Statistical analysis plan
DANBLOCK-BETAMI

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1. Administrative information

The trials "Danish Trial of Beta Blocker Treatment After Myocardial Infarction Without Reduced Ejection Fraction" (DANBLOCK) and "BETablocker Treatment After Acute Myocardial Infarction in Patients With Preserved Left Ventricular Systolic Function" (BETAMI) are separate trials until end of follow-up. At end of follow-up the trials will be combined and the primary results will be published as one study. This statistical analysis plan (SAP) describes data handling and planned analyses for the combined DANBLOCK-BETAMI trial.

1.1 Trial registration numbers

Danish Trial of Beta Blocker Treatment After Myocardial Infarction Without Reduced Ejection Fraction (DANBLOCK): EudraCT Number 2018-002699-42, NCT03778554.

BETablocker Treatment After Acute Myocardial Infarction in Patients With Preserved Left Ventricular Systolic Function (BETAMI): EudraCT 2018-000590-75, NCT03646357.

1.2 Protocol version used for preparation of the statistical analysis plan

The combined study does not have a joint protocol. The individual studies are conducted, monitored etc. according to their own protocols:

DANBLOCK: Protocol version 2.0, 07.11.2022 (attached in supplementary materials).

BETAMI: Protocol version 7.0, 30.05.2022 (attached in supplementary materials).

The present SAP only presents our predefined plan for joint analyses of the two studies.

1.3 Contributors for preparation of the statistical analysis plan

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The SAP has been approved by the DANBLOCK and BETAMI steering committees.

1.4 Signatures

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1.5 SAP Revision

Date of revision	Revision	Justification for revision

2. Introduction

2.1 Background and rationale for the DANBLOCK-BETAMI study

Beta-blockers (BB) have been widely used and recommended by international guidelines after myocardial infarction (MI) based on landmark trials conducted in the 1980s.[1–3] However, since then, several factors have led to questioning the continued use of BB therapy in a modern secondary preventive setting.[4] These factors include revisions in the criteria for MI and the use of highly sensitive troponins, which can now classify patients previously diagnosed with unstable angina as experiencing a MI.[5] Additionally, primary percutaneous coronary intervention (PCI) and new secondary preventive medical therapies such as statins and antihypertensive medications have been introduced.[6,7] These developments have reduced the risk of myocardial scarring and, consequently, the risk of fatal arrhythmias and heart failure (HF), which are conditions where BB therapy has been known to be beneficial.

Despite wide-spread use and tolerability patients treated with BB report side-effects, i.e. sexual dysfunction, cold hands and feet and fatigue.[8] A lower compliance to BB treatment compared to other cardiovascular medications is seen and is thought to be related to side effects.[9] On the other hand, BB treatment reduces angina symptoms, which has profound effects on quality of life. Thus, the benefit of BB treatment on survival outlook needs to be weighed against the impact on side effects as well as quality of life.

BB have an ubiquitous role in patients with reduced left ventricular ejection fraction (LVEF).[10] For patients with mid-range or preserved LVEF no randomized controlled trials have been performed testing the continued efficacy of BB therapy in a modern secondary preventive setting. The lack of evidence in the reperfusion era has resulted in divergence between guideline recommendations. In patients with ST-segment elevation MI the European Society of Cardiology (ESC) recommends BB

therapy with a class 2A recommendation, level of evidence (LOE) B.[11] On the contrary, the American College of Cardiology/American Heart Association (ACC/AHA) has a class I recommendation, LOE B.[12] The ESC has no recommendation on long-term BB therapy in patients with acute coronary syndromes presenting without STEMI and preserved LVEF[13], whereas BB therapy are recommended long-term by AHA/ACC with a class IIA recommendation, LOE C.[14]

2.2 Objectives

The aim of the DANBLOCK-BETAMI study is to evaluate the effectiveness and safety of BB therapy after MI. The study will investigate whether BB therapy is superior to no BB therapy following MI in patients with normal or mildly reduced LVEF in terms of reducing the risk of cardiovascular events. The primary endpoint is a composite of all-cause mortality, recurrent MI, revascularisation with PCI or coronary artery bypass graft (CABG), ischemic stroke, incident HF, or malignant ventricular arrhythmia and resuscitated cardiac arrest.

