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Heart Failure

The Expert's Approach

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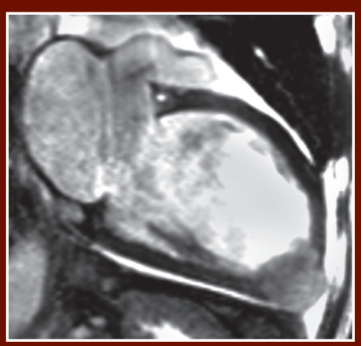

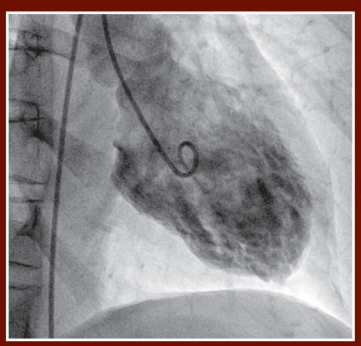



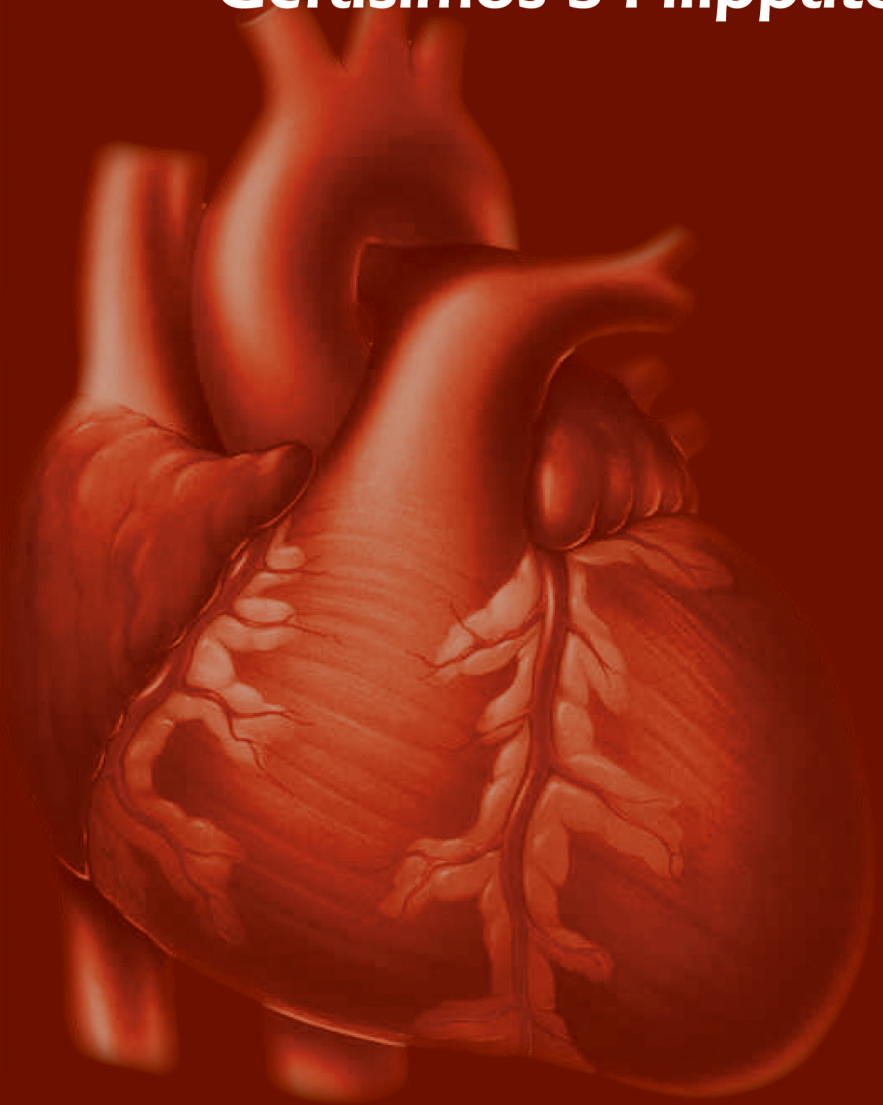

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Chapter 4

Management of Atrial Fibrillation in Patients with Heart Failure and Preserved and Low Ejection Fractions

Brian S Wasserman, Tyler W Barrett

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ABSTRACT

Atrial fibrillation (AF) is the most common sustained arrhythmia with an estimated prevalence in the developed world of 1.5–2% of the general population. AF and heart failure have a complex relationship, and patients with heart failure provide specific challenges and limitations in management. As many as 40% of patients with AF or heart failure develop the other condition and having both diseases is associated with increased mortality. International cardiology guidelines recommend that the management of patients with AF focus on three objectives: (1) rate control, (2) prevention of thromboembolism, and (3) correction of the rhythm disturbance. This chapter provides recommendations for the acute management of AF in patients with heart failure and preserved and low ejection fractions.

