



Original Article

# Accuracy of Physicians in Differentiating Type 1 and Type 2 Myocardial Infarction Based on Clinical Information

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ABSTRACT

**Background:** Physicians commonly judge whether a myocardial infarction (MI) is type 1 (thrombotic) vs type 2 (supply/demand mismatch) based on clinical information. Little is known about the accuracy of physicians' clinical judgement in this regard. We aimed to determine the accuracy of physicians' judgement in the classification of type 1 vs type 2 MI in perioperative and nonoperative settings.

**Methods:** We performed an online survey using cases from the Optical Coherence Tomographic Imaging of Thrombus (OPTIMUS) Study,

RÉSUMÉ

**Contexte :** Les médecins déterminent généralement s'ils sont en présence d'un infarctus du myocarde (IM) de type 1 (thrombotique) ou de type 2 (demande accrue ou apport réduit en oxygène) sur la base des renseignements cliniques. On en sait cependant très peu au sujet de la justesse du jugement clinique des médecins à cet égard. Nous avons donc cherché à déterminer si les médecins réussissent à distinguer correctement les IM de type 1 et de type 2 dans les contextes périopératoire et non opératoire.

Myocardial infarction (MI) is one of the leading causes of mortality worldwide.<sup>1,2</sup> In the perioperative setting, MI is one of the most common clinical complications after noncardiac surgery.<sup>3,4</sup> There is debate regarding the pathophysiology of perioperative MI. Patients undergoing noncardiac surgery are

susceptible to sympathetic nervous system activation, tachycardia, bleeding, hypertension, and hypotension, which can lead to cardiac oxygen supply-demand mismatch. Surgery also causes hypercoagulability and inflammation, which can trigger platelet activation, plaque destabilization, erosion, or rupture, leading to thrombus formation. These mechanisms fall within different categories of the Universal Definition of MI, type 1 (thrombotic) or type 2 (supply-demand mismatch).<sup>5</sup>

In the perioperative and nonoperative setting, it is unclear how accurate physicians are at determining whether a non-ST segment elevation MI (NSTEMI) is type 1 vs type 2 based only on clinical information. Physician judgement about MI etiology often has implications for patient management and may influence whether physicians opt for a conservative vs invasive treatment strategy.<sup>5</sup>

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**Ethics Statement:** The research reported has adhered to the relevant ethical guidelines.

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See page 583 for disclosure information.

which investigated the prevalence of a culprit lesion thrombus based on intracoronary optical coherence tomography (OCT) in patients experiencing MI. Four MI cases, 2 perioperative and 2 nonoperative, were selected randomly, stratified by etiology. Physicians were provided with the patient's medical history, laboratory parameters, and electrocardiograms. Physicians did not have access to intracoronary OCT results. The primary outcome was the accuracy of physicians' judgement of MI etiology, measured as raw agreement between physicians and intracoronary OCT findings. Fleiss' kappa and Gwet's AC1 were calculated to correct for chance.

**Results:** The response rate was 57% (308 of 536). Respondents were 62% male; median age was 45 years (standard deviation  $\pm 11$ ); 45% had been in practice for  $> 15$  years. Respondents' overall accuracy for MI etiology was 60% (95% confidence interval [CI] 57%-63%), including 63% (95% CI 60%-68%) for nonoperative cases, and 56% (95% CI 52%-60%) for perioperative cases. Overall chance-corrected agreement was poor (kappa = 0.05), consistent across specialties and clinical scenarios.

**Conclusions:** Physician accuracy in determining MI etiology based on clinical information is poor. Physicians should consider results from other testing, such as invasive coronary angiography, when determining MI etiology.

We previously conducted the **Optical Coherence Tomographic Imaging of Thrombus (OPTIMUS)** Study to determine the prevalence of a culprit lesion thrombus in patients experiencing a perioperative NSTEMI, compared with a matched cohort of patients experiencing a nonoperative NSTEMI, using intracoronary optical coherence tomography (OCT).<sup>6</sup> OCT is an accurate intravascular imaging technique for the detection of thrombus, and thus classification of MI etiology.<sup>7-9</sup> The main objective of this current study was to determine the accuracy of physicians' judgement in the classification of NSTEMI etiology (ie, type 1 vs type 2) in patients diagnosed with NSTEMI in both perioperative and nonoperative scenarios, using cases from the OPTIMUS Study.