3. Study methods

3.1 Trial design and randomization

DANBLOCK and BETAMI are prospective, randomized, controlled, open-label clinical trials evaluating the benefits of long-term oral BB therapy in MI patients with normal or mildly reduced LVEF. Patients will be randomized 1:1 to BB treatment or no BB treatment. In DANBLOCK patients are stratified by LVEF, whereas patients are stratified by site in BETAMI.

3.2 Type, dose, and administration of drug

If a patient is randomized to BB therapy the treatment is given orally. The type and dose of BB will be left at the discretion of the treating physician. The highest tolerated dose is recommended. Generic drug and accepted dosages will be:

- Bisoprolol up to a total dose of 10 mg daily

- Carvedilol up to a total dose of 50 mg daily

- Metoprolol succinate up to a total dose of 200 mg daily

- Nebivolol up to a total dose of 10 mg daily (DANBLOCK)

3.3 Framework, sample size and power calculation

The trial will be analyzed as an ordinary superiority trial and is designed to achieve a pre-specified number of events under modelled event rates. Actual number of (non-adjudicated) events will be monitored by linkage to Norwegian and Danish national registries. The last patient included will be followed for a minimum of 6 months.

3.3.1 Study power calculation for the combined DANBLOCK-BETAMI study

The original power calculation in BETAMI estimated a total of 794 first events to provide a power of 80% to detect a relative risk reduction of approximately 20% (11% primary end points with no BB vs 9% primary end points with BB; hazard ratio of 1.22). In DANBLOCK it was assumed that with a hazard ratio of 1.2 for the non-treated group compared to the treated the DANBLOCK trial had 80% power to detect the effect with an accumulation of 900 first events of the primary endpoint. Original sample size and power calculations for DANBLOCK and BETAMI can be seen in the protocols in supplementary material.

The primary analysis in the combined DANBLOCK-BETAMI study will be conducted as a Cox model adjusted for site (and hereby country). To illustrate the expected power, the power obtained with a true treatment effect of a hazard ratio of 1.2 and 50 equal sites is presented below. It becomes clear that if the follow-up is concluded with 950 first events one will have about 80% power which is considered acceptable and 950 primary events is thus the aim of the study. The study will be stopped when it is anticipated that this number of events will be reached within a minimum of a 6

month follow-up period or a reasonable time thereafter. The decision to stop the trial will be at the discretion of the combined steering committee.

Event count	Power
300	0.3511
400	0.4397
500	0.5295
600	0.6053
700	0.6751
800	0.7304
900	0.78
1000	0.8159
1100	0.8531
1200	0.8844
1300	0.911
1400	0.9255

3.4 Interim analysis for effect

No interim analyses are planned.

3.5 Timing of final analysis and outcome assessments

The final analyses will be performed when follow-up has ended, and all endpoints have been adjudicated. The minimum follow-up period will be 6 months.

Primary, secondary and safety endpoints are collected and monitored through registry linkage, hospital medical records, and questionnaires throughout the trial. Patient Reported Outcome (PRO) questionnaires are collected at baseline and 12 months after randomization in both studies. In DANBLOCK, PRO-questionnaires are also collected after 3- and 24-months follow-up. In BETAMI, PRO-questionnaires are also collected after 30 days, 6 months and 18 months follow-up.

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4. Statistical principles

4.1 Confidence interval and P values

For the primary outcome the level of significance will be 5% and a confidence interval (CI) of 95% will be reported. The secondary outcomes will also be assessed with a level of significance of 5% and a CI of 95%, however, as no adjustment of multiplicity is planned for the secondary outcomes any significant finding for these will be considered exploratory. Statistical comparisons will be performed using two-sided significance tests.