INTRODUCTION

Atrial fibrillation (AF) is the most common sustained arrhythmia with an estimated prevalence in the developed world of 1.5–2 fold of the general population.[1] The estimated prevalence in the United States ranges from 2.7 million to 6.1 million in 2010 and that number is expected to nearly double by 2050.[2] AF is associated with a fivefold increase in the risk of stroke, a threefold increase in the risk of developing heart failure and 1.5–2 fold increased risk of death.[3-7] The prevalence of AF increases as individuals age; 5.9% of those over 65 years of age, and 9% of individuals over 80 years are diagnosed with AF.[2,5] The lifetime risk for development of AF is estimated to be one in four for individuals 40 years of age and older.[2,6] Similar risk factors are associated with developing AF and heart failure. Among patients with new onset AF or heart failure in the Framingham Heart Study, 21% were newly diagnosed with both AF and heart failure on the same day.[8] The study also reported that 40% of patients with AF or heart failure developed the other condition and having both diseases was associated with increased mortality.[8]

Atrial fibrillation is defined as a "supraventricular tachyarrhythmia characterized by uncoordinated atrial activity with consequent deterioration of atrial mechanical function".[9] Atrial flutter is an atrial tachycardia characterized by a pattern of saw-tooth regular atrial activation on an electrocardiogram.[9] Atrial flutter may degenerate into AF and it commonly occurs together in patients with AF. Therefore, the 2008 American College of Cardiology (ACC)/American Heart Association (AHA) guidelines group the two arrhythmias together with regard to performance measures recommendations.[9] Previous landmark trials regarding treatment of AF have included patients with atrial flutter.[10,11] Given the significant association and the similar emergency department (ED) management and disposition, our recommendations for the acute management of patients with AF and heart failure will also apply to those patients with acute atrial flutter and heart failure unless specifically stated to the contrary.

The number of ED visits for complaints related to AF increased by 88% between 1993 and 2003 and now account for nearly 1% of all ED visits in the United States.[12,13] The ACC/AHA/European Society of Cardiology

(ESC) 2006 guideline for the management of patients with AF states that management involves three objectives: (1) rate control, (2) prevention of thromboembolism, and (3) correction of the rhythm disturbance.[14] Patients with heart failure provide specific challenges and limitations when managing acute AF exacerbations.

Atrial fibrillation and heart failure have a complex, bidirectional relationship. Heart failure commonly causes structural remodeling of the atria that increases susceptibility to development of AF and decreases the likelihood of the successful maintenance of sinus rhythm. Heart failure is a risk factor for stroke in patients with AF and an indication for anticoagulation. Conversely, prolonged rapid AF (or any other supraventricular arrhythmia) is known to cause a tachycardia-mediated cardiomyopathy and beget the development of heart failure. In these patients, cardiac function usually improves over time, even normalizing, with rate control.[15]

Box 1: Initial diagnostic workup for patients with atrial fibrillation

The ABC's of treating atrial fibrillation in patients with heart failure:

A: Airway—Ensure a patent and protected airway

B: Breathing—Evaluate for adequate ventilation and listen for signs of pulmonary edema or a precipitating pneumonia

C: Circulation and cardiac monitoring—Determine hemodynamic stability and decide on a rate vs rhythm control treatment strategy

D: Defibrillator/pacing pads—Apply to anterior/posterior chest early in ED evaluation for unstable patient—diuresis (in the patient with volume overload)

E: Electrocardiogram (12-lead) and evaluate risk for thromboembolism and need for anticoagulation (CHA_2DS_2-VASc)

CHA_2DS_2-VASc, congestive heart failure, Hypertension, Age ≥75 years, Diabetes mellitus, Stroke, Vascular disease, Age 65–74 years, Female Sex category

Atrial Fibrillation Classifications

Atrial fibrillation is characterized by the duration of the arrhythmia. This has implications for workup and therapy. In general, the longer the duration of AF, the lower the likelihood of a successful cardioversion from AF to sustained sinus rhythm. On the initial presentation, AF is classified as *first detected*. Paroxysmal AF is defined as two or more lifetime episodes that terminate spontaneously in less than 7 days (and usually <24 hours). *Persistent* AF episodes last longer than 7 days and may require cardioversion to terminate. *Permanent* AF refers to the treating clinician no longer attempting to restore sinus rhythm.[14] Patients with longstanding persistent and permanent AF may be difficult to differentiate without continuous rhythm monitoring. The term *lone AF* refers to patients younger than 60 years of age who have AF without clinical or echocardiographic evidence of cardiopulmonary disease, including hypertension.[14]

INITIAL ASSESSMENT OF THE PATIENT WITH ATRIAL FIBRILLATION AND HEART FAILURE IN THE EMERGENCY DEPARTMENT

The first priority in the ED management of patients with AF and heart failure is determining the stability of the patient with primary attention to airway, breathing and circulation (Box 1). Patients who are hemodynamically unstable directly related to their AF should be emergently cardioverted regardless of their anticoagulation status or duration of symptoms.

Unfortunately, making this determination is not always as clear as presented in Case Study 1 and the treating physician should follow a standard approach when treating all patients with acute AF to provide the most optimal care. While the physician is evaluating the patient's airway, breathing, and circulatory status, the nurse or paramedic should establish a large-bore (e.g., 14–16 gauge) IV access and attach the patient to the cardiac monitor. Consider administering supplemental oxygen, by nasal cannula or nonrebreather facemask, in patients with low oxygen saturations.

Airway

The physician caring for the patient should ensure that the patient's airway is patent and protected. An easy way to assess airway patency is to ask the patient to say their name. A patient who can speak their name fluently without garbled or gasping breaths has a patent airway at that time. Frequent reassessments of airway status are critical in the ED as a patient's airway status can rapidly deteriorate secondary to progression of their disease process or in response to administered medications. When a patient's airway is not protected, whether due to a primary respiratory process (e.g., critical pulmonary edema or hypercapnia) or cerebral hypoperfusion from circulatory collapse, the ED physician must secure the patient's airway preferably by intubating the patient with an appropriately sized endotracheal tube.