## Materials and Methods

### Study design

We undertook a cross-sectional online survey study that evaluated physician accuracy in judgement of MI etiology using real cases from the OPTIMUS Study database.

### Participants

From July 2017 to January 2018, we recruited anaesthesiologists, noninvasive and invasive cardiologists, and general internists (ie, the specialists most commonly involved with perioperative MIs) from 7 centres in Brazil, Canada, and Italy (Supplemental Table S1). We excluded investigators involved in the design of the survey, physicians originally

**Méthodologie :** Nous avons mené une enquête en ligne en utilisant les cas de l'étude OPTIMUS (*Optical Coherence Tomographic Imaging of Thrombus*), qui avait évalué la prévalence des lésions causant un thrombus au moyen de la tomographie par cohérence optique (TCO) endocoronaire chez les patients subissant un IM. Nous avons choisi au hasard quatre cas d'IM stratifiés en fonction de leur cause : deux cas en contexte périopératoire et deux cas en contexte non opératoire. Les médecins avaient accès aux antécédents médicaux, aux résultats des analyses de laboratoire et aux électrocardiogrammes des patients, mais pas aux résultats de la TCO endocoronaire. Le principal paramètre d'évaluation était la justesse du jugement du médecin concernant la cause de l'IM, mesurée en fonction de la concordance approximative entre le jugement du médecin et les observations à la TCO endocoronaire. Les coefficients de concordance kappa de Fleiss et AC1 de Gwet ont servi à corriger pour le hasard.

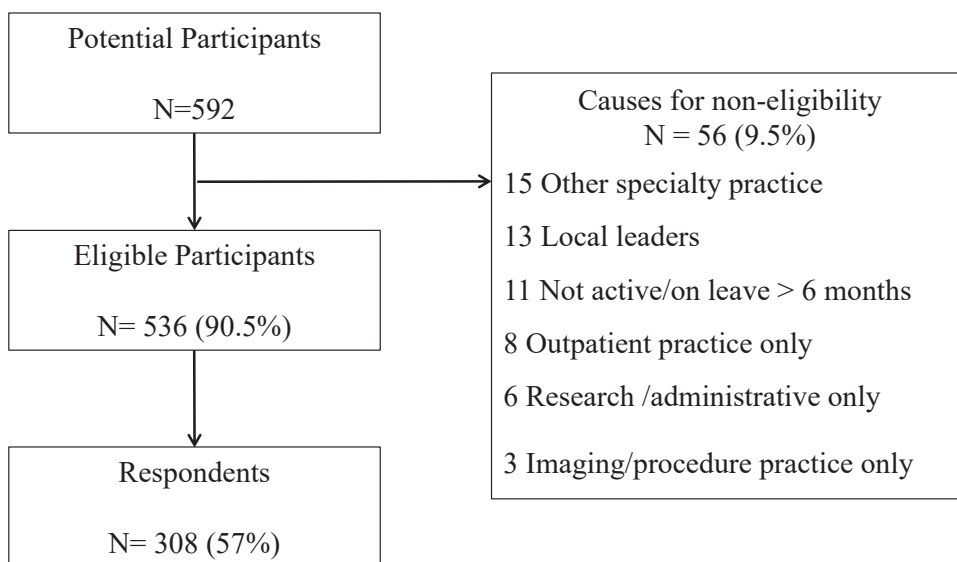
**Résultats :** Le taux de réponse était de 57 % (308 sur 536). Des participants, 62 % étaient des hommes et 45 % exerçaient depuis plus de 15 ans; l'âge médian était de 45 ans (écart-type :  $\pm 11$ ). La justesse globale avec laquelle les répondants ont déterminé la cause des IM était de 60 % (intervalle de confiance [IC] à 95 % : 57-63 %) : 63 % (IC à 95 % : 60-68 %) dans le cas des IM en contexte non opératoire et 56 % (IC à 95 % : 52-60 %) dans le cas des IM en contexte périopératoire. La concordance globale corrigée pour le hasard était faible (kappa = 0,05) et demeurait constante, sans égard au domaine de spécialité ou au scénario clinique.

