Continuing versus Suspending Angiotensin-Converting Enzyme Inhibitors and Angiotensin Receptor Blockers: Impact on Adverse Outcomes in Hospitalized Patients with Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2)

Rationale and Design of the BRACE CORONA Trial

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Short title: BRACE CORONA Trial: Rationale and Design

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Abstract

BACKGROUND: Angiotensin-converting enzyme-2 (ACE2) may increase due to upregulation in patients using angiotensin-converting enzyme inhibitors (ACEI) and angiotensin receptor blockers (ARB). Because renin-angiotensin system blockers increase levels of ACE2, a protein that facilitates coronavirus entry into cells, there is concern that these drugs could increase the risk of developing a severe and fatal form of COVID-19. The impact of discontinuing ACEI and ARBs in patients with COVID-19 remains uncertain.

DESIGN: BRACE CORONA is a pragmatic, multicenter, randomized, phase IV, clinical trial that aims to enroll around 500 participants at 32 sites in Brazil. Participants will be identified from an ongoing national registry of suspected and confirmed cases of COVID-19. Eligible patients using renin-angiotensin system blockers (ACEI/ARBs) with a confirmed diagnosis of COVID-19 will be randomized to a strategy of continued ACEI/ARB treatment versus temporary discontinuation for 30 days. The primary outcome is the median days alive and out of the hospital at 30 days. Secondary outcomes include progression of COVID-19 disease, all-cause mortality, death from vascular causes, myocardial infarction, stroke, transient ischemic attack, new or worsening heart failure, myocarditis, pericarditis, arrhythmias, thromboembolic events, hypertensive crisis, respiratory failure, hemodynamic decompensation, sepsis, renal failure, troponin, B-type natriuretic peptide, N-terminal-pro hormone and D-dimer levels.

SUMMARY: BRACE CORONA will evaluate whether the strategy of continued ACEI/ARB therapy compared with temporary discontinuation of these drugs impacts clinical outcomes among patients with COVID-19.

Keywords: ACE inhibitor; angiotensin receptor blocker; coronavirus; COVID-19; severe acute respiratory syndrome coronavirus 2

INTRODUCTION

In December 2019, the first cases of a novel infectious viral respiratory illness, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), were reported in Wuhan, China. The highly contagious coronavirus disease (COVID-19) caused by SARS-CoV-2 spread rapidly to more than 100 countries and was declared a global pandemic by the World Health Organization on March 11, 2020.[1] This new and threatening situation led to a rapid response by the medical and scientific community to identify the main characteristics of the disease and interventions to improve the outcomes of patients with COVID-19.

In infectious disease emergencies, such as the ongoing COVID-19 pandemic, trials of interventions need to be implemented as part of the efforts to control the spread of the disease and to improve patient outcomes.[2] Randomized clinical trials are the most reliable approach to evaluate the effects of these interventions.[3] In the context of public health emergencies, conducting a randomized clinical trial can be even more challenging.[4] The shortfalls of the contemporary clinical trial system include the increasingly prohibitive costs, local and national regulatory requirements, delays in approval, and unnecessary trial processes.[5] Over the past decade, innovations in trial design have been deployed to facilitate trial conduct. An attractive solution is registry-based randomized clinical trials.[6] By including randomization in a clinical registry with unselected consecutive enrolment, the advantages of a prospective randomized trial can be aligned with the strengths of a large-scale, all-comers clinical registry.[7] Prospective registry-based randomized trials may be a powerful tool for conducting studies efficiently and cost-effectively, particularly in an urgent situation like the current COVID-19 pandemic.

Study Rationale

Patients with COVID-19 and comorbidities have a worse prognosis than those with no underlying medical issues. However, other well-known cardiovascular risk factors commonly identified in these patients could also explain the higher risk of this population.[8,9] Renin-angiotensin system blockers are commonly used in patients with cardiovascular comorbidities since this group of drugs is routinely indicated for patients with heart failure, hypertension, and coronary heart disease. Angiotensin-converting

enzyme-2 (ACE2) may increase due to upregulation in patients using angiotensin-converting enzyme inhibitors (ACEI) and angiotensin receptor blockers (ARBs). Since SARS-CoV-2 (and other human pathogenic coronaviruses) binds to target cells through ACE2,[10] the worse prognosis in patients with cardiovascular disease could be related to the interaction with drugs commonly used in these patients that may facilitate virus aggression.[11]

On the basis of data indicating that ACE2 is an effective receptor for SARS-CoV-2, healthcare professionals and researchers are assessing the possible impact of ACEIs and ARBs in patients with COVID-19.[12] The ACE2 receptor is found on the surface of type II alveolar epithelial cells in the lungs as well as cells in the heart, kidney, liver, and gastrointestinal tract. There is uncertainty surrounding renin-angiotensin system inhibition in patients with COVID-19, with some hypothesizing that ACEI/ARB use may increase propagation of the virus and others hypothesizing that there may be a protective effect (Figure 1).[13]

SARS-CoV-2 gains entry into the cell by binding to ACE2. The use of an ACEI or ARB could enhance ACE2 abundance and consequently increase susceptibility to viral entry. In theory, this effect could increase the risk for or severity of COVID-19. On the other hand, an increase in the expression of angiotensin II drives lung injury by activating the type 1 angiotensin receptor (AT1R), producing inflammation and fibrosis. Decreasing the production of angiotensin II with an ACEI or blocking angiotensin II–AT1R activity with an ARB enhances the production of angiotensin (1–7) from angiotensin II and activates the Mas receptor, which attenuates inflammation and fibrosis resulting in a decrease in lung damage.[14] Indeed, the use of recombinant human ACE2 has been tested as a promising therapy for patients with severe acute respiratory distress syndrome.[15] Finally, renin-angiotensin system inhibition protects the cardiovascular system by lowering blood pressure, avoiding ventricular remodeling, and reducing plasminogen activator inhibitor-1.[16] Thus, withdrawal of these agents could be harmful since there is a potential risk of disease complications related to discontinuation of established therapies already proven effective in preventing cardiovascular events. As a result, there are

data supporting a potential benefit and also data indicating potential risk in maintaining these agents during COVID-19 infection, which reinforces the need of a prospective randomized study to address this clinical question.