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Case Study 1

A 77-year-old male arrives in your ED in severe respiratory distress. His blood pressure is 70/40 mmHg and his pulse is rapid and irregular at a rate of 140–170 beats/min. He is breathing nearly 30 times per minute and his pulse oximeter reads 88% on 6 L of oxygen by nasal cannula. He speaks in two to three word sentences but has obvious jugular venous distention, audible rales in both posterior lung bases and 3+ pitting lower extremity edema. His wife reports that he has known severe heart failure (EF <15%), hypertension, diabetes but no prior AF diagnosis. He was in his usual state of health until this morning when he reported palpitations. His 12-lead electrocardiogram shows AF. How should this patient be treated?

Treatment: This patient is clearly unstable and in acute decompensated heart failure with pulmonary edema that may be precipitated or worsened by his new AF with rapid ventricular response. Patients with severely impaired heart failure may decompensate quickly when their heart rhythm decompensates secondary to losing the atrial kick contribution to their already tenuous stroke volume. This patient needs emergent cardioversion and potentially advanced airway management with either noninvasive positive pressure ventilation or endotracheal intubation and mechanical ventilation. Our practice would be to administer a short-acting sedative [e.g., etomidate 0.15 mg/kg by intravenous (IV) route] and perform emergent synchronized cardioversion with a biphasic defibrillator at 200 Joules. Following successful cardioversion, this patient will require hospitalization to treat his decompensated heart failure as well as evaluation for long-term anticoagulation given his CHA_2DS_2-VASc score of 5.

Breathing

Once the patient's airway is stabilized, attention shifts to the patient's breathing and ventilatory effort. AF should not directly impair a patient's respiratory status unless the arrhythmia and associated diminished stroke volume compromises cerebral circulation resulting in diminished respiratory drive or AF causes acute decompensated heart failure and pulmonary edema. Consider initiating ventilatory support with noninvasive positive pressure ventilation early in the ED management of patients with signs of impaired ventilation (e.g., tachypnea, mild hypoxia, and use of accessory muscles) but who are mentating and protecting their airway. The early initiation of noninvasive positive pressure ventilation may provide sufficient ventilatory assistance for the patient, while other treatments for their AF and heart failure are administered and take effect.

Circulation

The initial evaluation of a patient's circulatory stability includes palpation of pulses, capillary refill, and signs of hypoperfusion (Flowchart 1). When a patient is obtunded and distal radial or pedal pulses are not palpable, then immediately palpate femoral and carotid pulses to ensure that the patient is not in pulseless electrical activity. Measure the patient's blood pressure and make an initial determination on whether the patient appears hypovolemic (e.g., dehydration secondary to a gastrointestinal illness or over diuresis), euvolemic, or hypervolemic (i.e., in volume overload). Patients who are hypovolemic should be volume resuscitated with a rapid infusion of 500–1,000 mL of IV normal saline or lactated Ringers' solution followed by reassessment of their circulatory status. Patients with a known low EF might require smaller crystalloid volumes and a slower infusion rate. Likewise, stable patients with signs of volume overload may benefit from diuresis and consideration of early cardioversion if they are dependent on their atrial kick to maintain adequate cardiac output. Once the clinician has stabilized the patient's respiratory and hemodynamic status, then they should perform a complete history including a detailed review of current medications, recent changes and medication compliance, a head-to-toe physical examination and order diagnostic studies that might identify specific risk factors for AF (e.g., thyroid studies, urine drug screen, and electrolytes) and determine the best individualized treatment for that individual's AF.

PRIORITIES IN MANAGING ATRIAL FIBRILLATION IN THE ACUTE SETTING

There are three main goals for the management of patients with AF in the acute setting: (1) ventricular rate control, (2) prevention of thromboembolism, and (3) correction of the arrhythmia.[14] Rate control refers to the use of atrioventricular (AV) nodal blockade to control the ventricular response to the atrial activity. The foremost thromboembolic complication is a cerebral embolism. Stroke prevention includes an assessment of the patient's risk for embolic events and prescription of the most optimal anticoagulation regimen when indicated. Heart failure and left ventricular dysfunction is a major risk factor for stroke and included in both the $CHADS_2$ and CHA_2DS_2-VASc scores.[16,17] Correction of the arrhythmia, or rhythm control, refers to maintenance of sinus rhythm via pharmacological or electrical means.

