Chapter 10
Cardioversion and Acute Atrial Fibrillation Management

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Introduction

There are more than six million people with known atrial fibrillation (AF) in the United States, and approximately 1.6 million new cases occur annually [1, 2]. Many such patients present to the emergency department (ED) and require acute care for the management of symptoms or an unfavorable hemodynamic profile. Traditionally patients with new-onset AF who present to the ED have been managed with a rate control strategy and admitted. Attempts to cardiovert appropriately selected patients to sinus rhythm is a patient-centered approach that has been shown to be a safe and cost-effective strategy that can negate the need for hospital admission for many lower-risk patients [3–6]. The decision to pursue an early rhythm control strategy depends on a variety of factors, including patient stability, age, precipitants, coinciding heart failure, duration of the AF episode, and more. However, there is tremendous variation across providers, hospital systems, and even regions with regard to how new-onset AF is managed in acute setting. US physicians infrequently attempt early cardioversion (26 % of the time) compared to higher rates as observed in the United Kingdom and Canada of 50 % and 66 %, respectively [7]. With an increasing focus on patient-centered care, crowded hospital wards, and enhanced systems to obtain prompt cardiology follow-up, many US hospitals are developing programs to cardiovert and discharge from the ED an increasing proportion of patients.

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AF presents in a variety of ways in the acute setting. Patients may be symptomatic or asymptomatic, and in a minority of cases, the AF may result in hemodynamic instability. Generally, patients with hemodynamic instability from AF have other cardiovascular diseases (e.g., aortic stenosis or coronary artery disease). AF rarely is sufficient in and of itself to cause hypotension or shock. Stable patients with AF, where the exact onset is unknown, or patients with AF whose onset is greater than 48 h prior to the arrival and not on therapeutic anticoagulation for >3 weeks, are not candidates for elective cardioversion in the ED or observation unit (OU) and require further treatment and assessment prior to any attempt at rhythm control. The general rationale herein is that a transesophageal echocardiogram is frequently needed for such patients to rule out a left atrial thrombus.

The purpose of the present review is to outline indications and techniques for cardioversion of new-onset AF – both pharmacologic cardioversion (PC) and electrical cardioversion (EC) – in the first 24–48 h after a patient arrives to the hospital/ED. Of note, the decision to manage patients with persistent or permanent AF with a focus on rate versus rhythm control has been studied in detail [8–10] and will not be discussed in this review. One of the central tenets of cardioversion is that symptomatic patients benefit from cardioversion whereas asymptomatic patients may not benefit.

The Unstable Patient with AF

A minority of patients will present with AF and have symptoms and signs of instability such as chest pain, persistent hypotension, mental status changes, or heart failure. Typically these patients will demonstrate AF with a rapid ventricular response and have heart rates greater than 150 beats per minute [11]. When these signs and symptoms are felt to be due to AF, advanced cardiovascular life support (ACLS) guidelines recommend immediate synchronized EC (see Fig. 10.1).

Approach to Emergency Electrical Cardioversion

The goal of EC in the unstable patient is to convert the destabilizing AF rhythm to sinus rhythm as safely and quickly as possible. Despite the urgency of the situation, there are several management considerations that need to be addressed such as airway support, pain control, procedural sedation, energy selection, optimal defibrillator pad placement, management of other medical conditions, and anticoagulation to mitigate stroke risk. At minimum the patient should be placed on a cardiac monitor, given supplemental oxygen, and have an IV placed from which point-of-care labs (blood and chemistry counts) may be obtained. Electrolyte abnormalities should be addressed as appropriate, and the EKG should be reviewed for abnormal findings (e.g., ischemia, hyperkalemia). In addition, the unstable patient with unknown onset

