Background There are few prospective studies assessing the benefits of rhythm control of atrial fibrillation (AF) in patients with heart failure and preserved ejection fraction (HFpEF), which accounts for 50% of all heart failure patients.

Objective Conduct a meta-analysis to assess the effects of rhythm control (ablation and/or antiarrhythmic medications) vs rate control on all-cause mortality in AF patients with HFpEF.

Methods Databases were searched for studies reporting the effect of rhythm control vs rate control on mortality in patients with HFpEF (Ovid MEDLINE, EMBASE, Scopus, Web of Science, Google Scholar, and EBSCO CINAHL). The search was not restricted to time or publication status. The primary endpoint was all-cause mortality. The minimum duration of follow-up required for inclusion was 1 year.

Results The literature search identified 1210 candidate studies; 5 studies and 16,825 patients were included. The study population had 57% men with a mean age of 71 ± 2.5 years. Rhythm control for AF was associated with lower all-cause mortality (odds ratio 0.735, 95% confidence interval 0.665–0.813; P < .001) as compared to rate control.

Conclusion Rhythm control for AF in patients with HFpEF was associated with decreased all-cause mortality.

Keywords Atrial fibrillation; Rhythm control; Rate control; Mortality; Heart failure with preserved ejection fraction; Hospitalization; Outcomes

Introduction Atrial fibrillation (AF) and heart failure (HF) are common comorbid conditions. AF is present in up to two-thirds of all patients with HF, with a higher prevalence in those with heart failure with preserved ejection fraction (HFpEF). Both diseases share common risk factors, and the pathophysiology of each predisposes to development of the other in a synergistic manner. The incremental cost for AF management exceeds $20 billion in the United States and is expected to increase. Both causes result in significant morbidity and mortality, including stroke, hospitalization, and death. However, comorbid AF with HF is associated with worse outcomes than either disease in isolation.

Current practice guidelines provide limited information regarding whether patients with comorbid AF/HF should be treated with rhythm or rate control. American College of Cardiology guidelines differentiate between patients who develop AF after a diagnosis of HF and those that develop HF because of AF causing tachycardia-induced cardiomyopathy, and only recommend rhythm control in the latter, as it is a reversible cause for HF. Heart Rhythm Society guidelines recommend catheter ablation in patients who are symptomatic and have failed medical therapy. These guidelines are still influenced by the landmark AFFIRM trial, which showed no survival benefit with rhythm control using antiarrhythmic drugs (AADs) and a trend toward higher mortality with rhythm control in HF patients.

The CASTLE-AF and the EAST-AFNET4 studies demonstrated significantly improved cardiovascular outcomes when employing an early rhythm control strategy. Subsequent subgroup analysis of this study reported improved outcomes with early rhythm control in patients with HF. There are few prospective studies assessing the benefits of rhythm control in patients with HFpEF, which accounts for 50% of all HF patients. We conducted a meta-analysis to examine the effect of rhythm control on mortality in patients with AF and HFpEF.

Methods

Data search

The systematic review was conducted with a protocol in accordance with the Preferred Reporting of Items for
Systematic reviews and Meta-Analyses (PRISMA) statement. A specialized librarian-tailored search strategy was used to systematically locate relevant articles. Searches were conducted in May 2021 using the following databases: Embase, Ovid Medline, CINAHL Plus with Full Text, Cochrane Central Register of Controlled Trials, Web of Science: Science Citation Index Expanded, and Latin American and Caribbean Health Sciences Literature (LILACS). Full search strategies and results for each database are available in Supplemental Table 1. Additional relevant citations were located through Google Scholar. Citations were exported to EndNote X9 (Clarivate, Philadelphia, PA) and uploaded to Rayyan (Rayyan QCRI, Qatar) after removal of duplicates.

