	30	Three interventional cardiologists – before training	—	0.33 for score tertiles
		50	Three interventional cardiologists – after training	0.88, 0.64, 0.66 for score tertiles	0.76 for score tertiles

3VD, three-vessel disease; LM, left main; MVD, multivessel disease.
[a]The kappa (κ) values represent the strength of agreement. This is considered to be fair between 0.21 and 0.40, moderate between 0.41 and 0.60, substantial between 0.61 and 0.80, and almost perfect between 0.81 and 1.00.[86]

stratify which patients can be revascularized with PCI or CABG and numerous publications support the prognostic capacity of the score in various patient populations.[29–33] Therefore, the SYNTAX score is increasingly used to guide treatment decisions and the new revascularization guidelines recommend the use of the SYNTAX score for treatment selection.[4,5] Despite the encouraging use of established SYNTAX Score threshold values ($\leq$22 and $\geq$33), the SYNTAX Score needs to be weighted in the context of the overall evaluation by the Heart Team which might overrule these threshold-based decisions.[34] A limitation of the SYNTAX Score is its notable intra-observer and inter-observer variability, which can cause inappropriate revascularization strategies (*Table 2*).[35–39] The inconsistency in the SYNTAX score is in part due to interpretations of coronary angiogram. The inaccuracy of grading vessel stenosis on angiograms has been addressed in a number of different studies in which a high inter-observer and intra-observer variability of angiogram analysis was demonstrated.[40,41] However, the correlation between angiogram interpretations and the 'normal' phantom study reference values increased when taking the mean of three ($r = 0.88$) and five ($r = 0.89$) physicians instead of the value of individual physicians ($r = 0.79$).[41] Another study showed that by replacing individual readings by panel readings, the appropriateness of the indication for CABG and PCI changed from necessary or appropriate to uncertain or inappropriate in 33 and 10% of the cases, respectively.[40] Within the Heart Team, the members can interpret the angiograms together and reduce errors, so that the SYNTAX score correctly represents the patient's lesions,[36] leading to more appropriate revascularization. Nevertheless, Heart Team treatment decisions in which the angiographic complexity is weighted with clinical co-morbidity, operator skills, local expertise, and patient preference are more likely to yield improved outcomes than those based on evaluation of angiographic complexity alone.

Interactive web-based programs can be used to provide information on different treatment strategies with corresponding risks and benefits, which could be helpful for both patients and physicians. For patients, it is mandatory that the program is user-friendly and easily interpretable so that it helps establish patient treatment preferences, and improve patient satisfaction.[42] For physicians, such programs can be used for comprehensive risk assessment and simulation of outcomes based on different treatment strategies. New insights into how the individual patient can potentially be treated with novel techniques could furthermore be provided. An example that is frequently used in oncology is the www.adjuvantonline.com website. To the best of our knowledge, no program exists for cardiology and its development should be promoted.

Inappropriate revascularization

Even though the imbalance in recommendations for therapy has been identified as early as the 1980s, recent study showed that inappropriateness rates remain high (*Table 3*).[43–58] In a recent study from the New York State database, of 24 545 PCI procedures performed for non-acute indications of stable CAD, 14.3% were performed inappropriately and in another 49.6% there was not sufficient information and either approach could be considered ('uncertain').[58] Evaluation of CABG procedures showed an inappropriateness rate of 1.1 and 8.6% were judged uncertain. However, it should be noted that a 'zero tolerance' for inappropriate procedures is not expected, due to patient preferences and factors not captured in the criteria.[48,59] In addition, the recently updated appropriateness criteria have been criticized for several limitations,[59] including the composition of the panel, the role of pre-procedural diagnostic testing, and the fact that it does not account for all possible scenarios of clinical care.

Substantial inter-hospital variation of treatment recommendation may explain why the rates of inappropriateness vary significantly between studies.[48,57] Cardiologists and surgeons frequently favour PCI or CABG, respectively.[17,60,61] Appropriateness ratings can therefore depend on specific individual choices that have been shown to vary across geographic regions, which in turn could be a surrogate for cultural differences.[62] However, it may also be evidence of particular excellence in PCI or CABG in certain centres. Thus, evaluation of an accurate rate of inappropriate revascularization will require adjustment for all these factors.

