


ORIGINAL RESEARCH

Multidisciplinary Heart Team Approach for Complex Coronary Artery Disease: Single Center Clinical Presentation

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BACKGROUND: The Heart Team approach is ascribed a Class I recommendation in contemporary guidelines for revascularization of complex coronary artery disease. However, limited data are available regarding the decision-making and outcomes of patients based on this strategy.

METHODS AND RESULTS: One hundred sixty-six high-risk coronary artery disease patients underwent Heart Team evaluation at a single institution between January 2015 and November 2018. We prospectively collected data on demographics, symptoms, Society of Thoracic Surgeons Predicted Risk of Mortality/Synergy Between PCI with Taxus and Cardiac Surgery (STS-PROM/SYNTAX) scores, mode of revascularization, and outcomes. Mean age was 70.0 years; 122 (73.5%) patients were male. Prevalent comorbidities included diabetes mellitus (51.8%), peripheral artery disease (38.6%), atrial fibrillation (27.1%), end-stage renal disease on dialysis (13.3%), and chronic obstructive pulmonary disease (21.7%). Eighty-seven (52.4%) patients had New York Heart Association III-IV and 112 (67.5%) had Canadian Cardiovascular Society III-IV symptomatology. Sixty-seven (40.4%) patients had left main and 118 (71.1%) had 3-vessel coronary artery disease. The median STS-PROM was 3.6% (interquartile range 1.9, 8.0) and SYNTAX score was 26 (interquartile range 20, 34). The median number of physicians per Heart Team meeting was 6 (interquartile range 5, 8). Seventy-nine (47.6%) and 49 (29.5%) patients underwent percutaneous coronary intervention and coronary artery bypass grafting, respectively. With increasing STS-PROM (low, intermediate, high operative risk), coronary artery bypass graft was performed less often (47.9%, 18.5%, 15.2%) and optimal medical therapy was recommended more often (11.3%, 18.5%, 30.3%). There were no trends in recommendation for coronary artery bypass graft, percutaneous coronary intervention, or optimal medical therapy by SYNTAX score tertiles. In-hospital and 30-day mortality was 3.9% and 4.8%, respectively.

CONCLUSIONS: Integrating a multidisciplinary Heart Team into institutional practice is feasible and provides a formalized approach to evaluating complex coronary artery disease patients. The comprehensive assessment of surgical, anatomical, and other risk scores using a decision aid may guide appropriate, evidence-based management within this team-based construct.

Key Words: cardiac surgery ■ percutaneous coronary intervention ■ quality improvement ■ revascularization ■ team-based care

See Editorial by Holmes and Mack

Determining the optimal treatment strategy for patients with complex coronary artery disease (CAD) requires assessment of each patient's presenting illness, clinical stability, coronary anatomy,

comorbidities, and goals of care. An informed decision to pursue percutaneous or surgical revascularization in patients with multivessel or left main CAD may be optimized when appropriate stakeholders—primary care

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CLINICAL PERSPECTIVE

What Is New?

- We designed an institutional Heart Team approach for complex coronary artery disease— inclusive of a structured coronary artery disease heart team form and simultaneous Interventional Cardiology and Cardiac Surgery consultation— that culminated in a well-attended interdisciplinary team meeting held for each high-risk patient.

What Are the Clinical Implications?

- Incorporating a structured Heart Team form that assesses formal risk stratification facilitates personalized decision-making for complex coronary artery disease patients.

Nonstandard Abbreviations and Acronyms

IQR	interquartile range
HT	Heart Team
OMT	optimal medical therapy
STS-PROM	Society of Thoracic Surgeons Predicted Risk of Mortality
SYNTAX	Synergy Between PCI with Taxus and Cardiac Surgery

physicians, cardiologists, interventional cardiologists, cardiac surgeons, patients, and family members— communicate and proceed in a coordinated, interdisciplinary manner. Professional society guidelines, risk calculators, and appropriate use criteria provide a framework that may help guide management at the bedside.^{1–5} However, the complexities of integrating patient-centered shared decision-making with evidence-based medicine in the context of multiple comorbid disease entities substantiate the potential benefit of a multidisciplinary team-based approach to medical care.^{6,7}

