



Characterization of cardiovascular clinical events and impact of event adjudication on the treatment effect of darapladib versus placebo in patients with stable coronary heart disease: Insights from the STABILITY trial

Claes Held, MD, PhD,^{a,b} Harvey D. White, DSc,^c Ralph A.H. Stewart, MD, PhD,^c Richard Davies, MS,^d Shani Sampson, BA,^d Karen Chiswell, PhD,^c Adam Silverstein, MS,^c Renato D. Lopes, MD, PhD,^c Ulrika Heldestad, BSN,^b Andrzej Budaj, MD, PhD,^f Kenneth W Mahaffey, MD, PhD,^g and Lars Wallentin, MD, PhD^{a,b}, on behalf of the STABILITY Investigators *Uppsala, Sweden; Auckland, New Zealand; King of Prussia, PA; Durham, NC; Warsaw, Poland and Stan*

Background Clinical Endpoint Classification (CEC) in clinical trials allows FOR standardized, systematic, blinded, and unbiased adjudication of investigator-reported events. We quantified the agreement rates in the STABILITY trial on 15,828 patients with stable coronary heart disease.

Methods Investigators were instructed to report all potential events. Each reported event was reviewed independently by 2 reviewers according to prespecified processes and prespecified end point definitions. Concordance between reported and adjudicated cardiovascular (CV) events was evaluated, as well as event classification influence on final study results.

Results In total, CEC reviewed 7,096 events: 1,064 deaths (696 CV deaths), 958 myocardial infarctions (MI), 433 strokes, 182 transient ischemic attacks, 2,052 coronary revascularizations, 1,407 hospitalizations for unstable angina, and 967 hospitalizations for heart failure. In total, 71.8% events were confirmed by CEC. Concordance was high (>80%) for cause of death and nonfatal MI and lower for hospitalization for unstable angina (25%) and heart failure (50%). For the primary outcome (composite of CV death, MI, and stroke), investigators reported 2,086 events with 82.5% confirmed by CEC. The STABILITY trial treatment effect of darapladib versus placebo on the primary outcome was consistent using investigator-reported events (hazard ratio 0.96 [95% CI 0.87–1.06]) or adjudicated events (hazard ratio 0.94 [95% CI 0.85–1.03]).

Conclusions The primary outcome results of the STABILITY trial were consistent whether using investigator-reported or CEC-adjudicated events. The proportion of investigator-reported events confirmed by CEC varied by type of event. These results should help improve event identification in clinical trials to optimize ascertainment and adjudication. (Am Heart J 2019;208:65-73.)

Clinical Endpoint Classification (CEC) is a standardized process for event adjudication in clinical trials. Central

adjudication plays a key role in clinical trials with the purpose of achieving consistent, accurate, independent, unbiased, and blinded evaluation of suspected clinical events reported by investigators, but its value has been debated.^{1,2} Previous studies have confirmed that the rate of myocardial infarction (MI) assessed by standardized adjudication or by investigator-reported results differed significantly.³ Different ways of identifying events, for example, using triggered events or screening of laboratory data such as troponins or electrocardiogram (ECG) for MI, could possibly increase the number of MI⁴ or bleedings.⁵ However, different types of MI, such as procedure-related MI (MI type 4a), may have different prognosis compared with spontaneous MI.⁶ In addition, studies have not been consistent in their definitions of end points, and there is a great need for standardization of

From the ^aDepartment of Medical Sciences, Cardiology, Uppsala University, Uppsala, Sweden, ^bUppsala Clinical Research Center, Uppsala University, Uppsala, Sweden, ^cGreen Lane Cardiovascular Service, Auckland City Hospital and University of Auckland, Auckland, New Zealand, ^dMetabolic Pathways and Cardiovascular Therapeutic Area, GlaxoSmithKline, King of Prussia, PA, ^eDuke Clinical Research Institute, Duke University Medical Center, Durham, NC, ^fPostgraduate Medical School, Grochowski Hospital, Warsaw, Poland, and ^gStanford Center for Clinical Research, Department of Medicine, Stanford University School of Medicine, Stanford, CA.

Submitted May 25, 2018; accepted October 28, 2018.

Reprint requests: Claes Held, MD, PhD, Uppsala Clinical Research Center (UCR), Dag Hammarskjöld's väg 38, SE-751 85 Uppsala, Sweden.

E-mail: claes.held@ucr.uu.se
0002-8703

© 2018 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

<https://doi.org/10.1016/j.ahj.2018.10.010>

end point definitions.⁷ A suggestion for these has been presented in a collaborative effort between the Food and Drug Administration and an expert panel,⁸ and the final framework was recently published.⁹ Different end points are more or less complex to classify because information is derived from multiple sources and classification often requires a great deal of clinical judgment. The quality of the source documentation such as the amount of information around each event is of utmost importance for accurate decision making by the CEC group. The rate and degree of discrepancy are generally good but differ depending on the type of end point and its subcategories. Structured evaluations of the CEC process and outcomes have not been extensively performed in different populations, and there is a need for more knowledge in this area of clinical research.