Table 3 Inappropriateness of revascularization procedures

Author, year	Country	Inclusion	Number of procedures for stable angina	Rate of inappropriateness, %	Rate of uncertian appropriateness, %
PCI					
Hilborne, 1993[52]	USA	1990	519	1%	42%
Bengtson, 1994[46]	Sweden	1990	56	5%	9%
Meijler, 1997[55]	The Netherlands	1992	891	33.4%	36.4%
Bernstein, 1999[47]	Sweden	1994–1995	447	36.7%	37.8%
Hemingway, 1999[50]	UK	1995	~328	43%	48%
Fitch, 2000[49]	—	—	204	15%	44%
Aguilar, 2001[43]	Spain	1997	467	15%	23%
Yim, 2004[44]	Korea	1997	228	8.8%	67.1%
Chan, 2011[48]	USA	2009–2010	144 737	11.6%	38.0%
Hannan, 2012[58]	USA	2009–2010	24 545	14.3	49.6
CABG					
Winslow, 1988[57]	USA	1979–1980, 1982	213	13	—
Gray, 1990[45]	UK and USA	1987–1988	319	16	
Bengtson, 1994[46]	Sweden	1990	307	1	8
McGlynn, 1994[54]	Canada and USA	1989–1990	~980	~15	
Meijler, 1997[55]	The Netherlands	1992	1054	4.5	13.4
Bernstein, 1999[47]	Sweden	1994–1995	1038	8.5	13.2
Hemingway, 1999[50]	UK	1995	~323	43	38
Fitch, 2000[49]	—	—	204	19	40
O'Connor, 2008[56]	USA	2004–2005	806	2.1	0
Hannan, 2012[58]	USA	2009–2010	8168	1.1	8.6

'~' indicates an approximate value that was calculated by combining the overall group and a percentage. For example, '34% of 287 patients had stable angina': $0.34 \times 287 = 97.6$ which would be listed here as ~98. Abbreviations as previously.

Underuse of revascularization

An important limitation of the appropriateness criteria is that it can only be applied to patients who underwent revascularization. Preferably, it should be applied to all patients after a diagnostic angiogram or stress test, so that these criteria can also be used to identify patients in whom revascularization is underused (*Table 4*).[51,63–66] On the basis of the existing studies, in 18–34% of patients in whom PCI was rated necessary or appropriate, no revascularization took place. For CABG patients, this number is ~25%. The incidence can vary for several patient groups; men are more likely to undergo revascularization than women, and whites more than blacks.[63] The study by Leape *et al.*[66] also found a large in-hospital variance in performance of necessary revascularization, ranging from 21 to 87% ($P < 0.001$). The clinical relevance of these findings was demonstrated by significantly higher rates of angina at 1 year [odds ratio = 1.97 (1.29–3.00)] in patients who received medical therapy while PCI would have been appropriate.[51] In a CABG patient group, this effect was even more pronounced, with an odds ratio of 3.03 [2.08–4.42] for angina. Furthermore, CABG patients appeared to have significantly lower rates of death or MI compared with patients who should have had revascularization [HR = 0.25 (0.17–0.35)]. In contrast, there was no evidence of a difference in death or MI rates between PCI and patients who received medical therapy [HR = 1.30 (0.80–2.08)].[51] A recent study by Hannan *et al.*[67] contradicted this finding. They showed that patients who should have had PCI were more likely to experience death [14.5 vs. 10.2%, HR = 1.46 (1.08–1.97)] or the composite of death or MI [21.2 vs. 16.5%, HR = 1.49 (1.16–1.93)] at 4 years when compared with those patients who did undergo PCI. Furthermore, Filardo *et al.*[64] showed that underuse of any revascularization was associated with significantly increased mortality during follow-up [multivariate HR = 3.23 (2.00–5.26)].

History of the coronary Heart Team

Initiated in early randomized trials comparing CABG with medical therapy for stable CAD,[68,69] a Heart Team was used to select patients eligible for randomization. Partly due to the introduction of PCI, interventional cardiologists and cardiac surgeons were increasingly targeting the same patient population. Randomized trials comparing CABG and PCI followed,[70,71] in which specialties worked in close proximity to ensure accurate patient selection and assume clinical equipoise between treatments. This provided new insights into decision-making as performed by a Heart Team. The EAST[72] and BARI[73] trials included nested registries along with the randomized cohorts, to demonstrate if physician or patient-treatment preferences yielded different results than patients in