**Conclusions :** La justesse du jugement des médecins évaluant la cause d'un IM en fonction des renseignements cliniques est faible. Les médecins devraient envisager de recourir à des tests additionnels, y compris la coronarographie invasive, avant de déterminer la cause d'un IM.

involved in the cases, physicians whose scope of practice did not include management of MI, and physicians on leave (ie, out-of-office message for more than 6 months). Representatives of each specialty were contacted by e-mail and invited to participate in the survey. Individuals were sent electronic reminders every 2 weeks. To maximize the response rate, we used a short questionnaire, emphasized the relevance of the topic, offered to provide the survey results, and assured confidentiality.<sup>10,11</sup> Local leaders directly contacted non-respondents to encourage participation.

### Data source

We developed cases for the survey from the OPTIMUS Study. The OPTIMUS Study was a prospective cohort study of 60 patients (30 patients who had a perioperative MI, and 30 patients who had a nonoperative MI) that used OCT imaging to determine the presence of intracoronary thrombus. Full methods of the OPTIMUS Study are published elsewhere.<sup>6</sup> In brief, eligible patients were aged  $> 18$  years, experienced an MI after noncardiac surgery or nonoperative MI that fulfilled the Universal Definition of MI,<sup>5</sup> and underwent cardiac angiography within 3 days of the event. For each included perioperative MI patient, a nonoperative MI patient was matched based on gender, age, and ECG ischemic changes. Patients were excluded if they had an ST segment elevation myocardial infarction, cardiac revascularization in the prior 6 months, cardiogenic shock, or estimated glomerular filtration rate  $< 35$  ml/min.



**Figure 1.** Participant flowchart.

After angiography, the culprit artery was identified for OCT imaging. OCT images were evaluated by a core laboratory (Cardiovascular Imaging Core Laboratory, Case Western Reserve University, Cleveland, OH). Two independent interventional cardiologists, blinded to whether patients had suffered a perioperative or nonoperative MI, reviewed all images and decided on the presence or absence of intracoronary thrombus.

We randomly selected 4 cases from the OPTIMUS Study that underwent successful OCT imaging and for which we had all the clinical progress notes and consults, ECGs, and troponin results. We divided the OPTIMUS cases into 4 groups according to both clinical scenario (perioperative and nonoperative MI) and the final MI etiology based on OCT results (type 1 and type 2 MI). We defined type 1 MI cases as the presence of thrombus at the culprit lesion based on OCT, and type 2 MI cases as the absence of thrombus or plaque rupture in the culprit artery based on OCT. Then, we randomly selected one case from each group. We prespecified that in the event the selected case did not have complete clinical information, serial troponin measurements, or an ECG, we would randomly select another case in that specific subgroup. All 4 cases selected were considered complete. Case details are provided in the [Supplemental Appendix S4](#).

### Primary outcome

The primary outcome was the accuracy of physicians' judgement of MI etiology (type 1 vs type 2) based on the clinical information without knowledge of the OCT results. The OCT findings were used as the "gold standard."

### Case assessment

Invited physicians received a login linked to a unique token to access the survey with full documentation for all cases. Each token could be used only once. We used LimeSurvey (<https://surveys.mcmaster.ca/limesurvey>), which is a free-access Internet-based survey platform. Each physician was invited to evaluate the cases, which were presented

in a random order unique to each token. Respondents were blinded to cardiac angiography and OCT results. For each case, physicians were provided with the original consulting physician's progress and consultation notes, ECG images, and laboratory results, including troponins, compiled until the day of cardiac angiography. Physicians were invited to indicate whether they believed the case was a type 1 or type 2 MI. They were also asked to provide data on their demographics, including their clinical practice (eg, years of practice, specialty, practice location, and percentage of practice devoted to clinical care). Details on the consent form and questionnaire are presented in the [Supplemental Appendix S3](#).