In the prospective randomized global STABILITY trial¹⁰ (clinicaltrials.gov NCT00799903) on 15,828 patients with stable coronary heart disease (CHD), darapladib did not reduce the primary composite outcome MACE (major adverse CV events; cardiovascular [CV] death, MI, or stroke) compared with placebo. The main results have been presented elsewhere.¹⁰

The main aims of this report were to (1) evaluate the proportion of investigator-reported CV events that were subsequently classified as same event by the CEC, (2) determine if there would be significant differences in treatment effect if analyses were run using investigator-reported events instead of CEC-adjudicated events, and (3) evaluate if concordance varied by region or size of sites.

Methods

Study design

The STABILITY trial was funded by GlaxoSmithKline. The study design has been previously presented.¹¹ The study was approved by national regulatory authorities and by local ethics committees or institutional review boards, according to local regulations, and all patients gave informed consent. Patients with stable CHD, defined as prior MI, prior coronary revascularization, or multi-vessel CHD confirmed by coronary angiography, were eligible. In addition, patients had to meet at least one of the following CV risk criteria: age ≥ 60 years, diabetes mellitus requiring pharmacotherapy, high-density lipoprotein cholesterol < 1.03 mmol/L, current or previous smoker defined as ≥ 5 cigarettes per day on average, significant renal dysfunction (estimated glomerular filtration rate ≥ 30 and < 60 mL/min per 1.73 m² or urine albumin/creatinine ratio ≥ 30 mg albumin/g creatinine), or polyvascular disease (CHD and cerebrovascular disease or CHD and peripheral arterial disease).

The CEC organization was led by the CEC chair at UCR in close collaboration with the CEC Coordinator whose responsibility was to lead the day-to-day activities during the trial. Reviewers had to be specialists in the clinically

relevant areas cardiology or neurology, and all underwent mandatory study-specific training on event definitions and the adjudication process. The following event categories were adjudicated in the study: (1) cause of death, (2) MI, (3) stroke, (4) urgent coronary revascularization for myocardial ischemia, (5) hospitalization for unstable angina (UA), and (6) heart failure (HF) requiring hospitalization. We do not report concordance for revascularization as investigators reported all coronary revascularizations but CEC determined only whether it was urgent or not. The clinical event definitions have been described in detail previously, as a Supplement to the main STABILITY results publication.¹⁰

Investigators were instructed to report all events with the potential to be adjudicated as one of the predefined study end points, regardless of the opinion of the investigator. The sponsor monitors encouraged submission of all possible end points according to a standardized process described in the site manual. If a suspected unreported event was identified by a reviewer, the reviewer was instructed to make a note back to the end point office. A query was then sent to the site asking if the investigator agreed, and a new event package was created and sent out for review according to the standard procedure. We did not use any data triggering system (ie, laboratories or ECG) to identify unreported events. Relevant prespecified source documents were collected by the CEC Office and translated to English if necessary. Each event was distributed via an electronic system and reviewed independently by 2 reviewers according to a prespecified process and detailed end point definitions described in the CEC charter. In case of disagreements in event categories or subcategories, phase II committee meetings were arranged where a consensus decision was taken. A continuous quality control process consisting of de novo adjudication of 5% of all events throughout the study period was used to evaluate consistency.

Statistics

The present analysis considered events collected from randomization through to the last follow-up for CV end point collection. To evaluate agreement between investigator-reported and CEC-adjudicated events, events were grouped into 4 categories: death, MI or hospitalization for UA, hospitalization for HF, and stroke or TIA. For each event category, a 2-way contingency table was created to classify all events in that category according to their investigator and CEC classification. For each event type, the number and proportion of investigator-reported events that were classified by the CEC as the same event type are reported.

To explore whether agreement rates differed by region, by size of site, or by randomized treatment group, we stratified investigator-reported events by each of these factors and used a χ^2 test to evaluate whether proportion of investigator-reported events classified as the same event by the CEC differed by levels of each factor. Five

Table I. Overall summary of end point event reporting and adjudication

Inv-reported event	No. of events	Confirmed by CEC as same event	Adjudicated by CEC as different event	Refuted by CEC as no event
Total MACE (CV death, stroke, MI)	2086	1720/2086 (82.5%)	80/2086 (3.8%)	286/2086 (13.7%)
Death	1064	1064/1064 (100%)	0/1064 (0.0%)	0/1064 (0.0%)
CV death	696	667/696 (95.8%)	29/696 (4.2%)	0/696 (0.0%)
Non-CV death	368	303/368 (82.3%)	65/368 (17.7%)	0/368 (0.0%)
MI	958	750/958 (78.3%)	25/958 (2.6%)	183/958 (19.1%)
Fatal MI	147	55/147 (37.4%)	4/147 (2.7%)	88/147 (59.9%)
Nonfatal MI	810	681/810 (84.1%)	34/810 (4.2%)	95/810 (11.7%)
MI not classified by Inv	1	0/1 (0.0%)	1/1 (100%)	0/1 (0.0%)
Stroke	433	303/433 (70.0%)	26/433 (6.0%)	104/433 (24.0%)
Fatal stroke	54	32/54 (59.3%)	7/54 (13.0%)	15/54 (27.8%)
Nonfatal stroke	378	263/378 (69.6%)	27/378 (7.1%)	88/378 (23.3%)
Stroke not classified by Inv	1	0/1 (0.0%)	0/1 (0.0%)	1/1 (100%)
TIA	182	96/182 (52.7%)	20/182 (11.0%)	66/182 (36.3%)
Hospitalization for UA	1407	358/1407 (25.4%)	120/1407 (8.5%)	929/1407 (66.0%)
Hospitalization for HF	967	486/967 (50.3%)	0/967 (0.0%)	481/967 (49.7%)
No event reported by Inv	33	0/33 (0.0%)	31/33 (93.9%)	2/33 (6.1%)