The multidisciplinary “Heart Team” (HT) approach has been espoused and deployed for multiple conditions relevant to cardiovascular medicine: valvular heart disease, peripheral vascular disease, pulmonary embolism, and cardiogenic shock.^{8–12} European professional society guidelines first mandated a team-based approach to decision-making for multivessel CAD in 2010.¹³ This was followed by American-centered guidelines in 2014 that provided a class I recommendation for the HT strategy in managing stable ischemic heart disease.¹ These recommendations follow from the data and experience of multiple large randomized clinical trials that have compared percutaneous

and surgical revascularization in patients with complex coronary disease. For instance, the Synergy Between PCI with Taxus and Cardiac Surgery (SYNTAX) trial included in its design a formalized protocol for assessment of patients by both interventional cardiology and cardiac surgery.¹⁴

Implementation of the rich evidence base guiding CAD management to the nuances of real-world practice can be challenging, thus supporting the role of an interdisciplinary model of care for ischemic heart disease.^{14–16} In this study, we describe the structure and deployment of a multidisciplinary HT for patients with complex CAD, as well as the clinical outcomes at a single institution with the use of this approach over a 3-year time period since its inception. Furthermore, in this team model, we created and employed a practical HT form that integrates the use of US and European practice guidelines, validated surgical and percutaneous coronary intervention (PCI) risk scores, and SYNTAX grading to aid in patient-centered decision-making. In addition, we implemented an interventional cardiology consultative service to provide formal recommendations for these patients with complex CAD presentations.

METHODS


Multidisciplinary HT Structure and Workflow

Starting in January 2015, the Massachusetts General Hospital has offered a multidisciplinary CAD HT consultative service for patients diagnosed with complex CAD and deemed high risk for surgical or percutaneous revascularization. The HT may receive electronic notification requesting a formal consultation by either an inpatient or outpatient cardiology physician. This may be requested following a cardiac catheterization that has provided an up-to-date assessment of a patient’s coronary anatomy and hemodynamics. Referring physicians may classify these patients as high risk based on several factors: multivessel distribution of coronary disease, left main involvement, low ejection fraction, chronic total occlusion, advanced patient age or frailty, socioeconomic factors, or other coexisting medical comorbidities. Once a consultation is requested, the patient is independently seen and assessed by an interventional cardiology service in tandem with the cardiac surgical service. Those participating physicians will then coordinate a multidisciplinary heart team meeting for that patient. The CAD HT was therefore developed based on a quality improvement initiative and has continued to operate at the Massachusetts General Hospital since its inception.


Furthermore, a structured HT form was designed to capture relevant clinical data before a formal

interdisciplinary team meeting. Requisite information included laboratory data, coronary angiography +/- right heart hemodynamic data, echocardiography, and

if warranted, noninvasive functional testing. A comprehensive risk profile was also conducted using validated risk stratification tools and documented in the "CAD



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MGH CAD Heart Team Meeting Date: enter a date. Prepared by: name

Patient: last name, first name Age: age/sex MRN: enter MRN Inpatient

Weight (kg): weight Height (cm): height BMI: BMI Code status: Choose an item.

Attending: attending's name Surgeon: surgeon's name Interventional: interventional name

DIAGNOSIS: Choose an item.
 Angina: Choose an item. HF class: Choose an item. EF: EF%
 Surgical valvular disease (AS, MR): describe valvular disease

Case History: 1-line summary

ANGIOGRAM (AHA $\geq 70\%$ or $FFR \leq 0.8$; ESC 51%-90% with ischemia/ FFR ; or 91%+)
 2-vessel CAD 3-vessel CAD Left main CAD ($\geq 50\%$ LMCA; ostial LAD+CFX 70%=LM equivalent)
 angiogram details
RHC: RA mean; RV sys/dia; PA sys/dia, mean; PCWP mean

SYNTAX SCORE: score
 (0-22 low, 23-32 intermediate, 33+ high) (ostial LAD+ostial CFX is not a left main for syntax; see ostial LAD example on next page)

SYNTAX II Score (points & 4y mortality): PCI: points/4y mortality%; CABG: points/4y mortality%

STS SCORE (Choose type): Mortality: score%; Morbidity or Mortality: score%; Stroke: score%
 (AHA: High-risk STS $\geq 5\%$; EHJ 2018 Table 5: Low-risk < 4%; Interm 4-8%, High > 8%)

PCI Risk (NCDR): Mortality: %; AKI: %; Bleeding: %; 1-year TVR: %

12+ months DAPT candidate? DAPT score (2+ favors 30 months): score
 Anticoagulated (for choose) HAS-BLED: score