### Survey development and testing

The questionnaire was developed by a multidisciplinary group of physicians who planned, discussed, and built the final questionnaire based on the results of survey testing. Feedback was collected to evaluate the content and the time needed to complete the questionnaire. A total of 14 of 17 invited physicians (including anaesthesiologists, cardiologists, and internists) participated in the survey development. All survey questions were presented, and the group was asked to judge the adequacy of documentation provided for the sample cases. Based on the information obtained through the development process, we expected that respondents would be able to complete a case within 5 minutes.

### Statistical analysis

We report number of physicians invited, reasons for exclusion, and response rate (number of respondents of the total invited who were eligible). Respondents' characteristics are presented as proportions for categorical variables, mean and standard deviation (SD) for normally distributed continuous variables, and median and interquartile ranges for non-normally distributed variables. We report overall clinical judgement accuracy as the proportion of physicians' answers that were concordant with OCT findings, and its 95% confidence interval (CI). A priori, we specified that we would

**Table 1. Participant characteristics**

Respondent profile	Respondents (N = 308)
Male	190 (62)
Age, y	45 ( $\pm$ 11.1)
Specialty	
Anaesthesia	137 (44)
Cardiology	51 (17)
Interventional cardiology	13 (4)
Internal medicine	107 (35)
Years practicing specialty	
< 5	51 (17)
5-15	117 (38)
> 15	140 (45)
Country where practicing medicine	
Brazil	84 (27)
Canada	148 (48)
Italy	76 (25)
Perioperative MIs managed in the past 12 mo	
None	75 (24)
1-9	142 (46)
10-30	63 (21)
> 30	28 (9)
Nonoperative MIs managed in the past 12 mo	
None	102 (33)
1-9	67 (22)
10-30	65 (21)
> 30	74 (24)
Time devoted to clinical practice, %	
< 20	41 (13)
20-50	49 (16)
> 50	218 (71)

Values are n (%) or mean  $\pm$  standard deviation.

MI, myocardial infarction.

report accuracy according to clinical scenarios (ie, perioperative and nonoperative), and the following physician characteristics: specialty (anaesthesia; internal medicine; cardiology); years of clinical work after completing training (< 5; 5-15; > 15); and proportion of time dedicated to clinical practice (< 20%, 21%-50%, > 50%). To estimate overall accuracy and the accuracy by subgroup, and the corresponding 95% CI, we used log-binomial generalized estimating equations to account for repeated measures per respondent. We report the accuracy by single clinical scenario with 95% CI using generalized linear models based on log-binomial distribution. We also explored whether physician and scenario characteristics independently predicted the accuracy of clinical judgement in univariate and multivariable generalized estimating equation models. Variables included in the model defined a priori were the following: clinical scenario, clinical specialty, years of clinical experience, and time dedicated to clinical practice. We performed a post hoc multivariate analysis including the number of MI cases per year managed by physicians in the last 12 months. Additionally, we reported clinical judgement accuracy by type 1 and type 2 MI.

Fleiss' kappa statistic was calculated for overall chance-correct agreement between physicians and OCT findings on the determination of MI etiology.<sup>12</sup> Fleiss' kappa is the chance-correct agreement measure for multiple raters, where values close to zero indicate agreement no better than by chance, and values close to one are considered to reflect perfect agreement. Fleiss' kappa values were interpreted as follows: values greater

than 0.75—strong agreement; values between 0.40 and 0.75—fair to good agreement; values < 0.40—poor agreement; and values < 0—no agreement.<sup>13</sup> We determined kappa by specialty and by clinical scenario (perioperative and nonoperative). We report kappa value and 95% CI.

To overcome the kappa paradox, which occurs when high raters' agreement can be translated into misleading smaller kappa values, we also determined Gwet's AC1 analysis.<sup>14-16</sup> We interpreted Gwet's AC1 analysis using the same parameters as those used for Fleiss' kappa.<sup>15</sup>

Analyses were completed using SPSS version 17.0 (IBM, Armonk, NY) and STATA version 12 (StataCorp, College Station, TX). We considered a 2-tailed *P*-value < 0.05 statistically significant.