4.2 Protocol deviations

Protocol deviations are only related to adherence to assigned treatment. Specifically, patients randomized to BB will be considered adherent until their prescription no longer covers a given timepoint - with an added grace period of 30 days. Patients randomized to no BB therapy will be considered adherent until they redeem a prescription for BB. Participants adherent to randomization group at 6 months are considered adherent for the full follow-up period.

4.3 Analysis population

All major treatment comparisons between the randomized groups will be performed according to the principle "intention-to-treat", i.e., participants will be analysed, and endpoints counted in the group to which they were assigned at randomization, irrespective of later crossover.

5. Trial population

5.1 Screening

Patients admitted to the hospital for MI will be screened for in- and exclusion criteria at all participating centers. However, only selected sites in DANBLOCK and one site in BETAMI are consecutively reporting the reasons for not being included in the trial. Patients fulfilling the study

entry criteria will be registered in the eCRF. Collected screening data will be summarized and presented in the main publication.

Information on all individuals experiencing MI during the study trial period are available through national registries. However, LVEF-values are not available in the Danish registries making it difficult to extrapolate to a screening population.

Screening data registered in the eCRF:

- Age

- Sex

- Site

- Inclusion criteria including date of index event and LVEF-value

- Exclusion criteria (see below)

5.2 Inclusion and exclusion criteria

	DANBLOCK	**BETAMI**
Inclusion criteria		
MI definition	Universal definition of MI	Universal definition of MI type 1
Time to randomization	Within 14 days following MI	Within 7 days following MI
Age	≥18 years	
LVEF	> 40%	≥40%
Revascularization	No specified criteria	PCI or thrombolysis
Exclusion criteria	• Clinical evidence of heart failure	

	• Pregnancy or of childbearing age not using safe anticonception throughout the study period
	• Lack of signed informed consent or lack of expected cooperation during follow-up
	• Decline to participate
	• Any medical condition where BB treatment is indicated according to the treating physician
	• Any medical condition where BB treatment is contraindicated according to the treating physician

5.3 Information to be included in the CONSORT flow diagram

- Number of sites with systematic screening and estimated number of patients assessed for eligibility

- Estimated number of patients excluded and reason for exclusion

- Number of patients randomized

- Number of patients allocated to BB or no BB

- Number of loss to follow-up

- Number of patients excluded from analyses and reasons for exclusion

5.4 Adherence, dosage, withdrawal and loss to follow-up

5.4.1 Dosage and adherence to BB therapy

A landmark summary of adherence to allocated study arm will be performed 6 months after inclusion of each patient. Participants will be described according to whether they became non-adherent before 6 months or experienced the main outcome; whatever occurs first. As previously

described patients randomized to BB will be considered adherent until their prescription no longer covers a given timepoint with an added grace period of 30 days. Patients randomized to no BB therapy will be considered adherent until they redeem a prescription for BB. Participants adherent to randomization group at 6 months are considered adherent for the full follow-up period. The landmark summary will preferably be performed in both cohorts but is dependent on acceptable time to updated registries.

Substudies and secondary analyses focusing on BB-dosage and adherence are planned.

5.4.2 Withdrawal of informed content

Patient consent withdrawals are possible at any time during follow-up and the day of withdrawal will be registered. Time to withdrawal will be summarized.

5.4.3 Loss to follow up

Loss to follow-up is expected negligible due to almost complete coverage by the national registries. Loss to follow-up will be registered in the national registries and reported as day of loss to follow-up (emigration).

5.5 Data collection

Data collected at baseline:

- Demographics

- Major comorbidities

- Procedures performed during index event (CAG, PCI, CABG)

- Lifestyle (smoking status and body mass index)

- Laboratory data, including eGFR, Hba1c, troponin, CKMB and lipids

- Patient reported outcomes on symptoms and quality of life measures

- **Measures for quality of life**: 12-Item Short Form Survey (SF-12, BETAMI) and EuroQol-5 dimension questionnaire (EQ5D, DANBLOCK).