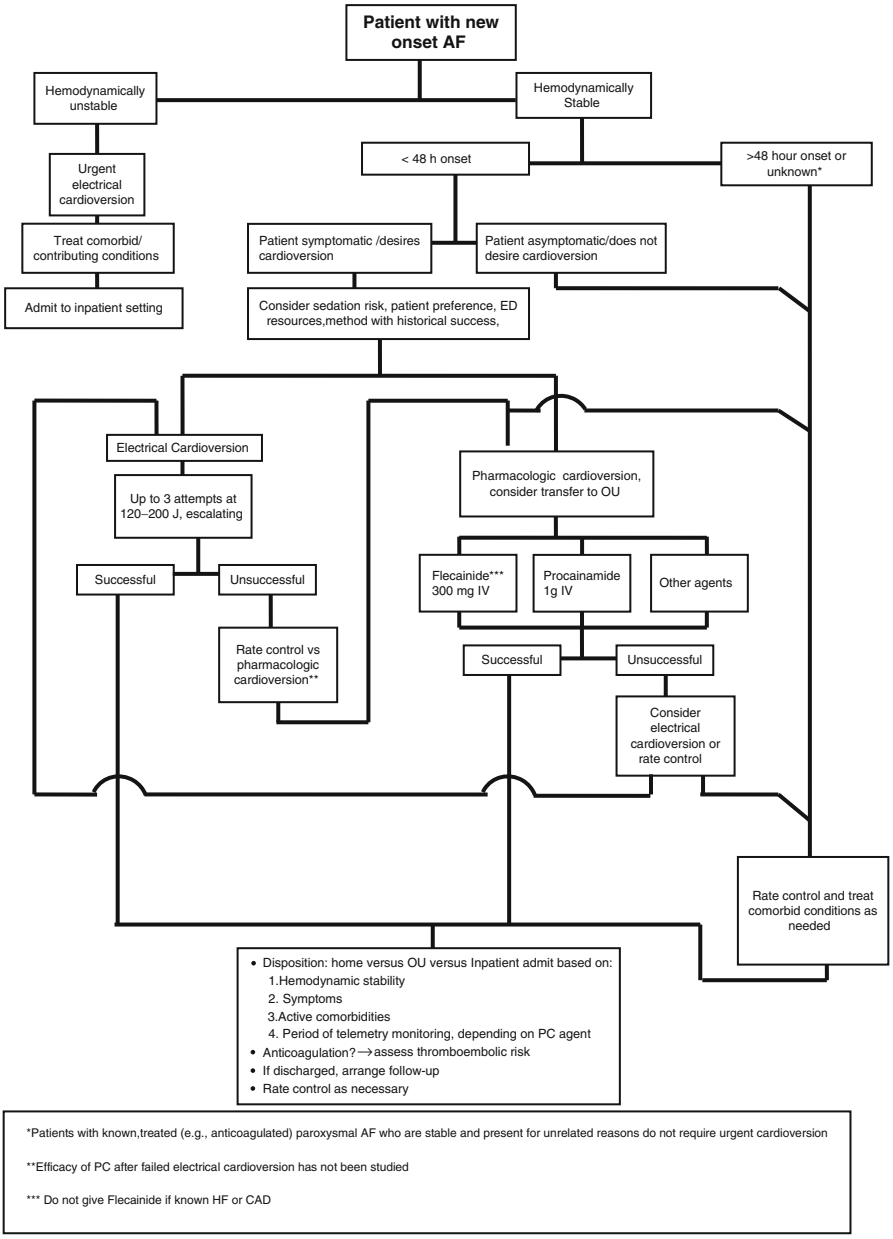

Fig. 10.1 Flow Chart

of AF, who is not already on anticoagulation and does not have a contraindication to anticoagulation, should be anticoagulated with an appropriate agent (see Chap. 20) before electrical cardioversion, if at all possible, or immediately after regardless of stroke risk (e.g., CHA2DS2-VASc) score [12].

Procedural sedation (see Chap. 20) should be considered for the unstable patient; however, limited time and unstable vital signs may limit options. After ensuring the patient has adequate airway support, pre-procedural pain control is paramount, and a bolus of intravenous medication (e.g., fentanyl) with quick onset of analgesia, and little effect on lowering blood pressure, can be considered. Short-acting sedative agents such as midazolam or propofol may be considered cautiously due to their potential effect of lowering blood pressure. Etomidate, which has less of an effect on blood pressure, may be a viable option for sedation of these patients. However, electrical cardioversion should not be significantly delayed for sedation of these high-risk patients.

Once the patient is deemed ready for the procedure, recommendations are to begin with synchronized cardioversion at 120–200 J biphasic or 200 J monophasic. If unsuccessful, one can repeat the cardioversion with increased energy, although there are no specific recommendations on escalating doses. It is also important to note that at equivalent energies, biphasic machines have a higher success rate than monophasic machines and with less thermal injury [13, 14].