There are several possible interactions between these medications commonly prescribed for cardiovascular disease and COVID-19 that might influence the prognosis of these patients. When the totality of evidence is taken into account, there is true equipoise between the maintenance or suspension of ACEI/ARB therapy in patients with COVID-19. To date, there is no high quality clinical evidence to confirm any of the theories and this question can only be clarified through a randomized clinical trial.[13] Our initial hypothesis is that continuing ACEI/ARBs will be beneficial for the overall course of the COVID-19 infection compared with withdrawing these agents.

METHODS

Study Overview

BRACE CORONA (ClinicalTrials.gov: NCT04364893) is an academically led, investigator-initiated, pragmatic, phase IV, multicenter, registry-based randomized trial. The study will be open-label with blinded endpoint assessment (PROBE) and will include approximately 500 patients on ACEI/ARB therapy with a confirmed diagnosis of COVID-19.

The BRACE CORONA trial is embedded in a registry of all patients with COVID-19 admitted at 32 sites in Brazil. Of these patients, the first 500 eligible for the trial will be approached to be randomized for maintenance or discontinuation of renin-angiotensin system inhibition. All of the data necessary for documenting baseline characteristics and outcomes, including ACEI and ARB doses, will have been collected already by the registry (Figure 2).

The study protocol was approved by the National Commission for Research Ethics (CONEP) from the Brazilian Ministry of Health. The study will be conducted in compliance with the protocol and adheres fully to the ethical principles of the Declaration of Helsinki, specifications of the International

Council for Harmonisation, and Good Clinical Practice. The protocol requires that each patient must provide informed consent before any study procedure is initiated.

Primary Objective

The primary objective of the trial is to determine whether continued use versus discontinuation of ACEI/ARB therapy increases days alive and out of the hospital over 30 days in patients on renin-angiotensin system inhibition hospitalized with COVID-19.

Secondary Objectives

The secondary objectives are to compare the impact of continued use versus discontinuation of renin-angiotensin system inhibition on COVID-19 disease severity, all-cause mortality, cardiovascular death, acute myocardial infarction, new or worsening heart failure, hypertensive crisis, transient ischemic attack, and stroke at 30 days. In addition, the incidence of myocarditis, pericarditis, arrhythmias requiring treatment, thromboembolic phenomena, respiratory failure, hemodynamic decompensation, sepsis, and renal failure will be compared between groups at 30 days. Cardiovascular biomarkers related to COVID-19 (troponin, B-type natriuretic peptide [BNP], N-terminal-pro hormone BNP, and D-dimer) will also be assessed.

Study Population

All patients hospitalized with suspected diagnosis of COVID-19 will be included in the registry and followed until the diagnosis is confirmed or refuted. Patients ≥18 years of age with a confirmed diagnosis of COVID-19 who are on chronic renin-angiotensin system inhibitor (ACEI/ARB) therapy will be assessed for the BRACE CORONA trial. Based on international data, around 80 to 90% of the patients included in BRACE CORONA should have the diagnosis of hypertension and 10 to 20% would have the diagnosis of heart failure.[17,18] Patients using sacubitril/valsartan for heart failure will not be included in the trial. Patients using more than three antihypertensive agents and those hospitalized for heart failure in

the last 12 months are not eligible for randomization. Patients with a clinical indication to stop ACEI/ARB therapy, such as those with hypotension, acute kidney injury, and/or shock, will be excluded. Full inclusion and exclusion criteria are shown in Table 1.

Randomization and Allocation

Eligible patients will be randomized using a 1:1 allocation ratio to either continue ACEI/ARB therapy (Group 1) or discontinue ACEI/ARB therapy for 30 days (Group 2).

Trial Interventions

Patients randomized to Group 1 will not change their renin-angiotensin system blocker therapy as a result of COVID-19. Dose adjustments and concomitant therapies will be at the discretion of the treating physician.

Patients randomized to Group 2 will discontinue their ACEI or ARB therapy for 30 days. These agents should be replaced by other drugs as needed and at the discretion of the treating physician. Beta blockers should be maintained in those patients are already using them for heart failure and the study protocol does not recommend any treatment modification beyond renin-angiotensin blockers. The use of hydralazine and nitrates is preferred in patients with heart failure, as they are commonly used and are the preferred treatment for those who cannot tolerate ACEI or ARB therapy. Patients with heart failure who deteriorate after medication withdrawal will be managed based on the hemodynamic profile with the use of diuretics and vasodilators in type B profile. Among vasodilators, the preference in the acute phase will be for short half-life medications with the possibility of using parenteral agents such as nitrates associated with hydralazine or not. The reintroduction of ACEI can be done after clinical compensation, preferably 30 days after randomization with stable renal function. For patients with hypertension, the study protocol recommends thiazide, calcium channel antagonists, or hydralazine as the preferred options (if patients are not already using one of these classes). Other anti-hypertensive agents may be used based on patient and physician preferences (e.g., beta-blockers commonly used in patients with ischemic heart disease or heart

failure). Thus, beta blockers are not recommended as first-line agents unless the in presence of heart failure or ischemic heart disease.[19] In these cases, they should be used regardless of blood pressure control.