- **Measures of depression and anxiety**: Hospital Anxiety and Depression Scale (HADS)

- **Measures of sexual dysfunction**: The International Index of Erectile Function (IIEF) and Female Sexual Function Index (FSFI), (short versions).

- **Measures of sleeping disorder**: Bergen insomnia Scale, Nightmare Frequency Questionnaire (BETAMI) and average sleep duration (BETAMI).

- **Angina burden following MI**: New York Heart Association classification (NYHA); Canadian Cardiovascular Society grading of angina pectoris (CCS); Seattle Angina questionnaire (SAQ) (for those who report angina symptoms).

- **Measures of personality**: Type D (distressed) personality disorder (BETAMI).

Data collected during follow-up:

Primary, secondary and safety endpoints are collected through registry linkage, questionnaires and hospital medical records throughout the trial as previously described. In addition, patient reported adherence and hospitalization will be assessed by questionnaires every 3 months in DANBLOCK and after 30 days in BETAMI. Follow-up data also include the BETAMI biobank at 6 months (BETAMI study only).

5.6 Patient characteristics in main publication

Data at baseline:

- Demographics
  - Age, sex, country and education

- Major cardiovascular risk factors and comorbidities

  - Hypertension, hyperlipidaemia, chronic kidney disease, diabetes, smoking, family history of cardiovascular disease and BMI

  - Previous cardiovascular disease: MI, coronary artery disease, PCI, CABG, stroke, peripheral artery disease, atrial fibrillation/flutter.

- Type of MI (NSTEMI/STEMI)

- LVEF-value

- Procedures performed at index event (CAG, PCI, CABG)

- Type and dosage of BB at randomization (for patients randomized to BB therapy)

- Prior BB therapy

- Medications related to CVD (antiplatelets, statins, ezetimibe, angiotensin inhibitors, anticoagulants, antidiabetics)

Details of how baseline characteristics will be descriptively summarized

Baseline characteristics will be presented as numbers with percentages for categorical variables and medians with interquartile ranges for continuous variables.

6. Analysis and endpoints

6.1 Endpoints

6.1.1 Primary endpoint

- A composite of all-cause mortality, recurrent MI (primary and secondary diagnosis in the administrative patient registries), revascularisation with PCI or coronary artery bypass graft (CABG), ischemic stroke, incident HF, malignant ventricular arrhythmia and resuscitated cardiac arrest.

It is noted that the original BETAMI primary endpoint was a composite of all-cause mortality or non-fatal MI and the original DANBLOCK primary endpoint was a composite of all-cause mortality, MI, stroke, unstable angina or HF.

All events included in the primary endpoint will be collected from the Norwegian and Danish Patient registries. All first events of each component of the primary endpoint (except all-cause mortality) will be adjudicated by a clinical endpoint adjudication committee. Please see supplementary material for definition of endpoints.

6.1.2 Secondary endpoints

Key secondary endpoints

The following key secondary endpoint will be included in the main publication:

- Each of the components of the primary endpoint, i.e.: All-cause mortality, recurrent non-fatal MI, revascularisation with PCI or CABG, ischemic stroke, incident HF, malignant ventricular arrhythmia and resuscitated cardiac arrest

Other secondary endpoints

Planned analyses of other secondary endpoints are described under 6.2.5

6.2 Analyses

The primary analysis will be performed on combined data between the two trials. Data will be transferred from the Norwegian data center to the Danish data center by an encrypted and password protected transfer method and according to a signed data transfer agreement and in accordance with the signed informed consent of each patient.