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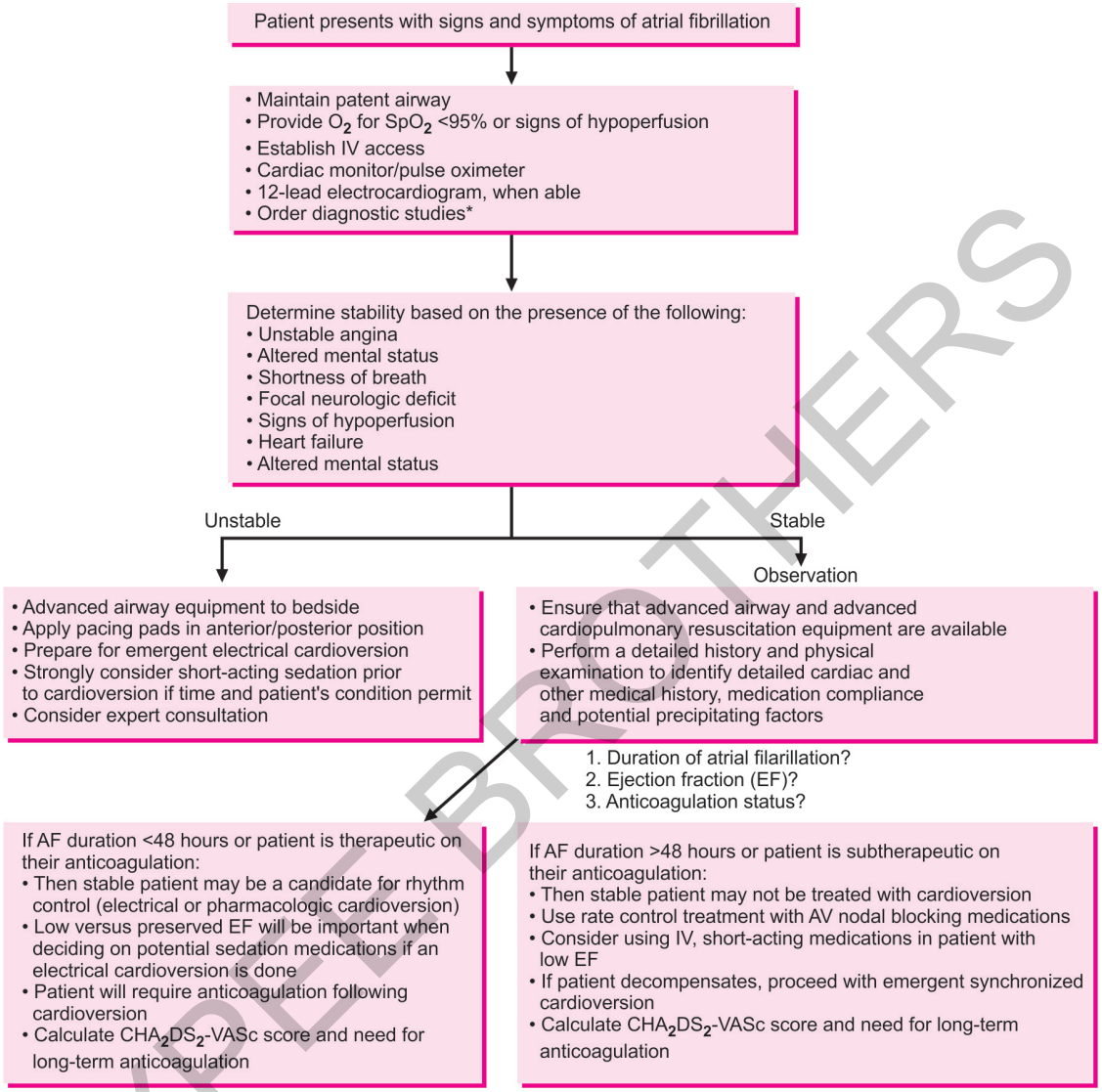

*Diagnostic Studies should include a chest radiograph, possible transthoracic or transesophageal elctrocardiogram based on clinical presentation. Laboratory studies may include the following (only to be ordered when clinically indicated): complete blood count with differential, basic metabolic panel (includes electrolytes), urinalysis, cardiac enzymes, brain natriuretic peptide, thyroid function studies and a urine or serum toxicology screen

O_2, oxygen; SpO_2, saturated oxygen; IV, intravenous; CHA_2DS_2-VASc, Congestive heart failure, Hypertension, Age ≥75 years, Diabetes mellitus, Stroke, Vascular disease, Age 65–74 years, Female Sex category; AV, atrioventricular

Flowchart 1 The acute management of patients with atrial fibrillation and heart failure in the emergency department

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RATE VERSUS RHYTHM CONTROL: WHICH TREATMENT IS BETTER?

Deciding between a rate versus rhythm control treatment strategy in the stable patient with AF and heart failure in the ED should be based on a number of important questions: (1) duration of this AF episode; (2) anticoagulation status; (3) current treatment regimen and response to prior rhythm control treatments; and (4) details of this specific AF episode.

- *Determine when this AF episode started*
  First, how long has the patient been in AF? Patients who are clearly aware of when their AF begins may be able to provide an accurate determination of the duration of their symptoms. Individuals whose duration of AF is less than 48 hours may be candidates for cardioversion in the ED with the estimated risk of stroke reported to be less than 1%.[18] Individuals whose symptoms have been ongoing for longer than 48 hours and those who are unaware of the duration

of their AF are at higher risk for stroke if cardioverted with estimates as high as 7%.[18]

- *Is the patient on anticoagulation and, if so, is it therapeutic?*
  Patients with known AF who are adequately anticoagulated [i.e., international normalized ratio (INR) between 2 and 3 if on warfarin or documented compliance with oral thrombin or factor Xa inhibitor agent] may also be safely cardioverted in the ED. Verifying compliance with the newer oral thrombin or factor Xa inhibitors is more challenging without an objective laboratory measure available in most EDs. The physician may need to decide on a case-by-case basis whether they trust the patient's report of medication compliance prior to attempting cardioversion in the stable patient. The physician should have a detailed discussion with the patient informing them of the increased risk of stroke in patients who are not adequately anticoagulated prior to the procedure. A signed written consent documenting these risks prior to the cardioversion is also important, especially in litigious nations such as the United States. Hemodynamically stable individuals who are not adequately anticoagulated should undergo a transesophageal echocardiogram to exclude an apical thrombus prior to cardioversion.
- *Is the patient already being treated with rate or rhythm control? How did the patient respond to prior cardioversion attempts?*
  Patients with AF are most often treated with either a rate control or rhythm control medication regimen with some patients taking both classes of medications. Large international multicenter trials compared outcomes with rate control and rhythm control strategies and found no significant difference in efficacy between the two options.[19,20] A personalized approach may identify patients who could benefit from a rhythm control strategy, such as those starting treatment for AF, who are symptomatic despite adequate rate-control, or who experience side effects of rate control medications. Patients whose cardiologist has chosen a rhythm control treatment and prefers maintenance of sinus rhythm should preferentially be cardioverted (electrically or pharmacologically) if there are not specific contraindications (e.g., subtherapeutic INR or not stable for sedation). Likewise, patients who have failed multiple prior cardioversion attempts may be treated with a rate control approach by their cardiologists and this would be the preferred treatment protocol in an acute AF exacerbation.
- *Are there specific events relative to this episode of AF that might impact your acute treatment?*
  Patients with paroxysmal AF might occasionally experience AF while suffering from infections such as pneumonia or gastroenteritis that causes profound volume depletion and electrolyte disturbances including hypokalemia. In patients with preserved EFs, an initial treatment with volume resuscitation with intravenous crystalloid (1–2 L of normal saline or lactated Ringers solution may be required) and repletion of electrolyte losses may result in improved ventricular rate control and spontaneous conversion back to sinus rhythm. Another patient who presents with crushing chest pain and first detected AF in the setting of an acute ST-segment elevation myocardial infarction (STEMI) is likely best served going immediately to the cardiac catheterization laboratory for coronary angiography and percutaneous coronary intervention rather than their reperfusion being delayed by an attempted cardioversion in the ED. In addition to the standard STEMI medications and discussion with your interventional cardiologist, the best initial treatment may be administering a short-acting beta-blocker intravenously to decrease ventricular rate and myocardial oxygen demand.