The study team will assist treating physicians during the process of drug replacement and decisions will be based on current guidelines.

Concomitant Therapies

Since BRACE CORONA is a pragmatic study, the types of ACEI or ARBs used will be defined according to local practice following international guidelines.[19-21] Details around different types of renin-angiotensin system blockers will be reported in the publication of the results.

Since there is currently no specific intervention proven to be beneficial in the treatment of COVID-19, patients will be treated according to current local standards of supportive care without systematic use of experimental therapies.

Study treatment compliance will be assessed based on medical prescription during hospitalization and after discharge.

Study Procedures

Data will be collected systematically for patients included in both the COVID-19 registry and BRACE CORONA trial. The data collected will include demographics, cardiovascular risk factors, relevant medical and surgical histories, clinical characteristics, concomitant medications, and laboratory data. Data collection will be performed during hospitalization until discharge and a phone call at 30 days will capture clinical events after discharge. The flowchart including both registry and clinical trial populations is presented in Figure 3. The detailed information collected during each study visit is provided in the Supplementary Appendix.

Clinical Outcomes

The primary outcome of the study will be days alive and outside of the hospital (DAOH) at 30 days. This endpoint will be calculated for each patient and the calculation will be from the date of randomization to 30 days post-randomization. The DAOH endpoint represents the follow-up time (30 days) subtracted from the hospitalization days and/or the days between death and the end of follow-up. This pragmatic endpoint encompasses not only the time to death but also all of the potential non-fatal complications that could lead to a prolonged hospitalization. A sensitivity analysis using a hierarchical approach between death (receiving zero DAOH) and length of hospitalization will also be performed. The main cardiovascular complications that could prolong hospitalization or lead to death will be assessed individually as secondary outcomes.

An independent clinical events committee, whose members are unaware of randomization assignment, will adjudicate the following secondary clinical outcomes: death from vascular causes, myocardial infarction, new or worsening heart failure, stroke, and transient ischemic attack at 30 days. All potential events detected in the electronic case report forms for patients included in the trial will generate an alert to upload source documents for the adjudication process. Detailed definitions of the secondary outcomes are described in the Supplementary Appendix.

Sample Size Calculation

The initial expected sample size for BRACE CORONA will be around 500 patients; however, this number may increase or decrease according to the recruitment rate, event rate, and data safety monitoring board (DSMB) assessments for efficacy, safety, and futility. Assuming a standard deviation of 4 days and DAOH of 24 days (based on the ongoing COALIZAO I study in Brazil [NCT04322123]), 500 patients will have 90% power to detect a mean ration of at least 1.10. We estimate the full cohort of patients will be enrolled in 3 to 4 months; however, this may be extended depending on the recruitment rate. There are currently no randomized studies in this field with reported outcomes and event rates to inform calculations about an accurate sample size.

Statistical Analysis

In order to maintain the benefits of randomization, the primary analysis will follow the intention-to-treat principle. Continuous variables will be described as medians (25th, 75th percentiles) or mean ± standard deviation according to the distribution. Medians will be compared using the Kruskal-Wallis test and means will be compared using the t-test. Categorical variables will be described by absolute and relative frequencies and the proportions will be compared using the Chi-square test. P-values <0.05 will be considered statistically significant.

As the primary outcome will be measured as DAOH at 30 days, the analysis will be based on the median of this outcome. The analysis of the distribution of DAOH at 30 days will be presented as histograms for the two groups (with and without discontinuation of renin-angiotensin system inhibitors) and the median and 25th and 75th percentiles of the general population and of each group will be calculated. The comparison between the groups will be made using a Quasi-Poisson model. Results will be presented as mean ratios between study groups with the respective 95% confidence intervals. Interaction tests will be performed for specific subgroups, including sex (male vs. female); age (>65 vs. ≤65 years); days of symptoms (divided into tertiles); history of myocardial infarction (vs. no); history of stroke (vs. no); history of heart failure (vs. no); history of hypertension (vs. no); use of ACEI vs. use of ARB; and length of ACEI or ARB use prior to enrollment.

Secondary endpoints of mortality at 30 days and cardiovascular events at 30 days will be compared log binomial models, reporting relative risks with the respective 95% confidence intervals.

All analyses will be performed using R software in its most current version.

ORGANIZATIONAL STRUCTURE

Funding and Trial Oversight

This is an investigator-initiated study with financial support from D'Or Institute for Research and Education (IDOR). No extramural funding was used to support this work. The study is being coordinated by IDOR and the Brazilian Clinical Research Institute (BCRI). Both institutions will coordinate data management; IDOR will manage the electronic clinical report form database the BCRI will manage the clinical events adjudication database. The Executive and Steering Committees, together with the operational teams from IDOR and BCRI, will oversee the medical, scientific, and operational conduct of the study. The Executive and Steering Committee members are responsible for the reporting of the results and the drafting and editing of this and forthcoming manuscripts. The authors are solely responsible for the design and conduct of this study, all study analyses, the drafting and editing of the paper and its final contents.

An independent DSMB will monitor safety and efficacy data on an ongoing basis with access to unblinded data. The DSMB will review the primary outcome of the study as well as the secondary outcomes through weekly evaluations and also through 2 formal interim analyses, including the HF group. The DSMB will use a p-value <0.001 in the interim analyses to declare a statistically significant difference in outcomes between study groups to guide their recommendations.[22,23] An overall p-value <0.05 will be used to declare statistical significance at the end of the study.