Abbreviations: *Inv*, Investigator; *CEC*, clinical end points classification; *TIA*, transient ischemic attack.

regions were defined: North America, South America, Eastern Europe, South Africa/Asia Pacific, and Western Europe/New Zealand/Australia. Sites were divided into 4 groups based on the quartiles of the distribution of total number of patients enrolled per site: ≤10, 11 to 18, 19 to 20, and ≥30 patients.

Kaplan-Meier curves were generated stratified by randomized treatment group to display the cumulative proportion of subjects experiencing a MACE (composite of CV death, MI, and stroke). To evaluate whether the treatment effect estimate would differ based on investigator-reported events compared with CEC-adjudicated events, we graphed Kaplan-Meier curves stratified by treatment group using the first investigator-reported MACE event and the first CEC-adjudicated MACE event. Cox proportional hazards regression was used to estimate the treatment effect for the primary and secondary CV end points, based on the first investigator-reported event and the first CEC-adjudicated event. Hazard ratios (darapladib vs placebo), 95% CIs, and *P* values are reported for each analysis.

For investigator-reported MI, stroke, hospitalization for HF, and hospitalization for UA events, we determined the proportion of patients in whom the event was followed by mortality within 30 days. We used a χ^2 test to evaluate whether the proportion with 30-day mortality differed based on whether the event was adjudicated by CEC as the same event or not.

Statistical significance was determined at the nominal 2-sided .05 level, with no adjustment for multiple comparisons. Calculations were performed using SAS v 9.4 (SAS Institute, Cary, NC).

Results

Overall, 7,096 events were adjudicated by the CEC. Of these, 2,086 primary outcome events (CV death, MI, or stroke) were reported by investigators during a median

follow-up of 3.7 years. There were 696 CV deaths, 368 non-CV deaths, and 958 MIs, of which 147 were fatal. In total, 433 strokes, 1,407 UA events and 967 HF events were reported by the investigators. The distribution of different types of investigator-reported end points and their disposition according to the CEC are listed in Table I. In total, 71.8% were confirmed by the CEC committee, whereas 3.1% were adjudicated as a different event and 25.1% as a nonevent according to the study-specific definitions. High concordance (>80%) was found for cause of death and nonfatal MI, whereas concordance was lower for hospitalization for UA (25%) and HF (50%) (Table I).

For the primary outcome, investigators reported 2,086 events, of which 82.5% were adjudicated as MACE. An additional 234 events (205 events reported by investigators but not classified by investigators as MACE, plus 29 additional events not reported by investigators but discovered during the CEC adjudication process) were adjudicated as MACE. The agreement between CEC and the investigators for the cause of death (CV vs non-CV) was 91.2%, with only a few CV deaths (2.7%) reported by investigator and adjudicated by CEC as non-CV death and 6.1% vice versa (Table IIa).

In total, 2395 events were considered for MI or hospitalization for UA (Table IIb). For these types of events, the total agreement between investigator and CEC was 46.3%. Of the 958 MI events reported by investigators, 78.2% were classified as MI by the CEC, whereas only 25.4% of the 1,407 hospitalization for UA events were classified as such by the CEC (Table I). For many of the disagreements, there was a bidirectional crossover between MI and UA (Table IIb). In 120 cases, the CEC process identified an MI, which had been reported as UA, and in 25 events, a suspected MI was reported by the investigators but was defined as UA by the CEC committee. There were 29 MI cases identified by

Table IIa. CV and non-CV death events

	CEC-adjudicated CV death	CEC-adjudicated No CV death	Total
Inv-reported CV death (n/%)	667/62.7	29/2.7	696/65.4
Inv-reported non-CV death (n/%)	65/6.1	303/28.5	368/34.6
Total (n/%)	732/68.8	332/31.2	1064/100.0

Agreement = 91.2%.

Abbreviation: *Inv*, Investigator.**Table IIb.** MI and hospitalization for UA events

	CEC-adjudicated MI	CEC-adjudicated hosp. for UA	CEC-adjudicated no MI or hosp. for UA	Total
Inv-reported MI (n/%)	750/31.3	25/1.0	183/7.6	958/40.0
Inv-reported hosp. for UA (n/%)	120/5.0	358/14.9	929/38.8	1407/58.8
Inv-reported no MI or hosp. for UA (n/%)	29/1.2	1/<0.1	0/0.0	30/1.3
Total (n/%)	899/37.5	384/16.0	1112/46.3	2395/100.0

Agreement = 46.3%.

Abbreviations: *hosp.*, Hospitalization; *Inv*, investigator.**Table IIc.** Hospitalization for HF events

	CEC-adjudicated hosp. for HF	CEC-adjudicated hosp. for no HF	Total
Inv-reported hosp. for HF (n/%)	486/50.2	481/49.7	967/99.9
Inv-reported hosp. for non-HF (n/%)	1/0.1	0/0.0	1/0.10
Total (n/%)	487/50.3	481/49.7	968/100.0

Agreement = 50.2%.