6.2.1 Analysis of the primary endpoint

The primary assessment will involve an intention-to-treat comparison among all randomized participants of the effects of allocation to BB versus no BB on time to first occurrence during the scheduled treatment period of the primary endpoints. Main secondary assessments will involve intention-to-treat comparisons among all randomized participants of the effect of allocation to BB on time to first occurrence of secondary endpoints

The primary endpoint is time to one of the components of the primary endpoint (time to first event), assessed after the last patient included has completed a minimum of 6 months of follow-up. The null hypothesis is that the rate of the composite primary endpoint in the allocation groups are equal. The primary analysis will be a Cox proportional hazards regression model with randomization group (prescription of BB) as the main covariate. The analysis will be adjusted for site and LVEF (the stratification factors in the randomization). A hazard ratio (HR) for BB vs no-BB with a 95% CI will be estimated, and a P-value for the null hypothesis of a hazard ratio equal to 1 will be computed. In addition, the survival curves for the 2 groups (BB and no-BB) will be estimated and plotted with the Kaplan-Meier estimator, and the equality of the survival curves will be tested with the log-rank test.

Decision rule:

- If the estimated HR is < 1 and the 95% CI does not contain 1, superiority of BB will be accepted

- If the estimated HR is > 1 and the 95% CI does not contain 1, superiority of no BB will be accepted

- If the 95% CI contains 1, no superiority will be accepted

6.2.2 Analyses of key secondary endpoints

The key secondary endpoints to be included in the main publication are in section 6.1.2. All-cause mortality will be analyzed in the same manner as the primary endpoint. All other secondary endpoints will be analyzed with a Fine-Gray competing risk regression model, with all-cause mortality as the competing risk and the same covariates as in section 6.1.2. All analyses of secondary endpoints will be interpreted as explanatory.

6.2.3 Additional analyses

An analysis of the primary endpoint will be done in which follow-up time is limited to 12 months. The analysis will be performed and presented as described in section 6.2.1, with the addition of right censoring at 12 months. The results of this analysis will be interpreted as exploratory.

6.2.4 Planned subgroup analyses

The following subgroup analyses are planned in the primary publication:

- Sex (Men and women)

- Age (Tertiles)

- Country (Denmark and Norway)

- Type of MI (NSTEMI/STEMI)

- LVEF-value (Midrange and preserved)

- BB dosage tertiles (dosage at randomization)

The subgroup analyses will be performed by adding an interaction term in the Cox model (as described in Section 6.2.1) between prescription of BB and the subgroup-defining factor. A P-value ≤ 0.05 for the interaction term will indicate a significant subgroup effect. A HR with 95% CI for BB vs no BB will be estimated for each subgroup and presented in a forest plot. For BB dosage, the lowest dose will be the reference dose, such that the comparisons will be (i) mid dose vs lowest dose and (ii) highest dose vs lowest dose.

6.2.5 Secondary endpoints and data to be included in substudies

The following data will be used in sub studies planned for later publications. Study data and planned analyses are not elaborated in detail as these will not be included in the main publication.

- To describe BB dosage and adherence obtained from the prescription registries.
- To determine whether long-term treatment with BB therapy reduces:
  - Cardiovascular mortality obtained from the Cause of Death Registry.
  - Hospitalization or electrical cardioversion for atrial fibrillation/atrial flutter and other tachyarrhythmia obtained from the Norwegian and Danish Patient Registry.
  - Hospitalization for unstable and stable angina obtained from the Norwegian and Danish Patient Registry. Also adjudicated from self-reported questionnaires (DANBLOCK) and hospital medical records (both trials).
  - Exercise capacity measured as VO2-peak at cardiac rehabilitation obtained from the Danish cardiac rehabilitation registry (DANBLOCK only).
- To determine whether long-term treatment with BB therapy increases:
  - Hospitalization for bradycardia, syncope or implantation of a pacemaker obtained from the Norwegian and Danish Patient Registry.
  - Hospitalization for asthma and chronic obstructive pulmonary disease obtained from the Norwegian and Danish Patient Registry.
  - Hospitalization for dysregulated blood pressure and blood pressure control obtained from the Danish registries (DANBLOCK only).
  - Hospitalization or out-patient visit for new-onset or dysregulated diabetes obtained from the Norwegian/Danish Patient Registry and from the Danish cardiac rehabilitation registry (DANBLOCK only).