An independent clinical events classification committee will adjudicate the causes of death and the clinical outcomes described as secondary outcomes, such as, death myocardial infarction, stroke, hypertensive crisis, and new or worsening heart failure.

DISCUSSION

The majority of patients affected by COVID-19 will have favorable clinical outcomes during the acute phase of the infection.[24] Nevertheless, the risk of severe forms of the infection increases significantly according to age and the presence of chronic comorbidities.[25,26] Among these comorbidities,

cardiovascular diseases are particularly important because of the intrinsic risk of adverse outcomes and the prevalence of these conditions in the global population.[25,26] Hypertension, diabetes, heart failure, and coronary heart disease are common comorbidities associated with worse prognosis among patients with COVID-19; however, the higher risk detected in this group could also be due to other related factors that may facilitate infection and increase propagation of the virus.[27]

Renin-angiotensin system inhibitors are routinely used for common cardiovascular conditions.[19-21] The benefits in reducing cardiovascular events are well established, mainly in long-term analyses of patients with chronic use of these therapies.[28,29] However, in some acute clinical conditions, these drugs are temporarily discontinued due to an imminent risk higher than the potential short-term benefit of these therapies.[30] There is currently an intense debate about the suspension or maintenance of chronic ACEI/ARB therapy in patients with COVID-19.[12,13,27,31,32]

The BRACE CORONA trial was designed to test the impact of discontinuation compared with maintenance of chronic ACEI/ARB therapy in patients with COVID-19. This is one of several questions facing physicians in the setting of COVID-19 and data are needed from randomized clinical trials like BRACE CORONA. Because renin-angiotensin system inhibitors increase levels of ACE2, a protein that facilitates coronavirus entry into cells, there is concern that these drugs could increase the risk of developing a severe and fatal form of COVID-19.[15] The presence of ACE2 in alveolar epithelial cells makes the lungs a preferred site of entry for the virus, which explains the respiratory manifestations in patients with COVID-19. This hypothesis of worse outcomes associated with the use of ACEI or ARB in patients with COVID-19 was recently shown in observational studies.[25,26] However, a cause-effect relation between the use of ACEI or ARB and adverse events in COVID-19 cannot be established since many confounding factors could explain a worse or better prognosis for these patients in observational analyses. In a recent retrospective study of hospitalized COVID-19 patients, all-cause mortality was lower among patients on ACEI/ARB therapy when compared with those not using ACEI/ARBs.[33] An observational analysis from a single-center study showed that ACEI/ARB use was not associated with severity of COVID-19 infection or worse outcomes in hospitalized patients with hypertension.[34]

Nonetheless, the effect of renin-angiotensin system inhibition on ACE2 is uncertain and the potential harm related to this mechanism is not well defined.[31,32] In addition, the use of ACEI or ARBs could be beneficial not only due to the well-known cardiovascular protection,[32] but also because of the potential respiratory system protection in patients affected by severe respiratory disease.[15,27] Considering that these high-risk patients with cardiovascular disease and COVID-19 are commonly hospitalized, the decision regarding the best approach for the management of renin-angiotensin system inhibitors is critical. In a scenario of apparent equipoise without high quality scientific evidence, the medical decisions in clinical practice have been heterogeneous. Thus, a randomized clinical trial is necessary to guide practice.

A multicenter randomized clinical trial conducted during a pandemic should follow the same steps commonly adopted in pivotal phase III trials. However, the critical and urgent nature of a pandemic encourages opportunities to create more efficient research processes, which can be adopted for use in clinical research conducted during non-pandemic times. In a new and threatening situation like the COVID-19 pandemic there is no specific evidence to guide medical therapy, yet there is an urgent need to quickly answer the clinical questions that arise in order to guide treatment of the hundreds of thousands of people infected with a potentially lethal disease. Collaborative pragmatic studies are one of the best solutions in this scenario.[5] BRACE CORONA took less than 3 weeks from protocol development to first patient randomized, including national ethics board review and approval, which is unprecedented in Brazil (Figure 4). The COVID-19 registry is already collecting the key clinical variables and outcomes that will be used for the randomized trial. Adding randomization to this structure allows for an efficient process, which can provide the scientific community with a streamlined approach to answer a relevant clinical question with less bureaucracy and at lower cost. In addition, clinicians on the frontline, who are already very interested in answering this medical question, will be highly engaged with the trial.

Source documents from potential events will be adjudicated by a clinical events classification committee. Since many different complications could occur due to the interaction between COVID-19, baseline cardiovascular condition, and therapies used by these patients, the primary study outcome chosen for BRACE CORONA (DAOH at 30 days) was also very pragmatic and encompasses the potential effect

of any relevant medical complication. Therefore, regardless of the type of in-hospital complication, it will be captured in the study and DAOH will ultimately represent a meaningful outcome of the net benefit from the patient's perspective. This efficient model of a registry-based randomized trial, which is the first of its kind in Brazil, has already been applied successfully in other countries[35,36] and represents a unique opportunity during the global crisis of COVID-19 that could serve as an important legacy to the medical community.

Conclusion

BRACE CORONA is a multicenter randomized trial in patients hospitalized with COVID-19 on renin-angiotensin system blockers that aims to determine whether discontinuation compared with maintenance of these drugs increases days alive and out of the hospital. The results of this study will help guide medical decision making regarding the best management of a high-risk population of patients infected with SARS-CoV-2. Most of all, BRACE CORONA reinforces the importance of pragmatic randomized clinical trials, which are effective models to provide rapid answers to inform clinical practice, especially in situations that require appropriate, rapid, and high-quality evidence to guide medical practice.