## Ethical considerations

The study protocol was approved by the Hamilton Integrated Research Ethics Board, and all participants signed an electronic informed consent form. All patient information was kept confidential, and all patient identifiers were removed from the source documents provided to physicians. Physicians were not linked to their responses. All information was obtained using a secure Web-based system, and stored in anonymous, aggregate form.

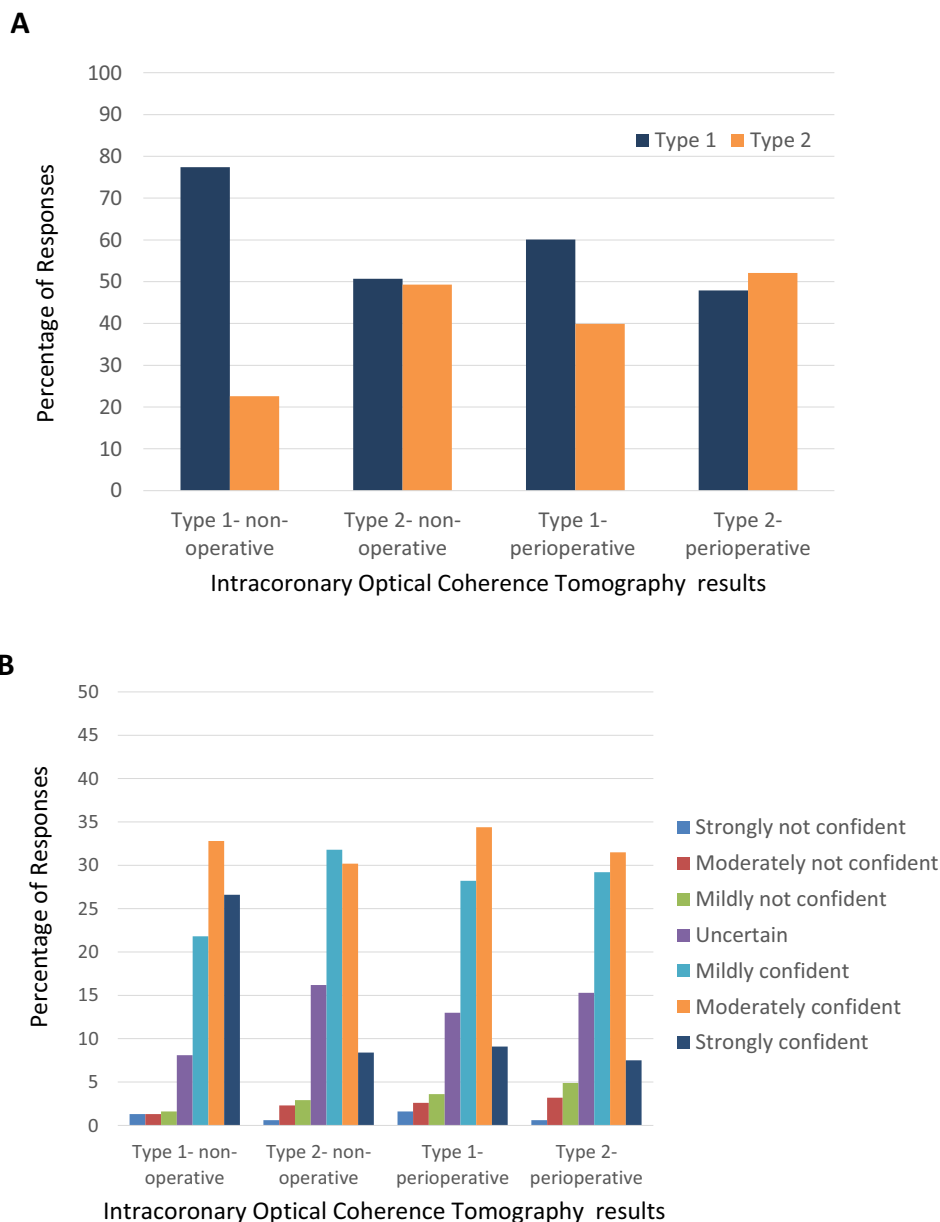
## Results

### Survey respondent characteristics

Among 592 potential participants, 56 (9.5%) were not eligible. Figure 1 shows reasons for exclusion. The response rate was 308 (57%). The proportions of respondents by country and by clinical specialty are presented in Supplemental Table S2. There were 1144 assessed cases, with an average of 3.7 cases (minimum 1; maximum 4) per respondent. Most physicians completed all cases (88%). Respondents were 62% male, and had a median age of 45 years (SD  $\pm$  11). With respect to specialty, 44% were anaesthesiologists, 35% were internists, and 21% were cardiologists. Respondent characteristics are presented in Table 1.