There have been no randomized controlled trials to date evaluating ideal defibrillator pad position for patients needing electrical cardioversion specifically for recent-onset AF. Most studies have employed a strategy of anterior-posterior (A-P) placement or right parasternal and left midaxillary position [referred to as anterior-lateral or (A-L)]. A recent systemic review of 13 AF studies found overall no statistical difference in cardioversion rate between these two approaches. Subgroup analysis of only biphasic shocks found a trend toward superiority of A-L placement [15]. Among the included studies, A-P placement varied from right infraclavicular and left infrascapular to left infraclavicular and left infrascapular. Other variants are the right upper chest sternal body and left third intercostal space at the angle of the left scapula [16]. Cardioversion has been shown to be safe for patients with implanted pacemakers/defibrillators although recommendations include biphasic current and A-P placement with pads at least 8 cm from the device [17]. If time allows, any moisture may be wiped off the skin and excessive chest hair removed as is recommended per ACLS defibrillation guidelines [11]. Another consideration for patients with defibrillators is the use of internal cardioversion, a lower energy (typically 20 J) and less painful option in lieu of external cardioversion.

Management After EC, a Focus on Anticoagulation

After successful cardioversion, there are several other management considerations. If not done before cardioversion, stroke risk needs to be assessed based on the duration of the acute AF episode (greater than or less than 48 h), current comorbidities,

contraindications to anticoagulation, and thromboembolic risk as defined by CHA2DS2-VASC stroke risk score. For patients deemed high risk (typically 2 or more points), intravenous or subcutaneous anticoagulation should be administered prior to cardioversion, or as soon as possible thereafter. Transition to an oral agent (warfarin or target-specific anticoagulant) should be made and continued for at least 4 weeks for patients with a CHA2DS2-VASc risk score ≥2. Previously unstable patients with a CHA2DS2-VASC score of 0 or 1 that had AF for less than 48 h (if this can be accurately determined) do not require further anticoagulation treatment. Aspirin may also be considered for score of 1 [12]. Keep in mind, however, that irrespective of CHA2DS2-VASc score, if AF is of greater than 48 h duration, anticoagulation should be prescribed for 4 weeks post-cardioversion (see Chap. 20).

The disposition for previously unstable patients with AF who have undergone cardioversion will generally be admission for further diagnosis and treatment including that required for any concomitant acute medical conditions. Any exception to this approach, such as admitting these patients to observation following cardioversion, would necessitate close coordination and consultation with Cardiology for management in the OU.

The Stable Patient with AF

The vast majority of patients who present with acute AF will be hemodynamically stable and do not require emergent cardioversion. Initially the focus for these patients will be on control of heart rate if they are presenting with AF and tachycardia. The subsequent management approach to these patients is guided by several key factors such as whether the time of onset of this episode of AF can be accurately determined, how symptomatic the patient is, what medications they are taking, what comorbidities are present, and patient/caretaker treatment preferences regarding early rhythm control. Patients with persistent AF will require coordinated long-term outpatient treatment, and acute management for these patients will focus on rate control and stroke prevention as needed.

In appropriately selected patients with new-onset AF of less than 48 h duration, an approach focused on early rhythm control has the potential to improve patient satisfaction and may decrease short-term healthcare costs [18, 19]. Often younger, healthier patients may prefer to be immediately converted back to normal sinus rhythm (NSR) for convenience or if the AF is producing symptoms such fatigue, dyspnea with exertion, or palpitations. Early attempts at cardioversion may also be more successful when compared to strategies that delay this procedure for days or weeks, possibly due to atrial remodeling, a process that encompasses structural and electrical changes that promote maintenance of AF [20, 21].

Previous Literature

Several studies have examined the safety and efficacy of early rhythm control in patients with new-onset AF of less than 48 h in duration [3, 5, 22]. The 48-h time period identifies patients who are at very low risk of left atrial thrombus formation and therefore do not require evaluation with echocardiography and treatment with anticoagulation prior to cardioversion. One caveat pertains to patients with AF less than 48 h that are at a high stroke risk (e.g., CHA2DS2-VASC = 2 or greater). It is advised that these patients receive heparin, factor Xa, or a direct thrombin inhibitor "as soon as possible before or immediately after cardioversion, followed by long-term anticoagulation" [12].

Considerations Before Cardioversion

Unlike the unstable patient, there is much more time to prepare for the cardioversion of patients with new-onset AF who are hemodynamically stable. This time allows for more detailed history, exam, and consideration and treatment of precipitating events such as electrolyte abnormalities, anemia, hypothermia, acute decompensated heart failure, pericarditis, and others. When the choice is made to move forward with cardioversion in the ED/OU, the first attempt can be done either pharmacologically with an antiarrhythmic agent or with electrical cardioversion as previously discussed. Some have advocated using antiarrhythmics before cardioversion as a majority will convert to sinus rhythm, and this does not require the resources of procedural sedation for electrical cardioversion [3, 23].