Echo: date; EF %%; LVEDD cm cm; RV fxn choose; RVSP mmHg; MR choose; AS choose; TR choose
Stress test: date; type: results
Viability test: date; type: results

CLINICAL RISK FACTORS:
Creatinine: creatinine; eGFR: eGFR Hct: hct Plts: plts INR: INR
 Diabetes A1c: A1c%; insulin, oral, diet
 COPD FEV1: FEV1
 PAD what territory
 Cerebrovasc Disease what territory, stroke or bleed

FRAILITY Score (Canadian study of health and ageing score): frailty score

COMORBIDITIES: list comorbidities
 (Examples: Cirrhosis Surgical Mortality (link), cancer, RV dysfunction, fragility, severe obesity, coagulopathy/hemophilia, hx XRT, severely calcified aorta, immunosuppression, hx severe stroke, limited life expectancy)

SUMMARY: additional info (include low EF or DM based recs; review STITCH for HF/ICMP driven)
 Guideline recommendation not possible based on current evidence

ACC/AHA 2017 Recommendation Class for Survival: PCI: class CABG: class
ESC 2018 Recommendation Class for Survival: PCI: class CABG: class
 (AHA: "if good candidate for CABG", ESC: Low predicted risk surgical patients only)

→ If not class I or IIa for mortality above, please fill out below for symptoms ←

ACC/AHA 2017 Recommendation Class for Symptoms: PCI: class CABG: class
ESC 2018 Recommendation Class for Symptoms: PCI: class CABG: class

Figure 1. Multidisciplinary heart team risk assessment and summary form.

Heart Team Decision Aid” shown in Figure 1. Within 24 to 48 hours of request, a scheduled multidisciplinary HT meeting is convened, consisting of a referring team physician, the patient’s primary cardiologist, ≥ 2 interventional cardiologists, and ≥ 2 cardiothoracic surgeons. Depending on each patient’s unique circumstance, additional participants may include other subspecialty consultants (eg, hematology, oncology, pulmonology, etc). The patient’s presenting illness, history, noninvasive, and invasive data are reviewed in detail, and a formal recommendation regarding management strategy of CAD is coformulated by participating team members.

Study Population and Data Collection

From January 2015 to November 2018, 166 patients deemed high risk for coronary revascularization underwent a HT consultation at our institution. We prospectively collected data on demographics, symptoms, comorbidities, noninvasive and cardiac catheterization results, and calculated Society of Thoracic Surgeons Predicted Risk of Mortality (STS-PROM) and SYNTAX scores. We also recorded data on HT participation, including attendant members, subspecialties represented, recommendation provided with respect to treatment strategy, and final treatment/mode of revascularization delivered. Study data were collected and managed using Research Electronic Data Capture (REDCap) electronic data capture tools hosted at Partners Healthcare. REDCap is a secure, web-based application designed to support data capture for research studies.¹⁷ This project was undertaken as a Quality Improvement Initiative at the Massachusetts General Hospital, and as such was not formally supervised by the Institutional Review Board per their policies. The authors declare that all supporting data are available within the article.

Practice Assessment/Outcomes

We retrospectively analyzed the revascularization strategy according to coronary anatomy complexity using the validated SYNTAX score calculated for each patient. We also stratified revascularization approach according to low (0–4%), intermediate (4–8%), and high (>8%) surgical risk groups using the estimated STS-PROM score. Periprocedural data, in-hospital mortality, and 30-day mortality were tracked and recorded for all patients. We also assessed for 30-day unplanned readmission rate for the overall cohort, and then stratified according to treatment strategy.

Statistical Analysis

Descriptive statistics were used to analyze demographics, comorbidities, results of noninvasive and

invasive testing, HT meeting data, details of revascularization strategies, and outcomes of the study cohort. Categorical variables are expressed as frequencies and percentages and continuous variables as mean \pm SD and/or median (interquartile range [IQR]) as appropriate. Statistical analysis was performed using SPSS version 23.0 (IBM Corp, Armonk, NY).