Case Study 2

A 66-year-old female with a history of paroxysmal AF and New York Heart Association (NYHA) class I heart failure with preserved EF presents to the ED with 12 hours of AF with ventricular rates in 110–120's. She is on warfarin and her INR is stable at 2.3. She denies any other symptoms and has been successfully cardioverted following her last AF episode 2 years ago. How would you treat this patient?

Recommended treatment: Given that this patient gives a detailed AF duration, is adequately anticoagulated with a therapeutic INR, and is normally in sinus rhythm, she is an excellent candidate for cardioversion in the ED. Physician and patient preference and the patient's prior response to cardioversion methods should determine whether electrical or pharmaceutical cardioversion is chosen. Following successful cardioversion, this patient should continue her warfarin and is a candidate for discharge home with outpatient cardiology follow-up.

WHEN RATE CONTROL TREATMENT IS BEST FOR YOUR PATIENT WITH HEART FAILURE AND ACUTE ATRIAL FIBRILLATION

Patients with acute AF often have signs and symptoms that are due to rapid ventricular rate rates including

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TABLE 1: Overview of intravenous rate control agents[14]

Drugs	*Mechanism*	*IV loading dose*	*IV maintenance*	*Side effects*
Metoprolol	β1 antagonism	2.5–5 mg (up to three doses 5 min apart)	Not applicable	Heart failure, hypotension, bradycardia, heart block, asthma
Esmolol	β1 antagonism	500 µg/kg	600 µg/kg/min	Heart failure, hypotension, bradycardia, heart block, asthma
Diltiazem	L-type Ca^{2+} channel blockade	0.25 mg/kg IV	5–15 mg/hour	Heart failure, hypotension, bradycardia, heart block
Verapamil	L-type Ca^{2+} channel blockade	0.075–0.15 mg/kg	Not applicable	Heart failure, hypotension, bradycardia, heart block
Digoxin	Na^+/K^+ exchange inhibitor, vagotonic	0.25 mg Q2h to total dose of 1.5 mg	0.125–0.375 mg/day	Bradycardia, heart block, digitalis toxicity

IV, intravenous; Q2h, every 2 hour

palpitations, dyspnea, angina/demand ischemia, and pulmonary edema. Patients with heart failure and preserved AF may be more symptomatic and cognizant of their AF onset as they are often without significant baseline cardiopulmonary complaints. Patients with severe heart failure and low EFs at baseline may report only a gradual worsening of their symptoms or an acute decompensation based on the contribution of the synchronized atrial contraction to their cardiac output. These often improve or resolve with adequate ventricular rate control through AV nodal blockade. Rapid ventricular rate frequently causes decreased stroke volume due to loss of atrial kick and inadequate diastolic filling times, especially in patients with inadequate reserve.

Rate control therapy may be delivered through multiple routes. The most commonly used forms for acute administration are IV administration, and continuous IV infusion (see Table 1 for detailed discussion on medications). Oral dosing is often given after stabilization. The patient's stability and comorbidities often dictate the choice of agent and route administered. There is some debate about the ideal heart rate target. Previously, a typical long-term goal was a ventricular rate of 60–80 beats/min; however, recent data suggests that lenient rate control with ventricular rates less than 110 beats/min may be adequate.[21] The presence of systolic dysfunction limits the therapeutic options for control of the ventricular rate. Digoxin can be used, however, it is rarely effective as monotherapy in patients with significant tachycardia, and has a slower onset than the other rate control agents. Patients with renal dysfunction also have increased risk of digoxin toxicity. In addition, recent data suggests that patients with AF on chronic digoxin therapy both with and without heart failure may have increased all-cause mortality.[22] Beta-blockers can be used in the absence of acute decompensated heart failure. However, in the acute setting these medications can negative inotropes and might incite or worsen heart failure symptoms. Small (e.g., 2.5 mg) doses of metoprolol or an esmolol infusion are preferred to assess hemodynamic tolerance. The non-dihydropyridine calcium channel blockers (CCB) (diltiazem, verapamil) are negative inotropes, and should be avoided in patients with reduced EF.

Case Study 3

A 75-year-old gentleman with a history of hypertension and mild heart failure (EF 40% on last ECG) presents to the ED with a complaint of palpitations and irregular heart beating for the past month. Today, he experienced near syncope when he arose from bed to use the bathroom. He did not lose consciousness but noticed his pulse was fast and called an ambulance. He denies chest pain, shortness of breath, or worsening lower extremity edema. His blood pressure on arrival was 145/95 mmHg; his pulse was irregular and measured at 137 beats/min. The patient takes only a daily 81 mg aspirin and is not on oral anticoagulants. He reports prior palpitations but has not been formally diagnosed with AF. His 12-lead electrocardiogram shows AF with rapid ventricular rate in 130s, evidence of LV hypertrophy but no signs of acute ischemia. How would you treat this patient? How might your treatment regimen change if the patient's EF was recently found to be only 15%?