Abbreviations: *hosp.*, Hospitalization; *Inv*, investigator.**Table II d.** Stroke/TIA events

	CEC-adjudicated stroke	CEC-adjudicated TIA	CEC-adjudicated no stroke or TIA	Total
Inv-reported stroke (n/%)	303/49.3	26/4.2	104/16.9	433/70.4
Inv-reported TIA (n/%)	20/3.3	96/15.6	66/10.7	182/29.6
Total (n/%)	323/52.5	122/19.8	170/27.6	615/100.0

Agreement = 64.9%.

Abbreviations: *Inv*, Investigator; *TIA*, transient ischemic attack.

the CEC that were not reported by the investigators as either MI or UA. This occurred either by review of laboratory reports and/or ECG findings or by identification by CEC staff reviewing the event information. The concordance between the investigators and CEC was also low for HF events, where about half of the reported events were refuted by the CEC (Table IIc).

In total, 615 events were reported by investigators as either stroke or TIA (Table II d). The agreement rate between investigators and CEC was 64.9%, with a small number of events reclassified by the CEC from TIA to stroke ($n = 20$) and from stroke to TIA ($n = 26$). About 30% of the reported stroke events were adjudicated as no stroke/TIA event or as TIA.

Treatment effect

There were no significant differences between randomized treatment groups in the proportion of investigator

events that were reported as the same event by the CEC (Table III). An analysis of whether the treatment effect of darapladib versus placebo was different using investigator-reported events or CEC-adjudicated events showed that overall results on the primary outcome did not differ (hazard ratio 0.96 [95% CI 0.87–1.06, $P = .38$] for investigator-reported versus hazard ratio 0.94 [95% CI 0.85–1.03, $P = .20$] for CEC-adjudicated) (see Figure 1). Similar findings were observed for all the separate end points CV death, MI, stroke, total coronary events, and hospitalization for HF. The Kaplan-Meier curves for the different groups are presented in Figure 2 for MACE, also showing similar findings based on investigator-reported or CEC-adjudicated first event.

Subgroup analyses of concordance by region or size of site

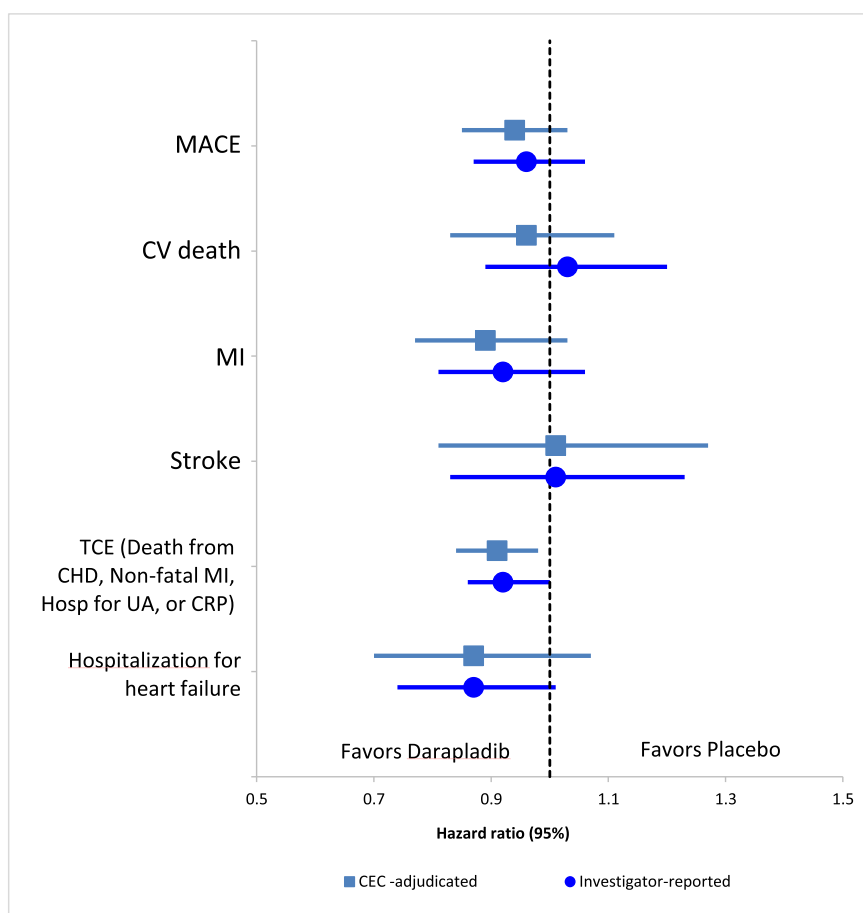
In subgroup analyses, we analyzed the concordance between site-reported and CEC-adjudicated events by

Table III. Classification of investigator-reported events by CEC, stratified by randomized treatment group

Investigator-reported event type	Both treatments	Randomized treatment		P
		Placebo	Darapladib	
CV death	667/696 (95.8%)	330/342 (96.5%)	337/354 (95.2%)	.3933
MI	750/958 (78.3%)	404/505 (80.0%)	346/453 (76.4%)	.1748
Stroke	303/433 (70.0%)	150/221 (67.9%)	153/212 (72.2%)	.3295
Hospitalization for HF	486/967 (50.3%)	256/514 (49.8%)	230/453 (50.8%)	.7641
Hospitalization for UA	358/1407 (25.4%)	189/729 (25.9%)	169/678 (24.9%)	.6671

For each type of investigator-reported event, the table shows the number and percentage of events adjudicated by CEC as the same type of event.