Conflict of interests

RDL: Research support from Bristol-Myers Squibb, GlaxoSmithKline, Medtronic, Pfizer; Consulting fees from Bayer, Boehringer Ingelheim, Bristol-Myers Squibb, Daiichi-Sankyo, GlaxoSmithKline, Medtronic, Merck, Pfizer, Portola.

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AF: Consulting fees Pfizer, Bayer, Daiichi-Sankyo, Boehringer, Servier.

GASA: Consulting fees from Pfizer and Servier.

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DCA: Research support from Boehringer Ingelheim. Consulting fees Pfizer, Bayer, Daiichi-Sankyo, Boehringer, Servier.

LM: No Conflict of interest.

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Figure Legends

Figure 1. A) Renin Angiotensin System and COVID-19: The spike proteins covering the coronavirus bind to ACE2 receptors primarily on type II alveolar cells, allowing the vírus to inject its RNA. The host cell is destroyed in this process. After infection, type II cells release inflammatory signals to recruit immune cells. When the immune system attacks the area of infection it also kills healthy alveolar cells. This may result in alveolar collapse due to loss of surfactant from type lI cells and acute lung injury.

In the renin-angiotensin-aldosterone system (RAAS), angiotensin I (Ang I) is converted to angiotensin II (Ang II) by ACE. Ang II mediates vasoconstrictive, pro-inflammatory, pro-oxidative and pro-thrombotic effects (possibly by increasing levels of PAI-1) through agonism of the Ang II type 1 receptor (AT1R). ACE2 converts Ang II to angiotensin (1-7), which finally binds to Mas receptor (MasR) and mediates many beneficial actions, including vasodilation and anti-inflammatory, anti-oxidant and anti-apoptotic effects. Thus, ACE2/Ang (1-7)/MasR axis has opposite actions to ACE/Ang II/AT1R axis.

ACE2 limits the adverse vasoconstrictor and profibrotic effects of Ang II through its degradation and by counteracting its actions through the formation of Ang (1-7). SARS-CoV-2 binding to ACE2 may attenuate residual ACE2 activity as a consequence of increased internalization and shedding of ACE2 from the cell surface further tipping the ACE/ACE2 balance to a predominant ACE/Ang II/AT1 axis signaling, in which Ang II may then foster pulmonary vasoconstriction and inflammatory and oxidative organ damage, ultimately progressing towards acute lung injury .

B) Effects of RAAS inhibition in COVID-19: There are different postulated mechanisms by which inhibition of the RAAS with an ACEI or ARB might be dangerous or protective in COVID-19.

Hypothesis 1 — RAAS inhibition is harmful in COVID-19 (left)

ACEI and ARBs could theoretically increase the risk of SARS- CoV-2 infection and more severe COVID-19 owing to the role of ACE2 as the viral binding site. Although ACEIs and ARBs do not directly affect ACE2 activity, this premise is based in part on the findings in some studies that ACEIs and ARBs may increase ACE2 levels and thus enhance viral entry.

Hypothesis 2 — RAAS inhibition is protective in COVID-19 (right)

ACEIs and ARBs may mitigate COVID-19 by attenuating Ang II-mediated acute lung impairment. Decreasing production of Ang II with an ACEI or blocking Ang II–AT1R actions with an ARB may reduce the levels of prothrombotic substances (such as PAI-1) and intensify the formation of Ang (1–7) by ACE2 and activation of the MasR, which attenuates inflammation and fibrosis and consequently may attenuate lung damage.

Abbreviations and Acronyms: ACE=angiotensin-converting enzyme; ACE2= angiotensin-converting enzyme-2; ACEI = ACE inhibitor; Ang (1-7)=angiotensin 1-7; Ang I=Angiotensin I; Ang II=angiotensin II; AT1R=Ang II type 1 receptor; AT2=type II alveolar cells; ARBs=angiotensin receptor blockers; COVID-19=coronavirus disease 2019; MasR=Mas receptor; PAI-1=plasminogen activator inhibitor 1; RAAS=renin-angiotensin-aldosterone system; SARS-CoV-2=severe acute respiratory syndrome coronavirus 2.

Figure 2. Design of the BRACE CORONA trial

Figure 3. Study flowchart

Figure 4. Study timelines

Table 1. Inclusion and exclusion criteria for BRACE CORONA trial

Inclusion Criteria
1. Patients aged ≥ 18 years hospitalized with a confirmed diagnosis of COVID-19 under use of angiotensin receptor blockers or angiotensin converting enzyme inhibitors; 2. The patient (or legal representative) must be able to give informed consent in accordance with ICH GCP guidelines and local legislation and/or regulations.
Exclusion Criteria
1. Hospitalization due to decompensated heart failure in the last 12 months 2. Use of more than 3 anti-hypertensive drugs 3. Use of Sacubitril/Valsartan 4. Patients under mechanical ventilation 5. Hemodynamic instability in the first 24 hours until the moment of confirmed diagnosis of COVID-19; acute renal failure; shock 6. Pregnancy

Highlights

- Renin-angiotensin system blockers are widely used in patients with cardiovascular diseases, but there are controversies about the use of these agents in patients with COVID-19.
- BRACE CORONA is a randomized trial testing continuing versus suspending angiotensin-converting enzyme inhibitors and angiotensin receptor blockers in patients with COVID-19.
- Our study will help clarify the role of angiotensin-converting enzyme inhibitors and angiotensin receptor blockers in patients with COVID-19.