RESULTS

Baseline Characteristics

From January 2015 through November 2018, the total number of patients undergoing coronary revascularization at the Massachusetts General Hospital was 6120 (4331 PCI; 1789 CABG). During this time period, 166 of these CAD patients were deemed high-risk and underwent formal HT consultation (166/6120, 2.7%). Table 1 depicts the patient demographics, comorbidities, presentation, noninvasive testing, and angiographic data for the cohort. The mean age was 70.0 (\pm 11.8) years, and 122 (73.5%) patients were male. Prevalent comorbidities included diabetes mellitus (51.8%), peripheral artery disease (38.6%), atrial fibrillation (27.1%), cancer (24.1%), chronic obstructive lung disease (21.7%), end-stage renal disease on dialysis (13.3%), and chronic liver disease (6.6%). More than one third of patients had at least mild frailty. The most common CAD presentation was non-ST-elevation acute coronary syndrome (111 [66.9%]), and 112 (67.5%) patients had Canadian Cardiovascular Society class III-IV angina. The median left ventricular ejection fraction was 45% (IQR 32, 60), and 87 (52.4%) patients had New York Heart Association functional class III-IV symptoms. The median STS-PROM score was 3.6% (IQR 1.9, 8.0).

With respect to coronary anatomic complexity, 67 (40.4%) patients had left main and 118 (71.1%) had 3-vessel CAD. A chronic total occlusion was present in 65 (39.2%) patients. The median SYNTAX score in patients without prior history of CABG was 26 (IQR 20, 34). The distribution of HT patients based on SYNTAX tertiles (after excluding $n=24$ prior CABG patients) was: low tertile, 35.9%; intermediate tertile, 33.8%; and high tertile, 30.3%. Among the 56 (33.7%) patients who had right heart catheterization data available, the median cardiac index was 2.1 (IQR 1.7, 2.5). From a surgical perspective, the median STS-PROM in the HT group was 3.6% (IQR 1.9, 8.0). The distribution of HT patients based on STS categories was: low risk, 53.6%; intermediate risk, 21.7%; and high risk, 24.7%.

CAD HT Profile and Clinical Outcomes

During the study period, the median number of physicians in attendance of the HT meeting was 6 (IQR 5, 8).

Table 1. Baseline Characteristics

Variable	n=166
Age, y	
Mean±SD	70.0±11.8
Median (IQR)	72 (63, 79)
Sex	
Male	122 (73.5)
Female	44 (26.5)
Body mass index, kg/m ²	28.2 (24.3, 32.0)
Diabetes mellitus	86 (51.8)
No therapy	13 (7.8)
Oral therapy	21 (12.7)
Insulin therapy	55 (31.3)
Hemoglobin A1c	6.8±1.2
Chronic obstructive lung disease	36 (21.7)
Home oxygen therapy	9 (5.4)
Peripheral artery disease	64 (38.6)
Serum creatinine, mg/dL	1.1 (0.9, 1.5)
ESRD on dialysis	22 (13.3)
Prior cerebrovascular disease	45 (27.1)
Carotid artery disease	29 (17.5)
Prior PCI	63 (38.0)
Prior CABG	24 (14.5)
Arrhythmia	
None	106 (63.9)
Atrial fibrillation	45 (27.1)
Atrial flutter	2 (1.2)
VT/VF	12 (7.2)
Hematocrit, %	34.7 (30.0, 39.5)
Platelet count, ×10 ³ per μL	187 (143, 244)
Liver disease	11 (6.6)
MELD score	11 (8, 23)
Child-Pugh Class	
A	8 (4.8)
B	2 (1.2)
C	1 (0.6)
Cancer	40 (24.1)
Immunocompromised	20 (12.0)
CSHA Clinical Frailty Scale	4 (3, 5)
≥5	62 (37.4)
CAD presentation	
STEMI	3 (1.8)
NSTEMI	89 (53.6)
Unstable angina	22 (13.3)
Stable angina	24 (14.5)
No angina	28 (16.9)

(Continued)

The median number of interventional cardiologists and cardiac surgeons in attendance was 2 (IQR 2, 3) and 3 (IQR 1, 4), respectively (Table 2). Other specialties in