Table 4 Underuse of revascularization procedures

Author, year	Country	Inclusion	Number of patients	Revascularization not given (%)	Outcome
PCI necessary/appropriate					
Kravitz, 1995[65]	USA	1990–1991	107	34% no PCI	3.7 vs. 5.6%
				25% no revascularization	—
Leape, 1999[66]	USA	1995	57	18% no revascularization	—
Hemingway, 2001[51]	UK	1996–1997	908	34% no revascularization	Death or non-fatal MI: HR = 1.30 [0.80–2.08]
CABG necessary/appropriate					
Kravitz, 1995[65]	USA	1990–1991	424	41% no CABG	16.7 vs. 9.7%
				25% no revascularization	—
Leape, 1999[66]	USA	1995	442	25% no revascularization	—
Hemingway, 2001[51]	UK	1996–1997	1353	26% no revascularization	Death or non-fatal MI: HR = 0.25 [0.17–0.35]
Revascularization necessary/appropriate					
Kravitz, 1995[65]	USA	1990–1991	671	25%	23.3% (none) vs. 9.3% (CABG) or 8.9% (PCI)
Leape, 1999[66]	USA	1992	631	26%	—
Filardo, 2001[64]	Italy	1995	1213	29%	Survival: HR = 0.31 [0.19–0.51]
Epstein, 2003[63]	USA	1991–1992	1526[a] and 2049[b]	23.9%[a] and 24.6%[b]	—

HR, hazard ratio; MI, myocardial infarction; other abbreviations as previously.
[a]According to RAND method.
[b]According to ACC/AHA method.

whom equipoise was assumed. Remarkably, 3-year survival of the EAST registry patients was slightly better than randomized patients (96.4 vs. 93.4%, $P = 0.044$), which suggests that the selection of treatment after discussion with a cardiologist, cardiac surgeon, and the patient provides better outcomes in comparison to randomization. Similar results were confirmed by the BARI trial, showing improved survival of registry patients over randomized patients at 7-year follow-up. The SYNTAX trial also included nested registries but differed from previous trials such as EAST and BARI registries in that inclusion was not also based on patient preferences, but specifically focused on inclusion of patients with assumed superiority of either PCI or CABG.[28] The SYNTAX Heart Team demonstrated the contemporary PCI/CABG distribution of patients with left main and/or three-vessel disease (*Figure 3*); in 58.5% of patients both PCI and CABG was suitable, while 6.4 and 35.0% could only undergo PCI and CABG, respectively, due to co-morbid and lesion-specific factors according to the Heart Team.[34]

Further evidence supporting Heart Team decision-making originated from the MASS-II trial in which patients were randomized to PCI, CABG, or medical therapy.[74] Before randomization, experienced clinical/non-interventional cardiologists recorded their personal choice of treatment. Survival comparison between the chosen and randomized treatment showed excellent outcomes and good clinical judgement with respect to CABG and medical therapy (*Figure 4*). However, survival was significantly worse in patients randomized to PCI in whom CABG or medical therapy would have been preferred. This speaks to the value of additional expertise that could have improved patient selection.

At present time, both European (2010) and American (2011) guidelines on myocardial revascularization were a joint effort of cardiology and surgical associations.[4,5] This concept recapitulates the Heart Team, where specialists work together to optimize treatment recommendations based on an exchange of knowledge and experience with specific therapies.

Heart Team organization and involvement

Organization and logistics

It has been shown that in cancer teams, up to 15% of treatment recommendations are not implemented.[75] This is most often the case when co-morbid conditions are not discussed at the multidisciplinary meeting, if patient preferences are unknown, or if further diagnostics became available after the meeting. As emphasized by the 'uncertain' classification in the appropriateness criteria, treatment decisions are frequently not substantiated because there is insufficient diagnostic data or inadequate documentation for an evidence-based decision. Therefore, it is crucial that all necessary patient information is available during the Heart Team meeting. The appointment of a non-clinical coordinator would be particularly helpful for gathering patient information or making sure this is accessible electronically, ensuring the necessary attendance and documentation of specialties that are present, and recording treatment recommendations.