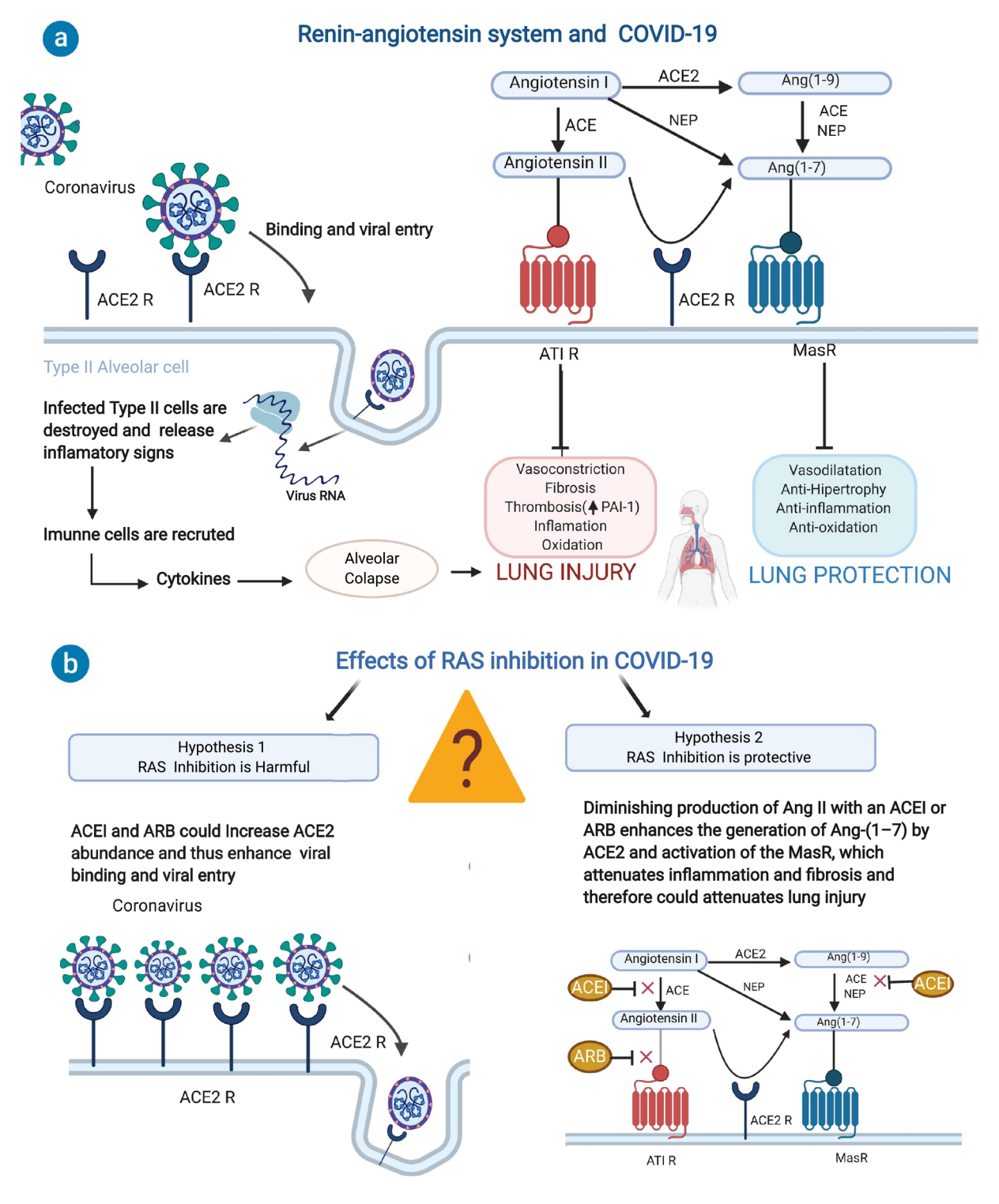

a
Renin-angiotensin system and COVID-19
Angiotensin I
ACE2
Ang(1-9)
ACE
NEP
ACE
NEP
Angiotensin II
Ang(1-7)
Coronavirus
Binding and viral entry
ACE2 R
ACE2 R
ACE2 R
Type II Alveolar cell
ATI R
MasR
Infected Type II cells are destroyed and release inflamatory signs
Virus RNA
Vasoconstriction
Fibrosis
Thrombosis(↑PAI-1)
Inflamation
Oxidation
Vasodilatation
Anti-Hipertrophy
Anti-inflammation
Anti-oxidation
Imunne cells are recruted
Cytokines
Alveolar Colapse
LUNG INJURY
LUNG PROTECTION
b
Effects of RAS inhibition in COVID-19
Hypothesis 1
RAS Inhibition is Harmful
?
Hypothesis 2
RAS Inhibition is protective
ACEI and ARB could Increase ACE2 abundance and thus enhance viral binding and viral entry
Diminishing production of Ang II with an ACEI or ARB enhances the generation of Ang-(1–7) by ACE2 and activation of the MasR, which attenuates inflammation and fibrosis and therefore could attenuates lung injury
Coronavirus
ACE2 R
ACE2 R
Angiotensin I
ACE2
Ang(1-9)
ACEI
ACE
NEP
ACE
NEP
ACEI
Angiotensin II
Ang(1-7)
ARB
ACE2 R
ATI R
MasR