Treatment: The initial priority in the acute management of AF is to determine stability. Although this patient's tachycardia is concerning, he appears hemodynamically stable and shows no signs of impaired perfusion to his vital organs based on the initial history and physical examination. The patient reports that his irregular heart beating has been ongoing on for at least a

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month and he is not on any oral anticoagulation. Therefore, he is at increased risk for a thromboembolic event if he were to be cardioverted and a rate control strategy is the best initial treatment option. Depending on the patient's antihypertensive regimen, acute AV nodal blockade with either an IV beta-blocker (e.g. metoprolol) or CCB (e.g. diltiazem or verapamil) would be the preferred initial treatments to slow the ventricular rate. If a single or repeat dose of the chosen rate control medications does not adequately reduce the ventricular rate, then the physician may proceed to a continuous infusion of the AV nodal blocker medication. Alternatively, adding a second agent such as digoxin or amiodarone may be necessary although amiodarone does have the potential to convert the rhythm to sinus.

If the patient had a low EF, our recommendation would still be to use a rate control treatment regimen but we would instead use short-acting AV nodal blockers agents such as esmolol that may be quickly titrated up or down depending on the patient's hemodynamics. Remember that if the patient decompensates and becomes hemodynamically unstable with impaired perfusion to vital organs, then emergent synchronized cardioversion is the recommended treatment.

Common side effects of AV nodal blocking are related to their mechanism of action. While hypotension often improves with rate control, some patients may experience lowered blood pressure due to beta-receptor or calcium channel blockade. Bradycardia and heart block can also be seen, especially when agents from different classes are combined or multiple doses are given in succession. Patients with existing conduction system disease, including the elderly, are more susceptible to these side effects.

Caution: Special consideration for Wolff-Parkinson-White or other pre-excitation syndrome must be given to patients with AF and signs of pre-excitation, including wide QRS complex, delta waves and very fast ventricular rates. AV nodal blockade can lead to preferential conduction down the accessory pathway, which can cause AF to degenerate into ventricular fibrillation and death. Drugs that should be avoided in patients with AF and pre-excitation include CCBs, adenosine, digoxin, and beta-blockers. IV procainamide and ibutilide have been used in this situation. IV amiodarone has also been given with good results despite lack of formal approval for acute AF. Cardioversion is also commonly used to restore sinus rhythm.

WHEN RHYTHM CONTROL TREATMENT IS BEST FOR YOUR PATIENT WITH HEART FAILURE AND ACUTE ATRIAL FIBRILLATION

In the acute setting, rhythm control refers to treatment intended to convert the patient from AF to sinus rhythm. This can be accomplished via electrical or pharmacologic means. Electrical cardioversion is the treatment of choice for unstable patients with AF, and is also used to restore sinus rhythm electively. The success of maintaining sinus rhythm depends on multiple patient factors. Patients who have longstanding persistent AF, significant structural heart disease, an unaddressed underlying cause and heart failure are less likely to remain in sinus rhythm after cardioversion. In addition, rhythm control is less successful in the elderly.

The major side effect of cardioversion is increased risk of thromboembolism, with stroke being the most devastating complication. This is because after conversion from AF to sinus rhythm, the atria are "stunned" for a time leading to increased thrombus formation. In addition, the change in rhythm from AF to sinus may cause already formed thrombus to dislodge and embolize. This increased stroke risk is present after spontaneous, electrical and pharmacologic cardioversion. The stroke risk is dependent on the duration of the AF episode and the patient's anticoagulation status. Patients with AF for less than 48 hours or for greater than 48 hours on adequate anticoagulation have an incidence of stroke after electrical cardioversion of less than 1%,[23] whereas patients with permanent AF not on anticoagulation have a stroke rate up to 7%.[18] Oral anticoagulation with warfarin or one of the newer thrombin or factor Xa inhibitors is recommended for at least 4 weeks after cardioversion. In unstable patients without contraindication, unfractionated heparin or low-molecular-weight heparin should be started as soon as possible. In stable patients for whom the duration of AF is unknown or greater than 48 hours, left atrial thrombus should be excluded by transesophageal echocardiogram or empiric anticoagulation given for 3–4 weeks prior to cardioversion. In stable patients for whom the duration of AF is known to be less than 48 hours, cardioversion can safely be performed without prior anticoagulation. Due to the fact that patients may be asymptomatic and thus the true duration unknown, some clinicians will still perform a transesophageal electrocardiogram. Another adverse effect of cardioversion is patient discomfort. The use of procedural sedation for the cardioversion procedure minimizes patient discomfort; however, these medications may induce hypotension, oversedation, respiratory suppression and delirium. The physician performing the sedation must carefully select the appropriate analgesic and sedative medications based on the patient's history, hemodynamics and in accordance with their institutional protocols. The risk of intracranial hemorrhage increases significantly (up to tenfold) with a preprocedure INR above 3.5.[24]

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Electrical Cardioversion

Synchronized direct-current cardioversion is one option for rhythm control treatment in the ED. Patients should be consented, when time and conditions permit, prior to the procedure and adequately sedated. Common sedation choices at our institution include etomidate and propofol but the choice of appropriate sedation medication should be determined based on a careful review of the patient's medical history, allergies and individual institutional protocols. The initial waveform energy is a subject of debate but the 2006 ACC/AHA/ESC guidelines recommend using an initial energy of 200 Joules or greater with monophasic defibrillators.[14] Our preference is to apply the defibrillator pads in an anteroposterior position and perform a synchronized cardioversion using 200 Joules with biphasic defibrillator. Patients undergoing electrical cardioversion have an increased stroke risk due to atrial stunning, and post-cardioversion oral anticoagulation is indicated. Furthermore, unless prolonged sinus rhythm is documented on a loop recorder, many clinicians will continue anticoagulation in patients on a rhythm control strategy due to the possibility of periods of asymptomatic AF.