### Accuracy of clinical assessment of MI etiology

Figure 2 presents the distribution of physicians' responses by OCT-based MI etiology and physicians' level of confidence in their judgement for each case. Overall accuracy of clinical judgement (ie, agreement between physicians and OCT) across 1144 cases was 60% (95% CI 57%-63%). Accuracy was 63% (95% CI 59.5%-67.5%) for nonoperative MI and 56% (95% CI 52%-60%) for perioperative MI. The majority of respondents were confident about their assessments. Table 2 presents overall accuracy, and accuracy according to MI type by training level and specialty. Overall MI accuracy was similar according to physician experience. Details are provided in the Supplemental Tables S3 and S4. In the univariate analysis to predict physicians' accuracy, only clinical setting (perioperative vs nonoperative) was statistically significant (risk ratio 0.88; 95% CI 0.80-0.97; *P* = 0.013]. None of the physician characteristics (eg, clinical specialty, years of clinical experience, and time dedicated to clinical practice) were associated with the level of accuracy, in either the



**Figure 2.** Distribution of (A) physicians' responses and (B) level of confidence by case (%).

univariate or multivariable model. The post hoc analysis including the number of MIs managed by physicians in the last 12 months did not yield different results. Details of the multivariate analysis are presented in the [Supplemental Tables S5 and S6](#).

Fleiss' kappa statistic was 0.05 for overall chance-correct agreement between physicians and OCT findings on the determination of MI etiology. Fleiss' kappa agreement was consistently poor by clinical specialty, and by clinical scenario. Gwet's AC1 values confirmed low chance-adjusted agreement ([Table 3](#)).

### Discussion

This multicenter international survey demonstrates poor physician overall accuracy (60%) for judging type 1 vs type 2

MI based on clinical data compared to OCT. Although physician accuracy in determining MI etiology was lower in the setting of perioperative MI compared with nonoperative MI (risk ratio 0.88; 95% CI 0.80-0.97), accuracy for nonoperative MI was also poor (accuracy 63%). Our study demonstrates that accuracy in classifying type 2 MI is lower than that for type 1 MI (51% vs 69%;  $P < 0.001$ ). Overall chance-correct agreement between physicians and OCT findings on the determination of MI etiology (type 1 vs 2) was poor (kappa = 0.05; Gwet's AC1 = 0.11), consistent across the nonoperative and perioperative settings and the various clinical specialties. Despite the low accuracy and agreement beyond chance, most physicians were confident in their judgement.



**Table 2. Accuracy of physicians' judgement compared to intracoronary optical coherence tomography**

Variables	Overall accuracy	Type I MI accuracy	Type II MI accuracy	P
Overall cases	60 (57-63)	69 (65-73)	51 (47-55)	< 0.001
By clinical scenario				
Nonoperative	63 (60-68)	77 (73-82)	49 (43-55)	< 0.001
Perioperative	56 (52-60)	60 (54-66)	52 (46-58)	0.057
By specialty				
Anaesthesia	63 (58-69)	84 (76-91)	42 (32-52)	< 0.001
Cardiology	59 (55-63)	61 (55-67)	56 (50-62)	0.308
Internal medicine	60 (55-65)	73 (67-79)	47 (40-54)	< 0.001
By years practicing specialty				
< 5	58 (51-66)	63 (53-73)	53 (43-63)	0.161
5-15	60 (56-65)	75 (69-81)	45 (39-52)	< 0.001
> 15	60 (56-65)	66 (60-72)	54 (48-61)	0.010
By time devoted to clinical practice, %				
< 20	60 (51-70)	58 (47-65)	62 (51-73)	0.501
20-50	61 (55-68)	75 (66-84)	47 (37-58)	< 0.001
> 50	60 (56-65)	69 (65-74)	49 (44-54)	< 0.001

Values are % (95% confidence interval), unless otherwise indicated.  
MI, myocardial infarction.