Figure 1

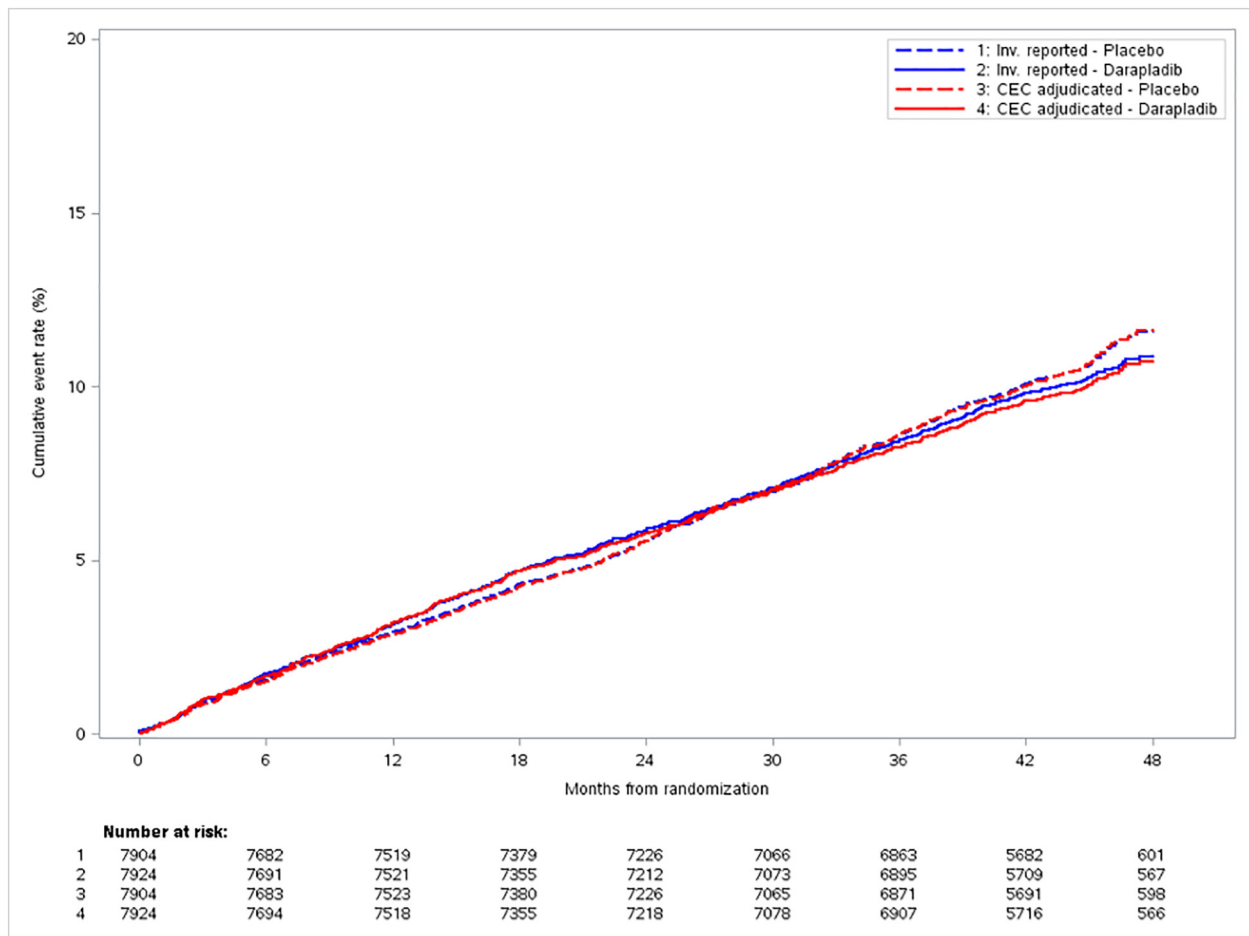


Comparison of hazard ratios for darapladib versus placebo for CEC-adjudicated and investigator-reported events. TCE, total coronary events; CRP, coronary revascularization procedure.

region. For MI, stroke, and hospitalization for UA, there was significant between-region variation in the proportion of investigator-reported events that were adjudicated as the same event by the CEC. For MI, Australia/New Zealand/Western Europe had the highest proportion adjudicated as the same event (84%) and South America had the lowest (61%). For

stroke, South Africa/Asia Pacific had the lowest proportion adjudicated as the same event (57%) compared with 68% to 77% in other regions. For hospitalization for UA, North America had the highest proportion adjudicated as the same event (33%) compared with 20% to 22% in other regions (Table IV). Other event categories did not differ in concordance by region.