Method of Cardioversion

Pharmacologic Cardioversion

The major agents for PC with Level 1A evidence include flecainide, ibutilide, propafenone, and dofetilide [12]. (Table 10.1) Procainamide, although not in the current AHA recommendations, is present in the 2010 Canadian guidelines [38] and has been used with success in ED-based studies of elective cardioversion [3, 23]. Medication selection is guided by practitioner preference and familiarity, potential contraindications (e.g., history of prior myocardial infarction, heart failure), and route of administration (oral vs. intravenous). If a patient presents in AF who is on a certain class of antiarrhythmic at home, it may be worthwhile to attempt pharmacologic cardioversion with a medication from a dissimilar class to take advantage of a different mechanism of action, or to consult a Cardiac Electrophysiologist for advice.

Table 10.1 Drug dosing for pharmacologic cardioversion of AF

Agent	Dosage and route	Considerations	Contraindications	Refs
Flecainide	200–300 mg PO × 1	Hypotension, ventricular arrhythmias	CAD, structural heart disease including CHF	[24–27]
Procainamide	1 g IV over 60 min	Hypotension, QT prolongation, arrhythmias	Electrolyte abnormalities, long QT, others	[3, 23, 28]
Dofetilide	500 mg PO × 1 (CrCl >60), 250 mg PO × 1 (60 < CrCl < 40), 125 mg Pox 1 (40 < CrCl < 20)	Renal dosing, QT prolongation, torsades de pointes	CrCl < 20	[26, 29, 30]
Ibutilide	1 mg IV over 10 min, may repeat × 1 (use 0.01 mg/kg if <50 kg)	QT prolongation, torsades de pointes, hypotension	Electrolyte abnormalities, long QT, others	[31–34]
Propafenone	450–600 mg PO × 1	Hypotension, ventricular arrhythmias	CAD, structural heart disease including CHF	[16, 24–27, 35]
Amiodarone	150 mg IV over 10 min, followed 1 mg/min for 6 h, then 0.5 mg/min for 18 h	Hypotension, bradycardia, QT prolongation, increased INR, phlebitis	Electrolyte abnormalities, thyrotoxicosis, long QT, others	[26, 36, 37]

Of note, rapid AF in the context of an antegradely conducting accessory pathway (e.g., Wolff-Parkinson-White syndrome) is a circumstance where ibutilide and procainamide have shown particular efficacy, while nodal blocking agents should generally be avoided [31]. "FBI" is a term often used to describe the characteristic appearance of AF in the presence of a manifest accessory pathway (fast, broad, and irregular). Should a patient present with these electrocardiographic features, procainamide and ibutilide are the preferred agents [31].

Flecainide and Propafenone

A placebo-controlled trial of patients with AF for 7 days or less found no statistical difference in conversion rates for 300 mg flecainide versus 600 mg propafenone at 3 h (59 % vs. 51 %) and 8 h (78 % vs. 72 %), respectively [24]. An additional study found that both medications were efficacious in the out-of-hospital setting for recent-onset (<48 h) arrhythmias in patients who responded to a loading dose of either medicine in the ED or inpatient setting [35]. Regarding propafenone's intravenous (IV) formulation, a review of trials comparing this to the oral route found the

parenteral option superior within the first hour of administration but no difference in conversion rates at 3 and 8 h [25]. Flecainide and propafenone are both Class IC agents and are contraindicated in patients with left ventricular dysfunction, sick sinus syndrome, congestive heart failure, or a QRS duration >110 msec [26].

Ibutilide

In early studies, ibutilide, a Class III antiarrhythmic, demonstrated a 30–50 % conversion rate of acute-onset AF, usually 60–90 min after IV infusion [32]. If unsuccessful, a repeat infusion can be attempted. Magnesium and potassium deficits must be repleted prior to infusion for optimal conversion success and to minimize QTc prolongation that could result in ventricular tachyarrhythmias [39]. Close cardiac monitoring is important as ibutilide carries a 2–3 % risk of inducing torsades de pointes, and this usually occurs during or shortly after the infusion [32]. Additionally, structural heart disease does not appear to confer increased risk or limit cardioversion success, nor does pretreatment with a patient's home medications.