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- New-onset peripheral artery disease or hospitalization for peripheral artery disease obtained from the Norwegian and Danish Patient Registry.

- To determine whether assigned group affects the following PRO:

  - Quality of life, symptoms of depression, anxiety, angina, sexual dysfunction and sleep disorders (both trials). Type D personality (BETAMI only).

- Comparison of locally adjudicated endpoints, registry-based endpoints and endpoints adjudicated by a blinded clinical endpoint adjudication committee (DANBLOCK)

- MINOCA (DANBLOCK)

- To determine whether long-term treatment with BB affects drug metabolism and biomarkers (BETAMI biobank).

- Joint meta-analyses with the ongoing REDUCE (ClinicalTrials.gov Identifier: NCT03278509) and REBOOT (ClinicalTrials.gov Identifier: NCT03596385) studies are planned. These are also superiority trials with comparable entry criteria. The analyses will give increased power and precision of facilitate clinical decision making on both primary and secondary end points, in addition to increased generalizability through a broader patient population. The metanalyses will be detailed later.

6.3 Missing data

Follow-up is through registry linkage as previously described. We anticipate no missing data on the primary or main secondary outcomes, with the exception of loss to follow-up due to emigration. Follow-up will be censored at the time of emigration. In secondary adjusted analyses (for later publications) missing data will be handled through multiple imputation.

6.4 Harms

6.4.1   Safety endpoints

The following safety endpoints will be reported in the main publication:

- A composite of all-cause mortality, recurrent MI, incident HF, malignant ventricular arrhythmia or resuscitated cardiac arrest at 30 days following randomization

- All-Cause Mortality: A table of all deaths within the follow-up period with number and frequency in each group obtained from the Norwegian and Danish Population Registries.

- Suspected Unexpected Serious Adverse Reaction (SUSARs): A table of all SUSARs within the follow-up period with number and frequency in each group. Reported by local investigators and obtained from the study databases.

6.4.2 Adverse events

All serious adverse events, including potential endpoints, are captured in the study database to be used for safety assessments and are reported continuously to regulatory authorities.

6.4.3 Details of guidelines for stopping the trial early

Two independent Data Safety Monitoring Boards (DSMB) are overviewing safety for DANBLOCK and BETAMI. The DSMB will recommend to the executive steering committees that the trials are stopped if one of the treatment arms has 50% more events than the other. All final decisions regarding trial modifications rest with the steering committees and are not subject to a pre-defined stopping criterion. The recommendation to either continue or stop the trials because of an unbalance in event rates between the treatment arms will be at the discretion of the DSMB. The DSMB may also recommend that the trials are stopped if the committee at any time is of the conviction that the risk to current and future trial patients outweighs the potential impact of premature termination on future clinical practice and should be based on emergent data on patient safety or trial conduct inconsistent with pre-trial assumptions available at ethics committee approval. In the event of a

decision to terminate the study, the principal investigator for each study will inform all investigators, relevant authorities and ethics committees of the termination.

7 Data handling and record keeping

Data is collected for participants who enter the randomized phase of the study. All data are entered into web-based electronic data systems (DANBLOCK: RedCap, BETAMI: Viedoc). A participant list will be linked to the national registries for collection of endpoints. A combined dataset for the two trials will be prepared and stored at secured Danish servers. This dataset forms the basis for all statistical analyses, which will be performed by Danish and Norwegian statisticians in collaboration. Internal database quality-control checks will be performed.

8 Supplementary materials

BETAMI, protocol version 7.0, 30.05.2022

DANBLOCK, protocol version 2.0, 07.11.2022

Definition of endpoints and standard operating procedures for adjudication

Definition of medication and diagnoses

9 References

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