Figure 2



Cumulative percentage of participants with MACE versus days from randomization. Stratified by treatment and event source. Inv, investigator.

Table IV. Classification of investigator-reported events by CEC, stratified by region

Investigator-reported event type	All regions	Region					P
		Australia, NZ, W. Europe	South Africa, Asia Pacific	E. Europe	South America	North America	
CV death	667/696 (95.8%)	114/117 (97.4%)	116/122 (95.1%)	209/218 (95.9%)	94/96 (97.9%)	134/143 (93.7%)	.4644
MI	750/958 (78.3%)	210/250 (84.0%)	88/112 (78.6%)	137/176 (77.8%)	38/62 (61.3%)	277/358 (77.4%)	.0037
Stroke	303/433 (70.0%)	89/118 (75.4%)	47/82 (57.3%)	72/94 (76.6%)	26/37 (70.3%)	69/102 (67.6%)	.0380
Hosp. for HF	486/967 (50.3%)	119/229 (52.0%)	65/128 (50.8%)	108/222 (48.6%)	27/57 (47.4%)	167/331 (50.5%)	.9505
Hosp. for UA	358/1407 (25.4%)	71/335 (21.2%)	55/241 (22.8%)	53/253 (20.9%)	22/100 (22.0%)	157/478 (32.8%)	.0003

For each type of investigator-reported event, the table shows the number and percentage of events adjudicated by CEC as the same type of event. Abbreviations: NZ, New Zealand; W., Western; Hosp., hospitalization.

We also divided sites based on quartiles of the number of patients/site to evaluate if there was a variation in concordance by size of site. For stroke events, we found marginal statistical significance of differences by site size

but no obvious trends (Table V). For the other event categories, we found no significant variation in the proportion of investigator-reported events that were adjudicated as the same event by the CEC.

Table V. Classification of investigator-reported events by CEC, stratified by site size

Investigator-reported event type	All sites	Site size (enrollment)				P
		≤10 pts	11-18 pts	19-29 pts	≥30 pts	
CV death	667/696 (95.8%)	42/43 (97.7%)	69/74 (93.2%)	130/135 (96.3%)	426/444 (95.9%)	.7000
MI	750/958 (78.3%)	61/73 (83.6%)	119/150 (79.3%)	167/218 (76.6%)	403/517 (77.9%)	.6395
Stroke	303/433 (70.0%)	15/21 (71.4%)	45/71 (63.4%)	92/115 (80.0%)	151/226 (66.8%)	.0447
Hosp. for HF	486/967 (50.3%)	32/59 (54.2%)	83/149 (55.7%)	130/244 (53.3%)	241/515 (46.8%)	.1386
Hosp. for UA	358/1407 (25.4%)	24/82 (29.3%)	65/255 (25.5%)	72/295 (24.4%)	197/775 (25.4%)	.8495

For each type of investigator-reported event, the table shows the number and percentage of events adjudicated by CEC as the same type of event. Abbreviations: pts., Patients; Hosp., hospitalization.

Discussion

In summary, the overall treatment effects on the primary composite outcome and on the individual components CV death, MI, or stroke, as well as total coronary events, were consistent regardless of whether the events were investigator reported or CEC adjudicated. There were, however, major differences in the reporting of individual events with large variability depending on the event categories. The concordance between the CEC and the investigators was highest for cause of death and nonfatal MI event categories. A lower concordance with greater heterogeneity occurred for UA and for HF events. The reasons for this might be a greater variability and complexity of the end point definitions with requirements of detailed symptom descriptions leading to a somewhat higher degree of subjectivity in the adjudication.

It should be noted that this study was performed before the agreement on and publication of the 2014 AHA/ACC Key data elements on standardized definitions for cardiovascular endpoints in Clinical trials,⁸ which most likely have improved the accuracy and slightly reduced the variability in event reporting.

The high concordance for cause of death was expected with rather few events changed between CV and non-CV death or vice versa during adjudication. There was a rather low concordance rate between investigators and CEC for MI versus UA. For the end point MI, the Third Universal definitions¹² were used. For UA, a requirement of symptoms of angina at rest >10 minutes was a basic criterium, and thus, many reported events were refuted when this symptom could not be confirmed. The information on symptom duration was often contradictory when comparing source documents with eCRF data. The low concordance for HF, where half of the reported events were refuted, is likely due to the strict definition in the CEC charter, which was mainly oriented toward identifying left-sided HF. Importantly, the investigators were instructed to report all suspected events, but signs of right-sided HF such as edema and jugular vein distension were not included in the definitions, and these events were therefore often refuted.

The relatively high rates of refuted events may have several explanations, but we do not always have explicit

answers. In many cases, the event was refuted because it did not fulfill the end point criteria. It is, however, critical to understand the investigator instructions in the site manual regarding reporting of events when interpreting our results. Thus, events reported by investigators do not necessarily reflect the opinion of the investigator but largely depends on the site instructions. These were written to cast a wide net to capture all suspected events. For instance, all coronary revascularizations were to be reported and the CEC then determined whether it was urgent or not.