Study selection
Studies were screened by 2 investigators (MA and RJ) independently at the level of title and abstract. Afterwards, full-length reports were evaluated for inclusion. The prespecified inclusion criteria were studies with at least 1 year of follow-up that reported all-cause mortality in patients with HFpEF and AF treated with rhythm control or rate control. Exclusion criteria were review articles, data reporting mortality without comparison between rate or rhythm control, concomitant HF with reduced ejection fraction, or publication in languages other than English. Any discrepancy was resolved by consensus. The year of publication, numbers of participants, and numbers of events/odds ratio (OR) were tabulated for eligible studies. The primary endpoint was all-cause mortality. Since data from Kelly and colleagues constitutes more than 75% of the population, the analysis was repeated after exclusion of this study. The analysis was also repeated after excluding the study by Kong and colleagues, since this was the only study that employed AADs as the exclusive method of rhythm control.

**Figure 1** Preferred Reporting of Items for Systematic Reviews and Meta-Analyses (PRISMA) flow chart. Flow diagram depicts study selection for inclusion in the meta-analysis according to the PRISMA statement for reporting systematic reviews and meta-analyses.

**KEY FINDINGS**

- Heart failure with preserved ejection fraction (HFpEF) and atrial fibrillation (AF) are common comorbid diseases that are associated with poor outcomes.
- A rhythm control strategy for AF in HFpEF is associated with decreased mortality.
- Both catheter ablation and antiarrhythmic drugs were used for rhythm control in the analyzed studies.

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Meta-analysis was performed using Comprehensive Meta-Analysis software, version 3 (Biostat, Englewood, NJ). We used a random-effects model to examine the association between rhythm vs rate control and outcomes and presented the results as an OR with 95% confidence interval (CI). The extent of heterogeneity was determined by I² (ranging from 0% to 100%). Statistical significance was considered with a P value < .05 and all tests were 2-sided. Funnel plot of standard error by log OR was applied to qualitatively assess publication bias.

Results

Literature search and study selection
The primary literature search identified 1210 potentially eligible studies. The process of study inclusion is illustrated in detail in Figure 1. MeSH words and databases used for systematic review are presented in Supplemental Table 1. A total of 1124 studies were excluded by screening the titles and abstracts. The remaining 86 articles were screened in full text for relevance. Five studies were eligible for meta-analysis for the outcome of all-cause mortality. Abstracts published with detailed information were included for 2 reasons: (1) it is recommended by the Agency for Healthcare Research and Quality (AHRQ), the Joanna Briggs Institute Reviewer’s Manual, PRISMA for systematic review protocols (PRISMA-P)¹⁶; and (2) analysis with and without including such data resulted in similar outcomes.

Study, patient, and procedural characteristics
The study population of 16,825 patients was 57% men with a mean age of 71 ± 2.5 years and mean left ventricular ejection fraction 61% ± 7%. Table 1 summarizes the basic characteristics of the included studies.¹⁷⁻²⁰,²²,²³ All 5 of the included studies were observational studies, and 4 studies used radiofrequency catheter ablation as the main intervention in the rhythm control arm. The studies did not stratify the results based on type of AF (paroxysmal vs persistent), duration of sinus rhythm maintenance, duration of AAD usage, and ablation techniques.

Association between rhythm control and mortality in patients with HFpEF and AF
Rhythm control for AF in patients with HFpEF was associated with lower all-cause mortality as compared to rate control (Figures 2 and 3; OR 0.735, 95% CI 0.665–0.813; P < .001). There was mild heterogeneity: df = 4 (P = .594), I² = 0; test for overall effect: Z = -6.7028 (P < .001). The analysis results were similar when Kelly and colleagues¹⁹ was excluded (OR 0.515, 95% CI 0.3–0.883; P = .01). The analysis results were also similar after removing the study that used AADs as the exclusive method of rhythm control (Kong and colleagues²¹: OR 0.538, 95% CI 0.325–0.892; P = .01).