Leadership is of the utmost importance for a team to be efficient as objectives need to be made clear, it can stimulate participation, encourage commitment to excellence, and drive innovation.[76] Active participation of all team members is a prerequisite, and the discussion should take place in a non-autocratic setting. To achieve a positive dynamic it is essential to have mutual respect

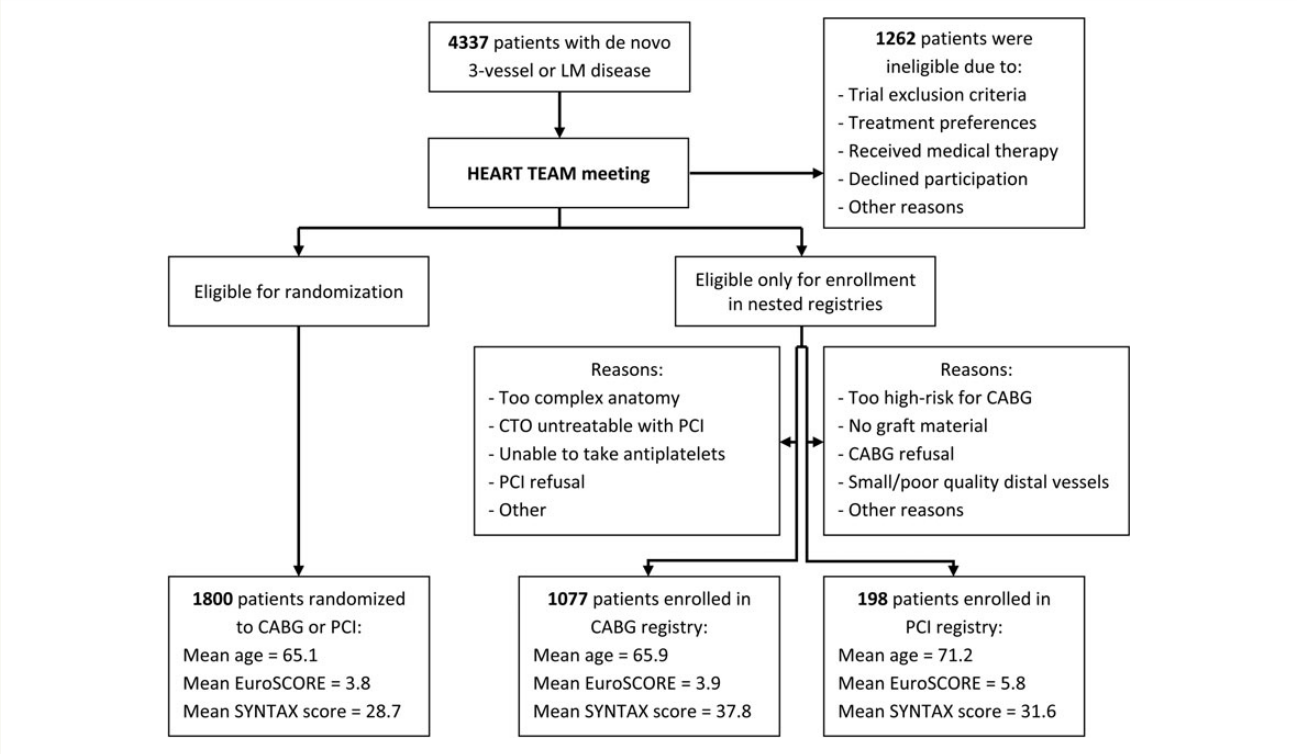

Figure 3 SYNTAX trial recruitment. CTO, chronic total occlusion; LM, left main; other abbreviations as previously.

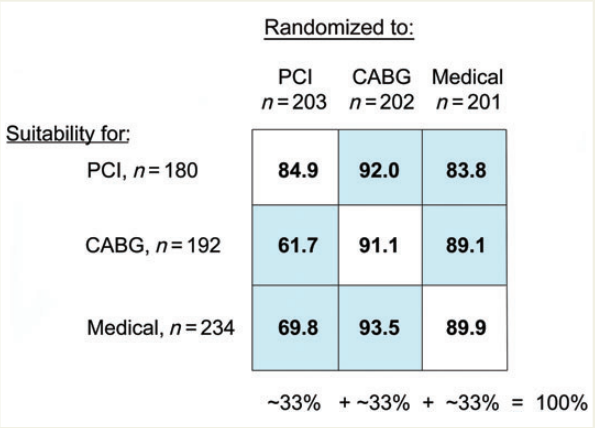

Figure 4 Probability of survival according to the treatment selection per randomization or clinical judgement. Before randomization in the MASS II trial took place, two experienced cardiologists had to state their preference of therapy. This table shows the survival of patients as they were treated by the randomized therapy, set out against the survival that would have been the case if the preferred treatment had been given. Copied with permission from Pereira *et al.*[74] Abbreviations as previously.

where all input is acknowledged with transparent positive and negative feedback.