Pearl: It is sometimes difficult to determine whether a patient truly is able to differentiate when their rhythm converts from sinus to AF or when they develop rapid ventricular rate related to their AF. Many patients may not be able to tell when they are in AF without rapid ventricular rate, and are still at increased risk for thrombus formation during these instances. If the physician has any concern that the AF duration may exceed 48 hours in a patient who is not adequately anticoagulated, err on the side of caution and perform a transesophageal electrocardiogram prior to cardioversion.

Pharmacologic Cardioversion

There are multiple antiarrhythmic drugs that can be used to restore sinus rhythm in patients with AF (Table 2). If a rhythm control strategy with pharmacologic cardioversion is to be pursued, a critical distinction is the presence of any structural heart disease. For patients without structural heart disease, flecainide, propafenone and sotalol are first-line agents; however, these are contraindicated in patients with left ventricular hypertrophy and coronary artery disease. Procainamide has shown to be about 50% effective in converting patients to sinus rhythm with a low incidence of side effects.[25]

The presence of heart failure and other comorbidities limits the available agents. The class III (potassium channel blocking) antiarrhythmics dofetilide, ibutilide and sotalol increase the QT interval and are associated with *torsades de pointes*. Sotalol is contraindicated in uncontrolled heart failure. Sotalol and dofetilide are contraindicated with changing renal function or severe renal dysfunction. Amiodarone is also a class III agent; however, it rarely causes *torsades de pointes*. Amiodarone can be given to patients with heart failure, and has the advantage of having beta-blocking properties in patients who remain in AF. The chronic toxicities of amiodarone including pulmonary, liver and thyroid dysfunction as well as the multitude of drug interactions with amiodarone make it a suboptimal chronic rate control medication. Consider switching a patient to a beta-blocker medication from amiodarone when AF persists. Class IC (sodium channel blocking) antiarrhythmic medications are contraindicated due to increased risk of death.[26]

Although electrical and pharmacologic cardioversion have not been compared head-to-head, in general it is

TABLE 2: Overview of rhythm control agents

Drugs	*Class*	*Side effects*	*Contraindications*
Procainamide	IA	Hypotension, nausea, QT prolongation, drug-induced systemic lupus erythematosus	Systemic lupus erythematosus
Flecainide	IC	Ventricular tachycardia/ventricular fibrillation	Heart failure, left ventricular hypertrophy
Propafenone	IC	Ventricular tachycardia/ventricular fibrillation	Heart failure, left ventricular hypertrophy
Amiodarone	III	QT prolongation, pulmonary, liver, thyroid toxicity, drug interactions	Baseline pulmonary, liver, thyroid dysfunction
Ibutilide	III	QT prolongation	Long QT, hypokalemia
Dofetilide	III	QT prolongation	Long QT, creatinine clearance <20 mL/min
Sotalol	III	QT prolongation, bradycardia	Long QT, uncontrolled heart failure

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thought that electrical cardioversion is more efficacious.[14] There is a role in certain patients for treatment with antiarrhythmic drugs prior to cardioversion; however, this is best done in conjunction with experts in arrhythmia management due to the risk of precipitating a potentially lethal arrhythmia.

STROKE PREVENTION

Thromboembolic phenomena, particularly stroke, are among the most feared complications of permanent AF. Stasis of blood in the left atrium, especially the left atrial appendage, may lead to thrombus formation that can then embolize distally to the cerebrovascular circulation. Stroke risk and treatment recommendations for patients with nonvalvular can be determined by the CHA_2DS_2-VASc clinical prediction score (Tables 3 and 4). Patients with valvular AF are at higher risk of stroke, and should be anticoagulated in the absence of contraindications.

Platelet inhibition is inferior to anticoagulation for stroke prevention in non-low risk patients with AF. Aspirin has uncertain benefit in very low risk (CHA_2DS_2-VASc = 0); however, it has not been shown superior to placebo. Current guidelines do not recommend aspirin for patients with a CHA_2DS_2-VASc score of 0 in the absence of another indication. Aspirin plus clopidogrel was shown to be superior to aspirin alone in high-risk patients who could not (or refused) to be treated with warfarin.[27] Stroke prevention with this combination was inferior to warfarin with similar bleeding risk, however.[28]

Warfarin has been widely studied for stroke prevention in AF. When a large meta-analysis showed that the average stroke rate per year for patients on warfarin was around 2%.[29] The mechanism of action for warfarin is inhibition of the vitamin K epoxide reductase complex 1 (VKORC1), which prevents activation of coagulation factors II, VII, IX, X. Warfarin has a high degree of inter- and intrapatient variation due to multiple drug interactions, dietary interactions and genetic variation in metabolism. Variations in VKORC1 can cause a variable response to warfarin.[30] Hepatic cytochrome P450 enzymes, primarily CYP2C9, metabolize warfarin and inhibition by drugs or genetic variation can have profound effects on elimination.[31] Increases in vitamin K intake can decrease the INR and dietary counseling is given to patients on warfarin. Numerous antibiotics can increase the effect of warfarin, due to alteration in the gut flora that activates vitamin K. For these reasons, patients on warfarin require frequent monitoring of the INR, with corresponding dose adjustment.