Missing key information is a limiting factor for confirmation of an event, despite a thorough CEC process,¹³ and sites were repeatedly queried for completeness. If key information cannot be obtained, disagreements are more likely to occur. A potential limitation of the current results is that for HF events, the end point definitions were mostly focusing on left-sided HF, but investigators were instructed to report all suspected HF events. We did not find any marked differences in concordance based on size of site, but we did identify some significant differences between regions for specific types of events. However, no region stood out as having generally lower or higher concordance. This highlights the importance of selecting sites able to provide reliable and complete high-quality data.

Another interesting end point for comparison is stent thrombosis where there were important discordances, although not statistically significant, between investigator-reported, CEC-adjudicated, and core laboratory evaluations in another study¹⁴ where CEC adjudicated all MI cases and deaths for potential stent thrombosis. However, we do not have these comparative data in the STABILITY trial, as investigators were not mandated to report stent thrombosis and angiography data were not systematically collected.

An important finding in the current analyses was the consistency in treatment effect estimates, whether based on investigator-reported or CEC-adjudicated primary outcome events in the trial. The CIs for the 2 groups clearly overlapped. However, there were, as described above, inconsistencies on separate events and a variability depending on type of event. Similar comparisons have been done previously but mostly in the fields of acute

coronary syndrome³ and in other research areas such as diabetes mellitus¹⁵ and respiratory diseases.¹⁶ This is, to our knowledge, the first comparison in stable CHD. As would be expected in a randomized double-blind clinical trial, there were no significant differences in concordance of events between randomized treatment groups in the proportion of investigator-reported events that were reported as the same event by the CEC.

The main purpose of the CEC process is to achieve high-quality results with low variability using a consistent and standardized adjudication process and with predefined end point definitions. Large pharmaceutical companies and Food and Drug Administration usually require end point adjudication, especially for phase 3 studies, but also other where an expanded indication might be targeted. In contrast, for phase 4 studies, other ways of end point follow-up might be suggested. In future CV studies, it would be of importance to increase efforts to collect more specific information on event categories with low concordance, such as HF, UA, and stroke, but also to improve the end point definitions by keeping the amount of subjective information as low as possible. Eventually, registry-based data, if available, for events such as death and MI, where concordance is highest and variability is acceptable,¹⁷ could be of interest. It would also be of importance to collect the opinion of the investigator as to what the event was when comparing results with CEC. If studies are run by cardiologists, suggestions have been proposed that CEC would not be required.¹⁸ Artificial intelligence has also been suggested to be evaluated as a mean to adjudicate events using electronic health record data.

Limitations

We did not systematically assess variability between reviewers. However, the regular general QC reports in the study of 5% of all adjudicated events did not indicate any change over time in disagreement rates, neither in major nor minor disagreements. The disagreement rate remained stable throughout the trial follow-up, indicating that there was no drift over time.

In summary, the primary outcome results (composite of CV death, MI, and stroke) in the STABILITY trial were consistent when comparing investigator-reported and CEC-adjudicated events. High concordance was found for death and MI, but with a significant variability depending on type of event, with lowest concordance observed for UA and for HF events.

Acknowledgements

The STABILITY study and the presented analyses were funded by GlaxoSmithKline. Editorial assistance was provided by Vendela Roos, PhD, Uppsala Clinical Research Center, Uppsala, Sweden, through funds from GlaxoSmithKline.

Disclosures

C.H.: institutional research grant, advisory board member, and speaker's bureau from AstraZeneca; institutional research grants from Bristol-Myers Squibb/Pfizer, Merck & Co, GlaxoSmithKline, and Roche Diagnostics; advisory board member for Boehringer Ingelheim, Bayer; safety committee board member for Idorsia. H.D.W.: research grants and personal fees from GlaxoSmithKline; research grants and advisory board member fees from AstraZeneca, advisory board member fees from Acetelion and Sirtex; research grants from Sanofi, Eli Lilly, National Institute of Health, Merck Sharp & Dohme, George Institute, Omthera Pharmaceuticals, Pfizer New Zealand, Intarcia Therapeutics Inc, Elsay Inc, Dal-GenE, and Daiichi-Sankyo Pharma Development. R.A.H.S.: grants and nonfinancial support from GlaxoSmithKline. R.D.: employee of GlaxoSmithKline. S.S.: employee of GlaxoSmithKline. K.C.: institutional grant from GlaxoSmithKline. A.S.: institutional grant from GlaxoSmithKline. R.D.L.: research grants from Amgen, Bristol-Myers Squibb/Pfizer, GlaxoSmithKline, Medtronic PLC, and Sanofi-Aventis; consultant/advisory board from Bristol-Myers Squibb/Pfizer, Bayer, and Boehringer Ingelheim. U.H.: institutional research grants from GlaxoSmithKline. A.B.: consulting fees from Sanofi-Aventis, AstraZeneca, Bristol-Myers Squibb/Pfizer, GlaxoSmithKline, Bayer, and Novartis; investigator fees from Sanofi-Aventis, AstraZeneca, GlaxoSmithKline, Novartis, Bristol-Myers Squibb/Pfizer, and Eisai; honoraria for lectures from Sanofi-Aventis, AstraZeneca, Bristol-Myers Squibb/Pfizer, and Novartis. K.W.M.: consulting/personal fees from Ablynx, Baim Institute, Boehringer Ingelheim, Bristol-Myers Squibb, Cardiometabolic Health Congress, Elsevier, GlaxoSmithKline, Mederger, Medscape, Mitsubishi, Myokardia, Oculeve, Portola, Radiometer, Springer Publishing, Theravance, UCSF, and WebMD; grants and consulting/personal fees from AstraZeneca, Johnson & Johnson, Merck, Novartis; grants from Afferent, Amgen, Apple, Cardiva Medical, Daiichi, Ferring, Google (Verily), Luitpold, Medtronic, Sanofi, St Jude, and Tenax; stock ownership in BioPrint Fitness. L.W.: institutional research grants from AstraZeneca, Boehringer Ingelheim, Bristol-Myers Squibb/Pfizer, GlaxoSmithKline, Roche Diagnostics, and Merck & Co; consulting fees from Abbott; holds 2 patents involving GDF-15 licensed to Roche Diagnostics.