The frequency and length of Heart Team meetings depend strongly on the caseload and complexity of patients. Ideally, the Heart Team should convene on a regular basis so that the length of the meetings can be kept to a minimum and each case can be discussed in 5–10 min. A lower number of meetings results in a higher number of cases to be discussed and physicians can become less motivated to actively attend lengthy meetings. For centres that do not have an on-site surgical department, Heart Team meetings can be organized through teleconference with the potential for integrated WebEx screen sharing. For complex cases, surgical consultation may be obtained through weekly meetings. Tumour boards often convene through teleconference to discuss patients to obtain multiple experts' opinions about treatment strategies and discuss whether referral to centres of excellence is warranted.

Logistics are of course the major barrier to convening the Heart Team. In some institutions, at least initially, *ad hoc* meetings between interventional cardiologist and cardiac surgeon may be the best approach to initiate collaboration. What works well in one institution may not be the optimal approach in another. Successful realization of regular multidisciplinary team evaluation is based on participation of all the necessary physicians.

Involvement

Clinical/non-invasive cardiologists, interventional cardiologists, and cardiac surgeons should always be present to evaluate whether optimal medical therapy, PCI, or CABG is the preferred treatment. However, other physicians with specific expertise can be added if necessary. An anaesthesiologist can assess surgical risk in potential CABG patients by providing input about the ability of the patient to safely undergo general anaesthesia. Residents and/or schooled

research nurses should have gathered the necessary data to interpret, and share the prepared score assessments on a plenary screen so that definition, typing, or re-calculation errors can be avoided through feedback by the rest of the team.

The concept of shared decision-making with physicians and patients has received more emphasis, and patients should be integrated in the process of decision-making (*Figure 5*). Involvement of patients' families and friends in the Heart Team can increase patient satisfaction.[77] A prospective cohort study of 3045 CABG patients treated at 16 hospitals showed that a 'supportive group culture' in hospitals was significantly correlated with higher patient physical and mental health scores as determined by SF-36 questionnaires 6 months post-CABG.[78]

Decision-making should be based on three key points: (i) knowledge transfer, in which it is equally important that the physician provides information to the patient and the patient to the physician, (ii) discussion, and (iii) reaching an agreement on which revascularization strategy will be performed in which patient preferences should be prioritized. It is crucial that during the exchange of information at least a team of one clinical/non-invasive cardiologist, an interventional cardiologist, and a cardiac surgeon is present to ensure that sufficient information on pros and cons of all therapies is provided to the patient.

Additional advantages

Physicians can be held accountable for inappropriate decision-making and can ultimately face medico-legal consequences. In general, team physicians 'share the burden' and this approach might potentially minimize medical malpractice exposure, because there is a shared responsibility of recommending the most optimal therapy to the patient. Nevertheless, all members of the team can be held accountable for decisions within their expertise.[79]

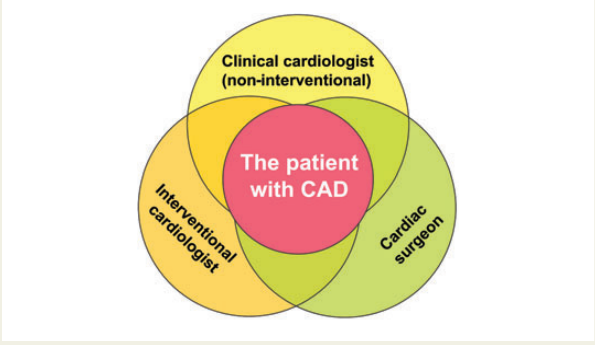

Figure 5 The basis for a Heart Team is involvement of necessary specialties and the patient to facilitate shared decision-making. Copied with permission from Wijns *et al.*[85] CAD = coronary artery disease.

In a group discussion, it is gratifying and self-assuring to be acknowledged for an opinion that is shared with peers, and multidisciplinary approaches have been linked to improved well-being of physicians.[80]

Another benefit of the Heart Team approach is creating a more robust clinical research program with enhanced quality of care monitoring. Studies suggest that the use of multidisciplinary teams can increase trial recruitment.[81] Information regarding existing and new therapies is more complete, and patients can interpret the advantages and disadvantages of these treatments to decide whether they are willing to be enrolled in a randomized trial.

Validation of the Heart Team

Although we have summarized the rationale in support of a Heart Team approach, it is difficult to upgrade the class 1C recommendation in the current guidelines.[4,5] Because of the lack of randomized data, it is crucial to perform observational studies to produce data on the pros and cons of the Heart Team. Currently, only a single study has reported that decisions made by the Heart Team are reproducible.[82]

Several hypothetical designs are listed in *Table 5*. Although there are limitations to such designs, these studies will provide the necessary insights into adoption of the Heart Team and determine whether joint decision-making and treatment recommendations can increase uniformity of care, adherence to practice guidelines, and decrease the number of patients receiving inappropriate care.