TABLE 3: Congestive heart failure, Hypertension, Age ≥75 years, Diabetes mellitus, Stroke, Vascular disease, Age 65–74 years, Female Sex category score[14]

Category	*Score*
CHF/left ventricular dysfunction	1
Hypertension	1
Age 65–74 years	1
Age >75 years	2
Diabetes	1
Stroke/TIA/thromboembolism	2
Vascular disease (MI, PAD, or aortic plaque)	1
Sex (female)	1

CHF, congestive heart failure; TIA, transient ischemic attack; MI, myocardial infarction; PAD, peripheral arterial disease

TABLE 4: Stroke risk/year by Congestive heart failure, Hypertension, Age ≥75 years, Diabetes mellitus, Stroke, Vascular disease, Age 65–74 years, Female Sex category score[14]

	Score (%)
1	1.3
2	2.2
3	3.2
4	4.0
5	6.7
6	9.8
7	9.6
8	6.7
9	15.2

The major side effect of all oral anticoagulants is bleeding and warfarin is among the top drugs implicated in serious adverse events and death. There are numerous clinical risk factors for bleeding. The 2012 update to the ESC guidelines recommend formal bleeding risk assessment in patients with AF for whom anticoagulation is being considered with a HAS-BLED [Hypertension, Abnormal renal/liver function, Stroke, Bleeding history or predisposition, Labile INR, Elderly (age > 65 years), Drugs/alcohol] score greater than or equal to 3.[1] Compared to the newer oral anticoagulants, warfarin does have the benefit of reversibility in the case of a bleeding event or overanticoagulation by using multifactor prothrombin complex concentrates, fresh frozen plasma and vitamin K.

Recently, new classes of oral anticoagulants have been released. Dabigatran, a direct thrombin inhibitor, as well as rivaroxaban and apixaban, both factor Xa

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inhibitors, have all been evaluated in clinical trials versus warfarin for prevention of AF, with favorable efficacy and safety profiles.[32-34] The role that these drugs will have in management of stroke prevention in AF is still evolving. They offer a potential benefit to patients who will require a defined period of anticoagulation (such as peri-cardioversion). The lack of rapid reversal agents for these newer anticoagulants is a primary concern when patients taking these medications present to the ED with uncontrolled bleeding.[35]

ADDITIONAL ACUTE MANAGEMENT CONSIDERATIONS

Investigation Additional Etiologies of First Detected Atrial Fibrillation

Although heart failure and its associated risk factors are both associated with the development of AF, the astute physician should also consider alternative underlying etiologies for first detected AF. In up to 50% of cases of acute AF, an underlying cause can be identified.[14] This is important for diagnosis as well as treatment. Often times treatment of the underlying condition will improve symptoms related to AF, whereas therapies that address only the AF are unlikely to succeed. Common underlying causes of acute AF include:

- Hyperthyroidism (including subclinical hyperthyroidism)
- Pericardial disease (pericarditis/effusion)
- Hypertensive urgency/emergency
- Ingestions: Cocaine, methamphetamine, theophylline, caffeine, alcohol
- Infection
- Pulmonary embolism.

While AF is common post-MI, it is rarely the only sign of ischemia or infarction. Evaluation for ischemia should be directed by other clinical factors and stress testing is not routinely recommended for patients with AF without other coronary artery disease risk factors.

SPECIAL CONSIDERATIONS

Patients with AF may present to the ED for complaints related to symptomatic bradycardia including AF with inappropriately slow ventricular response. The symptomatic bradycardia may result in insufficient cardiac output resulting in syncope, near syncope or decreased exercise tolerance. The bradycardia may be a consequence of worsening cardiac conduction disease. AF is associated with the development of sinus node dysfunction.[36-38] Among AF patients, a history of heart failure triples the odds of developing symptomatic bradycardia requiring permanent pacemaker implantation.[39] Symptomatic bradycardia may also be an iatrogenic complication of medications used for rate control. Medication-associated bradycardia may be due to an unexpected exaggerated response to proper adherence to dosing recommendations; however, intentional and unintentional overdose must be considered. A classic finding in digoxin overdose is AF with a slow ventricular response. Physicians should measure a digoxin level in patients taking digoxin who present with AF and slow ventricular rates to exclude digoxin toxicity.

EMERGENCY DEPARTMENT DISPOSITION AND FOLLOW-UP

The 2006 ACC/AHA/ESC guidelines are clear that a patient with a first-documented episode of AF, who achieves rate control, does not need a hospital admission.[14] Patients with underlying heart failure who present to the ED with first detected AF and acute decompensated heart failure most often require hospitalization in part to monitor their response to new rate or rhythm control medications. Discharge home from the ED with outpatient cardiology follow-up is appropriate for individuals without acute decompensated heart failure and who achieve ventricular rate control or convert to normal sinus rhythm. Patients who are discharged home from the ED must have their stroke risk assessed. The 2012 focused update of the ESC guidelines for the management of AF recommends using the CHA_2DS_2-VASc score for determining a patient's risk for stroke and thromboembolism and deciding on appropriate anticoagulation treatment.[1] Patients with AF who have CHA_2DS_2-VASc score greater than or equal to 1 should be started on either warfarin or one of the new, approved oral thrombin or factor Xa inhibitors.[1] Patients with underlying heart failure and AF, whether a new or established diagnosis, benefit from being followed closely as outpatients by both an arrhythmia specialist and a cardiologist expert in heart failure management.

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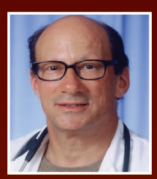

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