Dofetilide

Dofetilide is a Vaughan-Williams Class III antiarrhythmic drug that has never specifically been studied for cardioversion of new-onset AF in the ED. Nevertheless, dofetilide is listed in the 2014 American Heart Association AF guidelines for pharmacologic cardioversion and has been shown to be safe in patients with advanced heart failure [12, 26]. A double-blind study found dofetilide converted approximately 24 % of patients with chronic AF (defined as >7 day duration) at the highest dose of 500 mg in 24 h [29]. Dofetilide is contraindicated in patients with a QTc >440 due to risk of torsades de pointes (QTc >500 if the patient has a ventricular conduction delay). Of note, dofetilide requires renal adjustment and QTc monitoring post-conversion [12]. Given the potential prolonged time to conversion to sinus rhythm, and the subsequent need for QTc monitoring, an OU or inpatient admission is likely to be necessary when using dofetilide. Generally, dofetilide administration is restricted to approved providers who have completed an online safety course.

Vernakalant

A relatively atrial-selective drug with both Class I and III properties, vernakalant is currently used in Europe, Canada, and Australia for pharmacologic cardioversion of AF. In a recent clinical trial, it showed a 58 % conversion rate of AF to sinus rhythm at 90 min after infusion for arrhythmias lasting between 3 and 48 h. The large majority (98 %) of patients remained in sinus rhythm at 24 h, although this included individuals with initial symptoms up to 45 days in duration [40]. Vernakalant is not yet available in the United States.

Procainamide

A type 1A antiarrhythmic, procainamide was used as the antiarrhythmic of choice in the Ottawa Aggressive Protocol for pharmacologic cardioversion of patients presenting with AF onset less than 48 h due to its relatively rapid effect and reasonable safety profile. In the Ottawa study, procainamide IV administration resulted in 58 % of patients converting to sinus rhythm. In addition there were no significant complications such as death or stroke [3, 23]. Minor complications were primarily limited to transient hypotension and treatable arrhythmias, mostly asymptomatic bradycardias. As part of the protocol, patients who did not convert with pharmacologic cardioversion were then given the option for electrical cardioversion, with a resultant 92 % success rate [3].

Amiodarone

Amiodarone's ability to convert recent-onset AF is often delayed relative to other pharmacologic cardioversion options, as it usually requires a bolus followed by 24 h of infusion. A meta-analysis including 1174 patients showed that amiodarone converted 82 % of patients at 24 h versus placebo at 56 % [36]. This medication may be preferred in the context of left ventricular dysfunction and acute ischemia as well as when blood pressure is lower than the patient's baseline [26].

Pharmacologic Cardioversion Summary

In summary, there are a number of antiarrhythmics that can be used in attempted pharmacologic cardioversion of new-onset AF to normal sinus rhythm. The choice of what agent to use will be guided by patient comorbidities such as heart failure, coronary disease, and renal insufficiency; practitioner preference; as well as ED and pharmacy resources. Attempting pharmacologic cardioversion before electrical cardioversion has a reasonably high chance of success and uses less clinical resources. In addition, pharmacologic cardioversion can be used in conjunction with the OU as a place to monitor the patients over time for conversion to sinus rhythm or for the need for subsequent EC (Fig. 10.1).

"Antiarrhythmic" Effect of Rate-Controlling Agents

Anecdotally, AV nodal blocking drugs (e.g., beta-blockers and calcium channel blockers) have been correlated with a return to normal sinus rhythm in the ED. This is often in the context of controlling a rapid ventricular response. A 2008 study found that when randomizing patients with AF of less than 48 h duration to ED observation versus admission, 32 % of patients treated with rate control in the OU converted to sinus rhythm within 6 h without having the need for electrical cardioversion [41].

Electrical Cardioversion

Electrical cardioversion may be used for those patients who fail pharmacologic cardioversion as well as for those patients/providers that prefer electrical cardioversion as an initial therapy. Not infrequently, patients who have a history of episodes of AF that responded to electrical cardioversion may request that it be attempted first, in lieu of waiting the hours sometimes necessary for pharmacologic cardioversion to work. The current literature supports a higher success rate for electrical cardioversion compared to pharmacologic cardioversion. A recent prospective randomized control study found that electrical cardioversion was superior to IV propafenone for cardioversion (89 % vs. 74 %) with less time in the ED (180 min vs. 420 min) [16]. Regarding safety after electrical cardioversion, studies have demonstrated an excellent safety record with few complications [16, 18].