Limitations of the Heart Team

The Heart Team approach can cause delays in decision-making and treatment, inefficiency in care, and increased expense by foregoing '*ad hoc*' decisions. Heart Team meetings furthermore require an investment in time of surgeons, cardiologists, and ancillary personal, thereby increasing direct costs. One might therefore suggest that the Heart Team should only convene specifically for those cases in which there is a legitimate question regarding which revascularization strategy should be recommended, and whether treatment decisions can be made without a formal Heart Team meeting. Surgeons and (interventional) cardiologists can specify in a local

Table 5 Possible study designs to validate and evaluate the Heart Team concept

Exploring the reproducibility of the Heart Team by presenting treatment decision of specific cases to different Heart Teams. For example, this can be done for teams in different regions or teams with different inclusion/consistencies of physicians;
Assessing the change in treatment recommendation by comparing an initial individual physician's evaluation to a re-evaluation by the Heart Team;
Cluster randomized trial in which centres evaluate patients either in a Heart Team or according to the original referral patterns by the surgeon or cardiologist;
Before-and-after study to compare treatment decisions and outcomes before and after implementation of a Heart Team;
Comparison of treatment decisions and outcomes of different centres with and without Heart Team evaluation.

protocol which patients can be left out from a Heart Team meeting, e.g. patients with single vessel disease; according to the 2010 ESC/EACTS revascularization guidelines, patients with low lesion complexity (e.g. single- or double-vessel disease) may undergo *ad-hoc* stenting to avoid two separate catheterizations.[4] It is recommended to schedule an informal 'time-out' to allow surgical consultation in the catheterization laboratory; this concept could therefore accelerate the decision-making process in relatively simple cases and in patients with acute coronary syndromes. However, ischaemia, fractional-flow reserve, or the SYNTAX score should be recorded to allow the opportunity for active decision-making as well as the reasons for preclusion of a formal Heart Team discussion so that treatment decisions can retrospectively be acknowledged.

Still, the increased short-term costs associated with multidisciplinary meetings may be of concern. However, in the Netherlands for example, health care providers reimburse the Heart Team as it is likely to reduce inappropriate revascularization and improve outcomes on the long-term, which will compensate for these investments. In some fragmented health care systems, some payers might be concerned with increased short-term cost without acknowledging benefit from reduced long-term costs, and the different parties should attempt to come to an agreement so that the Heart Team approach is beneficial for all those involved.

In the early phase of PCI introduction, surgeons had the ability to influence hospital decisions postponing large-scale PCI use; in several institutions with highly influential cardiac surgeons, the adoption rate of PCI was lower than in other institutions where they were less influential.[83] There have been concerns that multidisciplinary decision-making can be based on autocratic individuals that consider themselves highest on the hierarchical tree.[80] This could result in revascularization strategies that are chosen by the highest rank without a real team discussion. Adherence to current clinical guidelines can then become questionable. Nevertheless, oncology studies have shown that the use of multidisciplinary teams resulted in treatment that is more congruent with evidence-based recommendations and guidelines.[3,77] Although it has been implied that improved concordance with revascularization guidelines can be achieved by multidisciplinary input,[9] this requires further investigation.

There is evidence suggesting that the longer a team has worked together, the more pleasant, interactive, and successful it becomes. The initial experiences of a Heart Team might therefore not always be positive, but it is crucial to maintain the initiative as it could eventually lead to better treatment recommendations and personal wellbeing.

Conclusions

Underutilization, overutilization, and inappropriate use of myocardial revascularization are common, and rates differ significantly between geographic regions and hospitals. Clinical and anatomical risk scores that are used for decision-making have notable inter- and intra-observer variability and this can therefore lead to inaccurate treatment recommendations. A balanced multidisciplinary Heart Team, consisting of at least a clinical/non-invasive cardiologist, interventional cardiologist, and cardiac surgeon, has the potential to (i) better interpret the available diagnostics, (ii) implement guideline directed therapy, (iii) consider local expertise, and (iv) through shared decision-making take into account patient preferences, to provide a more objective and uniform decision-making process. Even though definitive data from trials demonstrating a direct patient benefit to the Heart Team approach is lacking, indirect evidence from both cardiac disease and oncology fields strongly recommends the implementation of the Heart Team.

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