Table 1
Demographic data of the included studies

| Study            | Rhythm group type | Rate group type | Event (event/total no.) | Mean age (years) | Male (%) | Follow-up (months) | Mean EF (%) | HTN | DM | CHD | CVA | Rh | RA |
|------------------|-------------------|----------------|-------------------------|------------------|----------|-------------------|-------------|-----|----|-----|-----|----|----|
| Kong et al (2010)| AAD               | AAD            | 54/97                   | 70               | 70       | 46                | 62          | 63  | 64 | 64  | 64  | 64 | 64 |
| Machino (2016)   | AAD/CA            | AAD/CA         | 190/285                 | 70               | 70       | 48                | 62          | 64  | 64 | 64  | 64  | 64 | 64 |
| Rahman et al (2019)| AAD/CA     | AAD/CA         | 17/188                  | 67               | 75       | 28                | 67          | 67  | 67 | 67  | 67  | 67 | 67 |
| Kelly et al (2019)| AAD/CA   | AAD/CA         | 57/58                   | 81               | 83       | 12                | 81          | 83  | 83 | 83  | 83  | 83 | 83 |
| Zhang et al (2020)| AAD/CA | AAD/CA         | 15/40                   | 73               | 79       | 12                | 73          | 75  | 75 | 75  | 75  | 75 | 75 |

AAD = antiarrhythmic drugs; CA = catheter ablation; CHD = coronary heart disease; CVA = cerebrovascular accident; DM = diabetes mellitus; EF = ejection fraction; HTN = hypertension; Rh = rhythm group; RA = rate group.
The major finding of this study is that rhythm control in patients with HFpEF and AF was associated with a significant reduction in all-cause mortality. To our knowledge, this study is the first meta-analysis to report these findings. Catheter ablation was used as part of the rhythm control strategy in 4 of the 5 studies included in this meta-analysis. The results were still statistically significant with mild heterogeneity when we removed the only study that used AADs as the exclusive method of rhythm control.

Variability in the specific type of rhythm or rate control used in the individual studies may offer one explanation for the heterogeneity in outcomes. Kong and colleagues excluded patients in their analysis who underwent catheter ablation, and defined rhythm control as using class I or III antiarrhythmic medications. However, catheter ablation is a well-established rhythm control technique for treatment of symptomatic AF in patients that have failed drug therapy and is a class I recommendation for this cohort. The procedure may be associated with fewer complications than antiarrhythmic medications, which have significant side-effect profiles and have been associated with a trend for increased mortality as compared to rate control medications. This hypothesis is supported by the results of the CASTLE-AF trial, which demonstrated a mortality benefit in HF with reduced ejection fraction patients randomized to catheter ablation as compared to standard medical therapy, which included rhythm control with antiarrhythmic medications.

Atrioventricular nodal ablation with implantation of a biventricular pacemaker had a mortality benefit in the APAF-CRT mortality trial, which may indicate the benefit of maintaining a regular rhythm. Saksena performed subgroup analyses on patients with HFpEF and AF from the AFFIRM trial, finding no significant benefit for rhythm control over rate control in preventing HF progression or death. These conflicting observations are often attributed to (1) fewer effective methods for rhythm control in the past, using antiarrhythmic drugs with significant side-effect profiles; and (2)

**Discussion**

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inappropriate discontinuation of anticoagulation in rhythm-control patients in the past, leading to increased stroke and death, whereas more recent guidelines now recommend anticoagulation based on thromboembolic risk profile regardless of modality of arrhythmia management. Furthermore, older studies used symptom-triggered event monitoring, periodic electrocardiograms, or limited Holter monitoring, which has limited accuracy for AF assessment, compared to continuous mobile telemetry or cardiac implantable device monitoring.

Our findings are consistent with the known synergistic pathophysiology of AF and HFpEF. It is well known that mobile telemetry or cardiac implantable device monitoring.

Supplementary data associated with this article can be found at https://doi.org/10.1016/j.hroo.2022.06.009.

Conclusion
In our systematic review and meta-analysis, rhythm control for AF in patients with HFpEF was associated with decreased all-cause long-term mortality as compared to rate control.

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Authorship: All authors attest they meet the current ICMJE criteria for authorship.

Ethics Statement: The systematic review was conducted with a protocol in accordance with the Preferred Reporting of Items for Systematic reviews and Meta-Analyses (PRISMA) statement.

Appendix
Supplementary data
Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hroo.2022.06.009.

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