## Interpretation

These findings demonstrate that physicians were limited in their ability to predict beyond chance the underlying etiology of NSTEMI based on patients' clinical history, ECGs, and troponin levels. Indeed, studies have shown that presence of ischemic features (eg, ischemic symptoms, ischemic ECG findings), and even troponin levels, is not predictive of NSTEMI etiology.<sup>6</sup>

During the perioperative period, patients are exposed to sympathetic activation that can trigger hypertension, tachycardia, hyper-catabolism, and subsequent increase in cardiac demand. Moreover, surgery is associated with bleeding, hypotension, and anemia, resulting in a supply and demand imbalance.<sup>5</sup> However, surgery also leads to hypercoagulability, inflammation, and endothelial dysfunction, predisposing patients to thrombotic events. Several studies have demonstrated the occurrence of type 1 MI, in 26% to 50% of patients with perioperative MI.<sup>17-20</sup> Yet, some of these studies are limited by the use of inadequate methods to detect intracoronary thrombus. The OPTIMUS Study used OCT and identified thrombus at the culprit lesion in 13% of patients who have experienced a perioperative MI as compared to 67% of those who experienced a nonoperative MI.<sup>6</sup> Physicians should take into account prevalence of MI etiology in different clinical settings to guide diagnostic approaches and medical treatments. However, our study demonstrated that even among specialists from tertiary care academic hospitals, a significant proportion of patients suffering an MI were incorrectly classified without information from an invasive coronary assessment.

A physician's belief about whether an MI is type 1 vs 2 often has important therapeutic implications.<sup>21</sup> If an MI is thought to be type 1, the patient is more likely to receive dual antiplatelet therapy and anticoagulation. Conversely, if an MI is deemed to be type 2, the patient is more likely to receive general treatment for anemia, hypotension, or the triggers believed to be contributing to the ischemia process. In the perioperative setting in particular, mostly as a result of concerns for bleeding, patients with myocardial ischemia are discharged from the hospital with limited cardiovascular secondary prevention treatment.<sup>22</sup> Moreover, if a physician

assumes that a perioperative MI has occurred as a result of supply-demand mismatch, patients may not be advanced for further risk stratification (angiography and possible detection of plaques requiring treatment).<sup>23</sup>

The **Coronary CT Angiography to Predict Vascular Events in Noncardiac Surgery Patients Cohort Evaluation** (Coronary CTA -VISION) study demonstrated that among patients experiencing a perioperative MI, 72% had > 50% coronary obstructive disease, and only 4% had normal coronaries on computed tomographic angiography imaging.<sup>24</sup> A perioperative MI, regardless of whether it was type 1 or type 2, might be an opportunity to identify at-risk patients with asymptomatic coronary artery disease and offer medications with evidence for secondary cardiovascular prevention, such as aspirin, statins, and angiotensin-converting enzyme inhibitors. Recently, the **Management of Myocardial Injury After Noncardiac Surgery** (MANAGE) trial<sup>25,26</sup> demonstrated that an intermediate-dose anti-coagulation with dabigatran after a perioperative myocardial injury (including type 1 and type 2 MI) prevented major cardiovascular outcomes without increasing major bleedings at a mean of 16 months of follow-up.

Accuracy of diagnosing type 1 MI, compared with type 2, was significantly higher. These results suggest that physicians should be even more careful when making the diagnosis of type 2 MI. Physicians should not underestimate the impact of type 2

**Table 3. Fleiss' kappa (k) and Gwet's AC1 (first order agreement coefficient) agreement**

Group	k (95% CI)	Gwet's AC1 (95% CI)
All	0.05 (-0.05, 0.16)	0.11 (-0.24, 0.46)
Specialty		
General cardiology	0.11 (-0.18, 0.39)	0.37 (-0.43, 1.00)
Interventional cardiology	0.01 (-0.12, 0.13)	0.13 (-0.31, 0.57)
Internal medicine	0.05 (-0.05, 0.15)	0.16 (-0.26, 0.59)
Anaesthesia	0.04 (-0.05, 0.12)	0.04 (-0.07, 0.14)
Clinical setting		
Perioperative cases	0.01 (0.01, 0.02)	0.02 (-0.47, 0.52)
Non-perioperative cases	0.07 (-0.09, 0.24)	0.21 (-1.00, 1.00)

CI, confidence interval.