Table 1. Continued

Variable	n=166
CCS angina class	
0	20 (12.0)
I	2 (1.2)
II	4 (2.4)
III	33 (19.9)
IV	79 (47.6)
Heart failure	116 (69.9)
NYHA functional class	
I	7 (4.2)
II	22 (13.3)
III	34 (20.5)
IV	53 (31.9)
Cardiogenic shock	13 (7.8)
Cardiac arrest	10 (6.0)
STS PROM score	3.6 (1.9, 8.0)
Noninvasive assessment	
Echocardiogram	
LVEF, %	45 (32, 60)
LVEDD, mm	51 (45, 57)
Right ventricular dysfunction	37 (22.3)
RVSP, mm Hg	42 (35, 52)
≥ moderate AS	27 (16.3)
≥ moderate MR	50 (30.1)
Stress testing	
None	115 (69.3)
Yes, without ischemia	11 (6.6)
Yes, with ischemia	40 (24.1)
Viability testing	
No	130 (78.3)
Yes	36 (21.7)
Coronary angiogram	
Coronary artery involvement	
LMCA	67 (40.4)
LAD	158 (95.2)
LCX	142 (85.5)
RCA	142 (85.5)
Bypass graft	16 (9.6)
Number of diseased vessels	
1	9 (5.4)
2	37 (22.3)
3	118 (71.1)
Chronic total occlusion	65 (39.2)
SYNTAX Score (n=142)	26 (20, 34)

(Continued)

attendance 12/166 (7.2%) included: pulmonary in 3 (1.8%); hematology in 2 (1.2%); oncology in 3 (1.8%); and infectious disease, vascular surgery, endocrine, and primary care in 1 each (0.6%). Palliative care participated in formal consultation in 15/166 (9.0%) of this high-risk cohort.

Table 1. Continued

Variable	n=166
Right heart catheterization (n=56)	
RAP, mm Hg	8 (6, 11)
RVSP, mm Hg	42 (32, 52)
PASP, mm Hg	44 (32, 56)
PCWP, mm Hg	18 (12, 27)
CO, L/min	3.9 (3.2, 4.7)
CI, L/min per m ²	2.1 (1.7, 2.5)

Continuous variables are presented as means±SD or medians with interquartiles (Q1, Q3). AS indicates aortic stenosis; CABG, coronary artery bypass grafting; CAD, coronary artery disease; CCS, Canadian Cardiovascular Society; CI, cardiac index; CO, cardiac output; CSHA, Canadian Study on Health and Aging; IQR, interquartile range; ESRD, end-stage renal disease; LAD, left anterior descending; LCX, left circumflex artery; LMCA, left main coronary artery; LVEDD, left ventricular end-diastolic diameter; LVEF, left ventricular ejection fraction; MELD, Model for End-Stage Liver Disease; MR, mitral regurgitation; NSTEMI, non-ST-segment-elevation myocardial infarction; NYHA, New York Heart Association; PASP, pulmonary artery systolic pressure; PCI, percutaneous coronary intervention; PCWP, pulmonary capillary wedge pressure; RAP, right atrial pressure; RCA, right coronary artery; RVSP, right ventricular systolic pressure; STEMI, ST-segment-elevation myocardial infarction; STS PROM, Society of Thoracic Surgeons Predicted Risk of Mortality; SYNTAX, Synergy between PCI with Taxus and Cardiac Surgery; VF, ventricular fibrillation; and VT, ventricular tachycardia.

Of the 166 patients discussed at HT meetings, eventually 79 (47.6%) underwent PCI, 49 (29.5%) underwent CABG, 1 (0.6%) underwent hybrid revascularization, and 34 (20.5%) were treated with optimal medical therapy (OMT) only. The median duration between HT meeting and PCI was 1 (IQR 0, 3) day and that between HT meeting and CABG was 3 (IQR 1, 6) days. Figure 2 depicts the HT recommendation stratified by STS and SYNTAX scores. When stratified by predicted STS surgical risk, CABG was most often recommended for patients in the lowest surgical risk stratum (47.9%) and PCI was most often recommended for patients in the intermediate risk stratum (63.0%). OMT as the primary strategy was infrequently recommended, but more often as the predicted surgical risk rose. By SYNTAX score, there were no apparent trends in the relative recommendation for CABG, PCI, or OMT. Of the 34 patients who received a recommendation for OMT, 21 were hospitalized as inpatients. Four of these patients died in-hospital, 3 of whom were under comfort care only at the time of death.