Figure 1

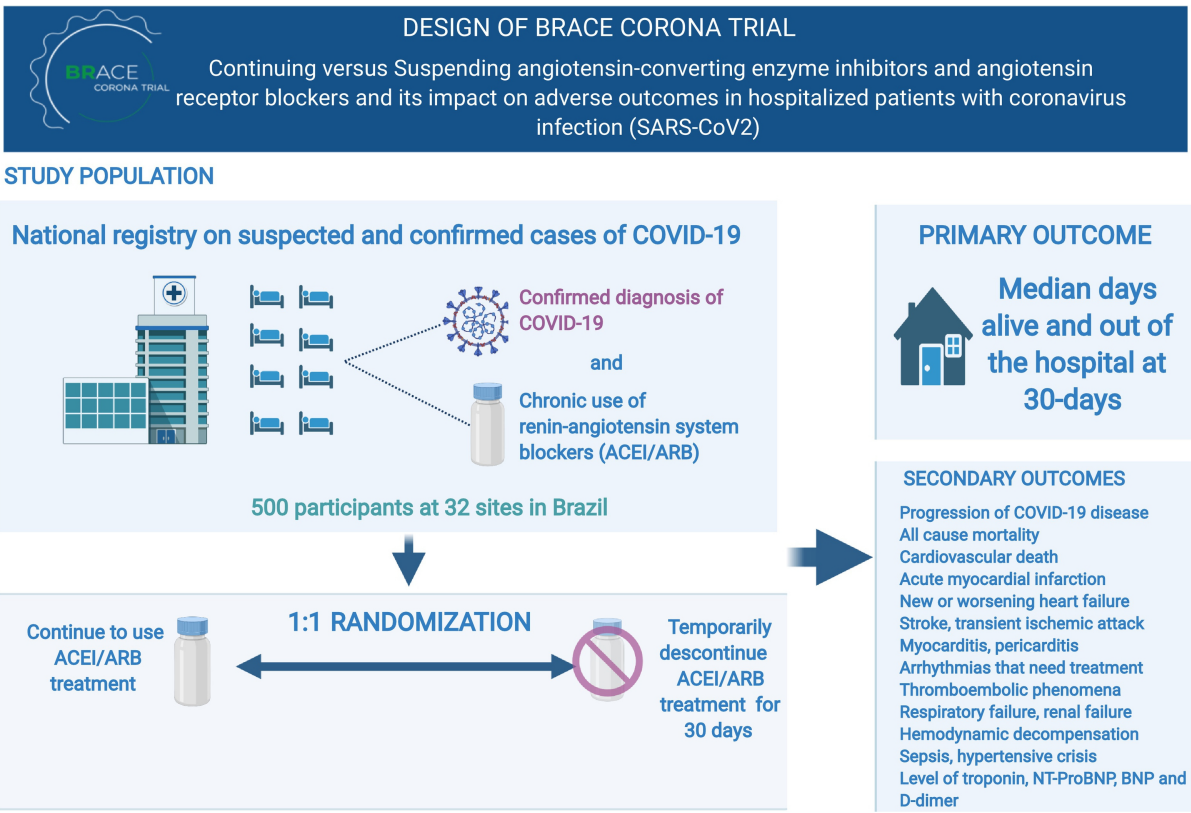
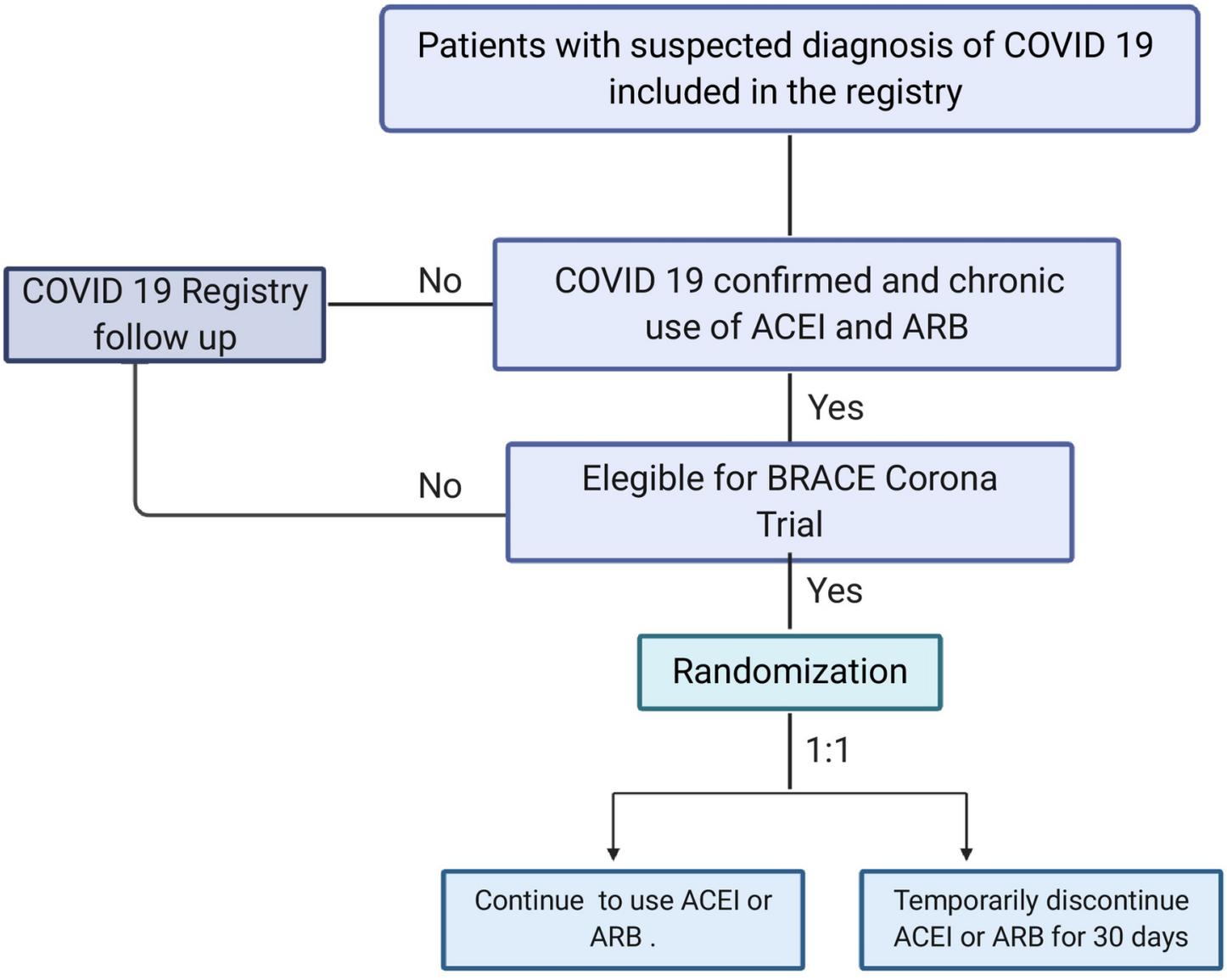