As mentioned previously, various energy intensities for electrical cardioversion of AF are used. The 2015 AHA/ACC/HRS guidelines do not provide specific recommendations, although most studies start at 100-200 J biphasic with increased energy for any needed subsequent shocks up to 200 J. Adhesive defibrillator pad placement is generally the same as for unstable patients described above. There is variability among clinicians regarding the number of unsuccessful shock attempts before pursuing a rate control strategy (if warranted), although most studies have employed up to three shocks in the hemodynamically stable patient with AF [5, 16].

Sedation

In patients with new-onset AF who are hemodynamically stable, there are various sedation options worth considering for EC. Common drugs for pain or sedation include morphine, fentanyl, etomidate, propofol, midazolam, ketamine, and others (see Chap. 20). Practitioners should use what they are most comfortable with, taking into account the specific patient comorbidities and hemodynamics (e.g., relative hypotension with propofol). To date, no studies have demonstrated that one sedation scheme is superior to another with regard to cardioversion success rate, and there is significant variability of agents used in various countries [7]. The safety and efficacy of the sedation portion of electrical cardioversion rely on detailed preparation for the procedure, appropriate agent selection and usage, as well as careful monitoring of the patient throughout the periprocedural period.

Considerations/Contraindications for Cardioversion of Stable AF

The key consideration when deciding whether or not to cardiovert a patient with AF who is not hemodynamically unstable is whether or not the patient is symptomatic. Asymptomatic patients can be managed safely with rate control and anticoagulation as appropriate based on stroke and bleeding risk. Cardioversion of the stable patient

with AF should not be attempted in instances where a precipitant (thyrotoxicosis, pericarditis, valve disease, hypovolemia, sepsis, etc.) has been identified but not yet treated. Multiple other factors should be considered when deciding between electrical and pharmacologic cardioversion. Electrical cardioversion has the advantage of being immediate but the risks from the use of sedation may make it less desirable in a busy ED setting. Other factors to consider include the fact that older, more frail patients, those with relative hypotension, patients who have recently eaten, and those with difficult airways' may make procedural sedation for cardioversion higher risk. Additionally, procedural sedations for electrical cardioversion can be relatively resource intensive in the acute setting, potentially requiring significant time for the physician, nursing, and respiratory staff, as well as additional equipment resources. This may limit the use of electrical cardioversion for any setting with limited resources.

Disposition

After cardioversion of a stable patient with AF, the disposition can vary from admission to the inpatient floor, transfer to the OU, or discharge to home with cardiology follow-up (see Chap. 20). Generally the goal of early cardioversion is to facilitate discharge to home and avoid a potentially costly admission. However, utilizing the OU is an appropriate strategy for these patients and has been shown to be safe and result in a shorter length of stay versus patients admitted to the hospital [41]. For patients in whom cardioversion was unsuccessful, the need for rate control and anticoagulation (based on their CHA2DS2-VASC score) should be considered, and many of these patients may still be discharged with appropriate Cardiology and primary care follow-up. A key issue is transitional care management of anticoagulation since the 2–3 weeks after cardioversion are a particularly high-risk time period for thrombus formation. Cardiology consultation can be considered for a discussion of the risks and benefits of bridging anticoagulation after cardioversion.

Conclusion

Historically, therapy for the stable patient with new-onset AF involved rate control and admission to the hospital despite the fact that most patients with AF are at low risk for near-term adverse events [42]. In the last 10–15 years, in part driven by a better understanding of AF and its prognosis, AF is increasingly being managed by ED physicians without admission by providing select, lower-risk patients the opportunity for cardioversion to restore their native rhythm safely and expediently. In rare cases, urgent electrical cardioversion is needed to regain hemodynamic stability, but the vast majority of ED cardioversions are carried out electively for symptomatic patients when onset of AF is determined to be 48 h or less. While electrical cardioversion has generally shown greater success across many studies, it is reasonable to

try pharmacologic cardioversion first in stable patients since it requires fewer resources (e.g., sedation and monitoring). Among pharmacologic cardioversion agents, flecainide and procainamide have reasonable success in a short-time period with overall favorable side effect profiles. Other antiarrhythmic agents may be selected for certain patient populations based on comorbidities and other considerations. In summary, utilizing cardioversion for stable and unstable patients with new-onset AF in the acute setting is a safe and efficacious strategy that practitioners in the ED should be prepared to provide. Physicians should familiarize themselves and their staffs with contemporary cardioversion treatment strategies in light of the increasing number of patients being diagnosed with new-onset AF and presenting for acute care.

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