Details of the revascularization strategies are shown in Table 3. In patients who underwent PCI, left main stenting was performed in 29 (36.7%). Drug-eluting stents were used in a majority (96.2%) of the patients. Intracoronary imaging was used in 30 (37.9%), atherectomy in 38 (48.1%), and mechanical circulatory support in 23 (29.1%) patients. In patients who underwent CABG, the left anterior descending coronary artery was bypassed in 47 (95.9%). All procedures were

Table 2. Multidisciplinary Heart Team Meeting Data and Outcomes

Patient status at the time of meeting	
Inpatient	119 (71.7)
Outpatient	47 (28.3)
Number of attendees	
Total	6 (5, 8)
Cardiac surgeons	3 (1, 4)
Interventional cardiologists	2 (2, 3)
General cardiologists	1 (1, 2)
Formal Heart Team recommendation	
OMT	23 (13.9)
PCI	64 (38.6)
CABG	44 (26.5)
Hybrid	2 (1.2)
Other*	4 (2.4)
Defer†	29 (17.5)
Outcomes	
Successful PCI	79 (47.6)
Heart team meeting to PCI, d	1 (0, 3)
Successful CABG	49 (29.5)
Heart Team meeting to CABG, d	3 (1, 6)
Hybrid	1 (0.6)
OMT only	34 (20.5)
Length of stay, d (n=113)	16 (11, 24)
30-d readmission rate	31 (18.7%)
Outcomes of patients who underwent revascularization (n=129)	
Myocardial infarction	5 (3.9)
Stroke	3 (2.3)
AKI requiring dialysis	3 (2.3)
Transfusion	42 (32.6)
In-hospital mortality	5 (3.9)
30-d postprocedure mortality (n=125)	6 (4.8)

AKI indicates acute kidney injury; CABG, coronary artery bypass grafting; ICD, implantable cardioverter-defibrillator; LVAD, left ventricular assist device; OMT, optimal medical therapy; PCI, percutaneous coronary intervention; and TAVR, transcatheter aortic valve replacement.

*Other recommendations included TAVR (n=1), ICD (n=1), and LVAD (n=2).

†Additional studies/evaluation needed.

performed on-pump and mechanical circulatory support was used in 7 (14.3%) patients. Twelve (24.5%) patients underwent concurrent (eg, CABG+valve) cardiac surgical procedures.

Among 129 patients who underwent revascularization (PCI or CABG), the in-hospital mortality was 3.9%. Other in-hospital major adverse events included myocardial infarction (5 [3.9%]), stroke (3 [2.3%]), acute kidney injury requiring dialysis (5 [3.9%]), and blood transfusion (42 [32.6%]). The overall 30-day postprocedure mortality rate was 4.8% (Table 2). For patients who underwent CABG (n=49), the observed 30-day mortality rate was 2.2%, while the expected 30-day mortality based on estimated STS-PROM was 4.1%.

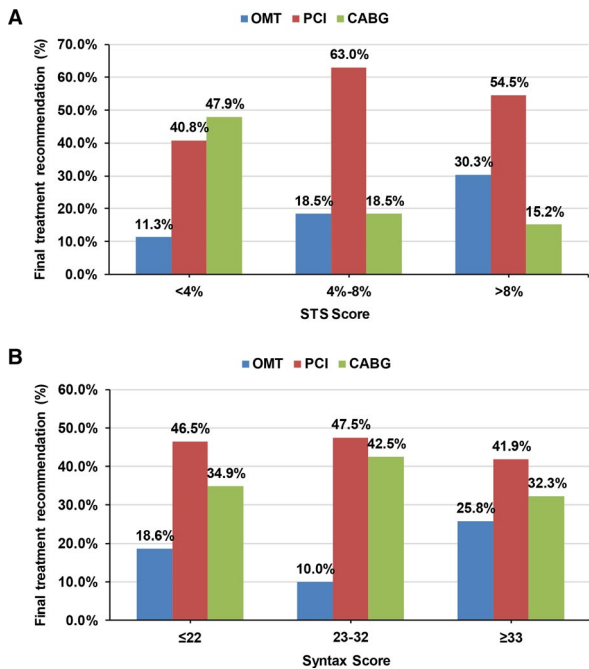


Figure 2. Heart team recommendation stratified by STS predicted risk of mortality (A) and SYNTAX scores (B). CABG indicates coronary artery bypass grafting; OMT, optimal medical therapy; PCI, percutaneous coronary intervention; STS, Society of Thoracic Surgeons; and SYNTAX, Synergy Between PCI with Taxus and Cardiac Surgery.