DESIGN OF BRACE CORONA TRIAL
BRACE CORONA TRIAL
Continuing versus Suspending angiotensin-converting enzyme inhibitors and angiotensin receptor blockers and its impact on adverse outcomes in hospitalized patients with coronavirus infection (SARS-CoV2)
STUDY POPULATION
National registry on suspected and confirmed cases of COVID-19
Confirmed diagnosis of COVID-19
and
Chronic use of renin-angiotensin system blockers (ACEI/ARB)
500 participants at 32 sites in Brazil
1:1 RANDOMIZATION
Continue to use ACEI/ARB treatment
Temporarily descontinue ACEI/ARB treatment for 30 days
PRIMARY OUTCOME
Median days alive and out of the hospital at 30-days
SECONDARY OUTCOMES
Progression of COVID-19 disease
All cause mortality
Cardiovascular death
Acute myocardial infarction
New or worsening heart failure
Stroke, transient ischemic attack
Myocarditis, pericarditis
Arrhythmias that need treatment
Thromboembolic phenomena
Respiratory failure, renal failure
Hemodynamic decompensation
Sepsis, hypertensive crisis
Level of troponin, NT-ProBNP, BNP and D-dimer

Figure 2



Clinical Outcomes:

Primary outcome: Median days alive and out of the hospital at 30-days

Secondary outcome: Progression of COVID-19 disease, all-cause mortality, death from vascular causes, myocardial infarction, hypertensive crisis, stroke, new or worsening heart failure, transient ischemic attack, myocarditis, pericarditis, arrhythmias, thromboembolic events, respiratory failure, hemodynamic decompensation, sepsis, renal failure, troponin, B-type natriuretic peptide, N-terminal-pro hormone and D-dimer levels.

Figure 3

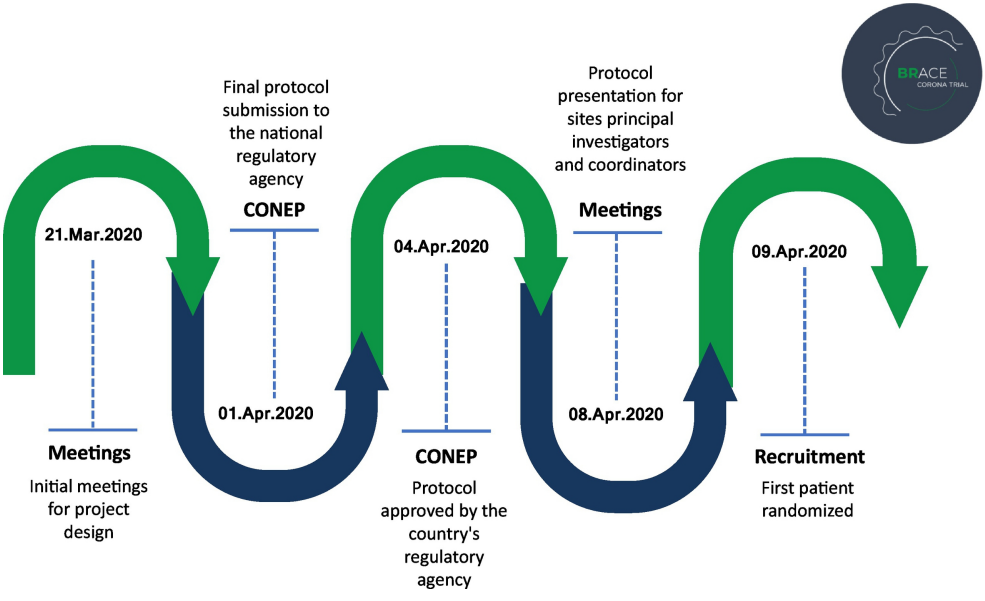

BRACE
CORONA TRIAL
21.Mar.2020
Meetings
Initial meetings for project design
Final protocol submission to the national regulatory agency
CONEP
01.Apr.2020
04.Apr.2020
CONEP
Protocol approved by the country's regulatory agency
Protocol presentation for sites principal investigators and coordinators
Meetings
08.Apr.2020
09.Apr.2020
Recruitment
First patient randomized

Figure 4