MI on short- and long-term outcomes in both nonoperative and perioperative settings. A recent systematic review and meta-analysis has shown that among 25,872 patients, type 2 MI patients had almost 3 times higher inpatient, 30-day, and 1-year mortality, compared to those with type 1 MI. Operative stress was the most common trigger of type 2 MI. Patients labeled as type 2 MI were less likely to be referred to cardiac angiography, compared with those with type 1 MI.<sup>27</sup>

### Strengths and limitations

To our knowledge, this is the first study assessing the accuracy of physician judgement of MI etiology in nonoperative and perioperative settings. The strength of this study is the use of real cases and the ability to compare physicians' judgements based on clinical information with OCT results. Physicians were exposed to scenarios similar to those to which they are exposed in daily clinical practice, where they commonly make decisions on MI etiology and determine next steps in investigation and treatment. This is a multicentre study, in 7 institutions, with a reasonable response rate, and most physicians completed all survey cases. We randomized the order of the cases to keep response rates similar across all cases.

This study has limitations. To minimize the length of the survey and increase the response rate, only 4 cases were included. It is possible that cases presented may not be representative of the variety of patients seen in practice, causing a measurement effect; however, we selected random cases from the OPTIMUS Study. Also, in order to include perioperative and nonoperative settings, and type 1 and 2 etiologies, the case prevalence in our sample (50% and 50%) was different from the actual prevalence of type 1 vs type 2 MI in the perioperative setting. Some physicians believe that type 2 MI is more common than type 1 MI after noncardiac surgery.<sup>28,29</sup> Physicians were not aware of the stratification, but given the low number of cases and the purpose of the survey, they may have guessed the even distribution of cases in the survey across settings and etiologies. This approach would have given them a 50% probability of guessing the etiology by chance, which is close to the accuracy we eventually found. The reported confidence in their responses, however, is a signal that they were not simply guessing, but rather based their responses on a believed knowledge. A substantial proportion of the physicians had not managed a considerable number of MIs in the year preceding the survey. However, when our results were restricted to just cardiologists, or to physicians who had managed more than 30 MIs in the preceding year, the overall accuracy of physicians' judgements compared to OCT results did not improve compared to the overall cohort.

A nonresponse effect could be an issue; however, this study had a higher response rate than many survey studies. Although OCT is arguably the best objective assessment of the MI etiology, it is not 100% accurate. Thrombus could have been dissolved already in patients classified as having had a type 2 MI; in the OPTIMUS study, the mean number of days from MI diagnosis to OCT was 1.9 (SD  $\pm$  1.1) days in the perioperative MI group and 1.5 (SD  $\pm$  0.7) days in the nonoperative MI group. Some readers may believe that the Universal Definition of MI angiography criteria for type 1 MI (ie, identification of a coronary artery thrombus) is too restrictive and should be expanded to include identification of plaque rupture. Although

the definition of type 1 MI used in this study was identification of coronary artery thrombus, none of the cases of type 2 MI used in this survey had evidence of plaque rupture.

Finally, we measured the chance-corrected agreement based on Fleiss' kappa that could underestimate the agreement when there is a high rate of agreement in one specific category. However, Gwet's AC1 should be a more stable measure of agreement, as it is less affected by prevalence and marginal probability.<sup>16</sup> Our survey demonstrated similar results with the 2 measures, as expected when the prevalence of categories (type 1 and 2 MI in our case) was 0.5.

### Conclusions

Physicians' capacity to accurately determine type 1 vs type 2 MI based on clinical information is poor, consistent across different specialties, for both perioperative and nonoperative MI. Physicians should take this information into account when making treatment decisions based upon clinical assessment of type 1 vs 2 MI. There is a need for additional strategies to better define MI etiology and guide clinical management.

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