Therefore, the observed/expected mortality ratio for this group was 2.2/4.1=0.54.

For the entire high-risk cohort, the 30-day unplanned readmission rate was 31/166, or 18.7%. Specifically, 13/79 (16.4%) of PCI patients, 11/49 (22.4%) of CABG patients, and 6/34 (17.6%) of OMT patients were hospitalized within 30 days. The single patient who underwent hybrid surgical and percutaneous revascularization was also readmitted.

DISCUSSION

The concept of the multidisciplinary “Heart Team” has been successfully employed and championed in several areas within the field of cardiovascular medicine. For instance, the structural HT evolved from the advent and dispersion of transcatheter aortic and mitral valve therapies. Institutional experiences of dedicated pulmonary embolism response teams have also been well-described in the literature.^{9,10} This interdisciplinary team-based philosophy has even been extrapolated to conditions such as cardiogenic shock and critical limb ischemia.^{8,18} These initiatives derive from the belief that patient care may best be optimized when leveraging the expertise and experience of subspecialists, each of whom can intimately understand and weigh in on the nuances of a

Table 3. Revascularization Strategies

PCI	n=79
Vessels treated	
LMCA	29 (36.7)
LAD	50 (63.3)
LCX	40 (50.6)
Ramus	3 (3.8)
RCA	25 (31.6)
Bypass graft	7 (8.8)
DES	76 (96.2)
BMS	4 (5.1)
No. of stents implanted	2 (1, 4)
IVUS	28 (35.4)
OCT	2 (2.5)
Rotational atherectomy	22 (27.8)
Orbital atherectomy	13 (16.5)
Laser atherectomy	3 (3.8)
Mechanical circulatory support	23 (29.1)
IABP	1 (1.3)
Impella	20 (25.3)
ECMO	1 (1.3)
LVAD	2 (2.5)
Staged PCI	7 (8.9)
CABG	n=49
Vessels bypassed	
LAD	47 (95.9)
LCX	38 (77.6)
RCA	33 (67.3)
LIMA graft	49 (100.0)
On-pump	49 (100.0)
Mechanical circulatory support	7 (14.3)
IABP	6 (12.2)
Impella	1 (2.0)
Concurrent surgical procedure	12 (24.5)
AVR	4 (8.2)
MVR	2 (4.1)
Mitral annuloplasty ring	2 (4.1)
LAA ligation	5 (10.2)
Other	3 (6.1)

AVR indicates aortic valve replacement; BMS, bare metal stent; CABG, coronary artery bypass grafting; DES, drug-eluting stent; ECMO, extracorporeal membrane oxygenation; IABP, intra-aortic balloon pump; IVUS, intravascular ultrasound; LAA, left atrial appendage; LAD, left anterior descending; LCX, left circumflex artery; LMCA, left main coronary artery; LVAD, left ventricular assist device; MVR, mitral valve replacement; OCT, optical coherence tomography; PCI, percutaneous coronary intervention; and RCA, right coronary artery.

patient’s disease state relevant to his or her presenting illness.

Similar to other cardiovascular disease entities, complex CAD presents multiple challenges with respect to patient-centered shared-decision making,

periprocedural risk stratification, antiplatelet and anticoagulant treatment strategy, and downstream clinical implications based on mode of revascularization.¹⁹ To date, the development and integration of the HT approach to the care of CAD patients has been previously published in a few single center observational studies, each with variable reports of use of predicted surgical risk and SYNTAX scoring in team-based recommendations.^{20–25} It is, however, unclear how widely adopted a formalized, team-based strategy to coronary revascularization may be, despite its classification as a Class I recommendation in current professional society guidelines.¹

We provide a report on the design, implementation, and 3-year outcomes of a HT consultative service for the management of high risk, complex CAD patients at a single institution. We build upon prior HT studies by devising a succinct yet practical HT decision aid that integrates relevant patient data; SYNTAX score; STS-PROM and PCI risk calculation; formalized interventional cardiology consultation service at the bedside, professional guidelines grading; and technical considerations for revascularization. We then deployed this clinical tool in the construct of our interdisciplinary model while longitudinally collecting outcomes following either medical therapy or revascularization in our complex CAD population.