References

1. Sephehvand N, Zheng Y, Armstrong PW, et al. Alignment of site versus adjudication committee-based diagnosis with patient outcomes: insights from the Providing Rapid Out of Hospital Acute Cardiovascular Treatment 3 trial. *Clin Trials* 2016;13(2):140-8.
2. Granger CB, Vogel V, Cummings SR, et al. Do we need to adjudicate major clinical events? *Clin Trials* 2008;5(1):56-60.
3. Mahaffey KW, Harrington RA, Akkerhuis M, et al. Disagreements between central clinical events committee and site investigator assessments of myocardial infarction endpoints in an international

- clinical trial: review of the PURSUIT study. *Curr Control Trials Cardiovasc Med* 2001;2(4):187-94.
- Mahaffey KW, Held C, Wojdyla DM, et al. Ticagrelor effects on myocardial infarction and the impact of event adjudication in the PLATO (Platelet Inhibition and Patient Outcomes) trial. *J Am Coll Cardiol* 2014;63(15):1493-9.
 - Kosmidou I, Mintz GS, Jatene T, et al. Impact of bleeding assessment and adjudication methodology on event rates and clinical trial outcomes: insights from the HORIZONS-AMI trial. *EuroIntervention* 2018;14(5):e580-7.
 - Damman P, Wallentin L, Fox KA, et al. Long-term cardiovascular mortality after procedure-related or spontaneous myocardial infarction in patients with non-ST-segment elevation acute coronary syndrome: a collaborative analysis of individual patient data from the FRISC II, ICTUS, and RITA-3 Trials (FIR). *Circulation* 2011;125(4):568-76.
 - Kikkert WJ, Tijssen JGP, Piek JJ, et al. Challenges in the adjudication of major bleeding events in acute coronary syndrome: a plea for a standardized approach and guidance to adjudication. *Eur Heart J* 2016;37(14):1104-12.
 - Hicks KA, Tcheng JE, Bozkurt B, et al. 2014 ACC/AHA key data elements and definitions for cardiovascular endpoint events in clinical trials: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Data Standards (writing committee to develop cardiovascular endpoints data standards). *J Am Coll Cardiol* 2015;66(4):403-69.
 - Hicks KA, Mahaffey KW, Mehran R, et al. 2017 Cardiovascular and stroke endpoint definitions for clinical trials. *Circulation* 2018;137(9):961-72.
 - Stability Investigators, White HD, Held C, et al. Darapladib for preventing ischemic events in stable coronary heart disease. *N Engl J Med* 2014;370(18):1702-11.
 - White H, Held C, Stewart R, et al. Study design and rationale for the clinical outcomes of the STABILITY Trial (STabilization of Atherosclerotic plaque By Initiation of darapladib Therapy) comparing darapladib versus placebo in patients with coronary heart disease. *Am Heart J* 2010;160(4):655-61.
 - Thygesen K, Alpert JS, Jaffe AS, et al. Third universal definition of myocardial infarction. *Eur Heart J* 2012;33(20):2551-67.
 - Bolland MJ, Barber A, Doughty RN, et al. Differences between self-reported and verified adverse cardiovascular events in a randomised clinical trial. *BMJ Open* 2013;3(3). pii: e002334.
 - Popma CJ, Sheng S, Korjian S, et al. Lack of concordance between local investigators, angiographic core laboratory, and clinical event committee in the assessment of stent thrombosis: results from the TRACER angiographic substudy. *Circ Cardiovasc Interv* 2016;9(5), e003114.
 - Frederich R, Alexander JH, Fiedorek FT, et al. A systematic assessment of cardiovascular outcomes in the saxagliptin drug development program for type 2 diabetes. *Postgrad Med* 2010;122(3):16-27.
 - Frei A, Siebeling L, Wolters C, et al. The inaccuracy of patient recall for COPD exacerbation rate estimation and its implications: results from central adjudication. *Chest* 2016;150(4):860-8.
 - Kjoller E, Hilden J, Winkel P, et al. Agreement between public register and adjudication committee outcome in a cardiovascular randomized clinical trial. *Am Heart J* 2014;168(2):197-204.e1-4.
 - Seltzer JH, Turner JR, Geiger MJ, et al. Centralized adjudication of cardiovascular end points in cardiovascular and noncardiovascular pharmacologic trials: a report from the Cardiac Safety Research Consortium. *Am Heart J* 2015;169(2):197-204.