Overall, patients who underwent HT consultation in our prospectively collected cohort were older; severely symptomatic by both New York Heart Association and Canadian Cardiovascular Society class; medically complex based on coexisting comorbidities (eg, chronic pulmonary disease, peripheral artery disease); anatomically complex by SYNTAX grading; and often intermediate or high surgical risk by STS risk score. Reassuringly, all patients referred for revascularization underwent successful CABG or PCI with an in-hospital mortality rate that was relatively low (3.9%) for this high-risk patient cohort. In the PCI subgroup, the use of intracoronary imaging, atherectomy, and mechanical circulatory support were frequent, thus attesting to the technical complexity required for PCI of HT patients. Meanwhile, for the CABG subgroup, approximately one quarter of these patients underwent a concurrent surgical procedure (eg, valve replacement). Furthermore, the actual 30-day mortality rate was 2.2%, which was favorably lower than the mean estimated STS-PROM of 4.1% (observed/expected 0.54). Notably, the 30-day readmission rate was high across the entire cohort (18.7%) and among all management strategy subgroups (16.4% PCI, 22.4% CABG, 17.6% OMT). This attests to the high-risk, medically complex nature of this population.

From this study, we first highlight the utilization of risk assessment scores and other validated instruments to provide quantitative data that could better

inform the patient, referring cardiologist, and proceduralist regarding all potential therapeutic options including OMT. By incorporating STS PROM, SYNTAX scores, relevant calculated PCI risks, and American Heart Association and European Society of Cardiology guideline references, the HT has offered the opportunity to comprehensively discuss appropriate indications for revascularization as well as quantified risk assessment for each revascularization strategy. Furthermore, these HT meetings often incorporated technical discussions among proceduralists. For instance, a cardiac surgeon may articulate whether or not a patient would be a candidate for off-pump bypass, hybrid CABG-PCI options, or if coexisting valvular disease would also need to be treated in tandem. An interventional cardiologist on the team might discuss the role for atherectomy, extent of revascularization in a single or staged setting, radial versus femoral access, adjunctive hemodynamic support (ie, percutaneous ventricular assist device, heart failure/durable left ventricular assist device/transplantation assessment before PCI), or optimal dual antiplatelet therapy/triple therapy regimens post-PCI.

We found that high-risk CAD HT meetings were well attended by both interventional cardiologists and cardiac surgeons (median total attendees 6). This is important in that—beyond the consulting interventional cardiologist and cardiac surgeon—additional attendance was otherwise voluntary. When stratifying the HT recommendations by SYNTAX score, we found that a larger proportion of patients in the low (<23) and intermediate (23–32) SYNTAX tertiles received a recommendation for PCI relative to patients in the highest SYNTAX tertile (≥ 33). This practice pattern might suggest that the CAD HT operated in the context of contemporary trial data (ie, SYNTAX trial). Furthermore, when analyzing recommendations according to STS-PROM, the recommendation for surgical revascularization decreased while optimal medical therapy proportionally increased with each STS-PROM category (low <4%, intermediate 4–8%, and high >8%; Figure 2).

Limitations are present in this institutional case series. Data were generated from a single center, and randomization was not feasible as the new HT structure was adopted when first implemented. It would be challenging to capture how the efficacy of decision-making evolves with institutional experience and maturation of the HT model. Furthermore, not all complex CAD patients during this study period may have been captured because of clinical urgency or other logistical issues. Longer-term follow-up and the impact of incomplete revascularization will be of importance in future investigations.

From the current experience, we conclude that the formulation of a multidisciplinary process by which all high-risk CAD patients are comprehensively

risk-stratified and evaluated is safe and realistically achievable in a busy tertiary referral system. Interdisciplinary HT meetings were well-attended by both interventional cardiologists and cardiac surgeons. Based on formal recommendations made in the context of the patient's stratified anatomic and surgical risks, the HT practice patterns regarding revascularization strategy appeared to account for anatomical and patient-specific risks. Future study in this area of healthcare delivery may focus on whether or not such constructs have measurable, meaningful impacts on informed consent and patient-reported outcomes.

CONCLUSIONS

The organization and deployment of a multidisciplinary HT for complex CAD is realistically achievable and helps provide a formalized construct to guide medical decision-making for both healthcare providers and patients. The utilization of this interdisciplinary model of care enables individualized risk assessment as well as an evidence-based approach to coronary revascularization. The integration of SYNTAX, STS-PROM, and other validated risks scores into the comprehensive HT evaluation of complex CAD is feasible, informative, and effective for guiding care in high-risk patients.

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