A REVIEW ON CARDIAC ARRHYTHMIA AND CARDIAC ABLATION: INVASIVE TECHNIQUES AND FUTURE PERSPECTIVE

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ABSTRACT

Cardiac arrhythmia is a group of conditions in which the heartbeat is irregular, too fast, or too slow and is characterized by abnormal electrical conduction in the heart resulting in ineffective pumping. Dysfunctional nodes in the cardiac muscles lead to irregular heartbeat patterns that can potentially induce severe complications such as cardiac arrest. In western nations it mainly effects elderly population, and in India, it is a common cause of mortality and morbidity in the young. The last decade has witnessed the emergence of a number of therapeutic protocols, both invasive and non invasive, to treat this rhythm disorder. The normal rhythm of the heart -“normal sinus rhythm” can be disturbed due to failure of automaticity, such as sick sinus syndrome, or through over activity-inappropriate sinus tachycardia. Ablation is a non surgical technique, mainly used in its treatment and is of various types like radiofrequency ablation, trans catheter ablation, catheter ablation and Cryo ablation. Atrial fibrillation is the commonest arrhythmia encountered. It doubles the risk of death and increases potency of stroke 5 to 7 times compared to a person without AF. In addition, AF may cause CHF and uncomfortable symptoms related to a rapid heart rate. AF can be treated either by using non surgical or surgical methods like MAZE and Robotically assisted and Minimally Invasive Surgery.

KEYWORDS: Ablation, Sinus rhythm, Sinus tachycardia, Catheter, MAZE, Robotically Assisted and minimally Invasive Surgery etc.

INTRODUCTION

Cardiac arrhythmia, also known as cardiac dysrhythmia or irregular heartbeat, is a group of conditions in which the heartbeat is irregular, too fast, or too slow. A heart rate that is too fast above 100 beats per minute in adults is called tachycardia and a heart rate that is too slow -- below 60 beats per minute is called bradycardia.[¹] Many types of arrhythmia have no symptoms. When symptoms are present these may include palpitations or feeling a pause between heartbeats. More seriously there may be light headedness, passing out, shortness of breath, or chest pain.[²] While most types of arrhythmia are not serious, some predispose a person to complications such as stroke or heart failure.[¹, ³] Others may result in cardiac arrest.[³] There are four main types of arrhythmia: extra beats, supraventricular tachycardia’s, ventricular arrhythmias, and bradyarrhythmias. Extra beats include premature atrial contractions and premature ventricular contractions. Supraventricular tachycardia’s include atrial fibrillation, atrial flutter, and paroxysmal supraventricular tachycardia. Ventricular arrhythmias include ventricular fibrillation and ventricular tachycardia.[³, ⁴] Arrhythmias are due to problems with the electrical conduction system of the heart.[¹] Arrhythmias may occur in children; however, the normal range for the heart rate is different and depends on age.[³] A number of tests can help with diagnosis including an electrocardiogram (ECG) and Holter monitor.[⁵]

Most arrhythmias can be effectively treated.[¹] Treatments may include medications, medical procedures such as a pacemaker, and surgery. Medications for a fast heart rate may include beta blockers or agents that attempt to restore a normal heart rhythm such as procaainamide. This later group may have more significant side effects especially if taken for a long period of time. Pacemakers are often used for slow heart rates. Those with an irregular heartbeat are often treated with blood thinners to reduce the risk of complications. Those who have severe symptoms from an arrhythmia may receive urgent treatment with a jolt of electricity in the form of cardio version or defibrillation.[⁶] Arrhythmia affects millions of people.[⁷] In Europe and North America, as of 2014, atrial fibrillation affects about 2% to 3% of the population.[⁸] Atrial fibrillation and atrial
flutters resulted in 112,000 deaths in 2013, up from 29,000 in 1990. Sudden cardiac death is the cause of about half of deaths due to cardiovascular disease or about 15% of all deaths globally. About 80% of sudden cardiac death is the result of ventricular arrhythmias. Arrhythmias may occur at any age but are more common among older people.

**CLASSIFICATION**

Arrhythmia may be classified by rate (tachycardia, bradycardia), mechanism (automaticity, re-entry, triggered) or duration (isolated premature beats; couplets; runs, that is 3 or more beats; non-sustained= less than 30 seconds or sustained= over 30 seconds). It is also appropriate to classify by site of origin.

**Atrial**
- Sinus bradycardia
- Premature atrial contractions (PACs)
- Wandering atrial pacemaker
- Atrial tachycardia
- Multifocal atrial tachycardia
- Supraventricular tachycardia (SVT)
- Atrial flutter
- Atrial fibrillation (Afib)

**Junctional arrhythmias**
- AV nodal reentrant tachycardia
- Junctional rhythm
- Junctional tachycardia
- Premature junctional contraction

**Ventricular**
- Premature ventricular contractions (PVCs), sometimes called ventricular extra beats (VEBs)
- Premature ventricular beats occurring after every normal beat are termed "ventricular bigeminy"; PVCs that occur at intervals of 2 normal beats to 1 PVC are termed "PVCs in trigeminy". Three premature ventricular grouped together is termed a "run of PVCs" in general, runs lasting longer than three beats are referred to as ventricular tachycardia
- Accelerated idioventricular rhythm
- Monomorphic ventricular tachycardia
- Polymorphic ventricular tachycardia
- Ventricular fibrillation
- Torsades de pointes

**Heart blocks:** These are also known as AV blocks, because the vast majority of them arise from pathology at the atrioventricular node. They are the most common causes of bradycardia: First degree heart block, which manifests as PR prolongation. Second degree heart block.

Type 1 Second degree heart block, also known as Mobitz I or Wenckebach
Type 2 Second degree heart block, also known as Mobitz II

Third degree heart block, also known as complete heart block. First, second and third degree block also can occur at the level of the sinoatrial junction. This is referred to as sinoatrial block typically manifesting with various degrees and patterns of sinus bradycardia.

**Sudden arrhythmic death syndrome:** Sudden arrhythmic death syndrome (SADS) is a term used as part of sudden unexpected death syndrome to describe sudden death due to cardiac arrest brought on by an arrhythmia in the presence or absence of any structural heart disease on autopsy. The most common cause of sudden death in the US is coronary artery disease specifically because of poor oxygenation of the heart muscle, that is myocardial ischemia or a heart attack.

Approximately 180,000 to 250,000 people die suddenly of this cause every year in the US. SADS may occur from other causes. There are many inherited conditions and heart diseases that can affect young people which can subsequently cause sudden death without advance symptoms. Causes of SADS in young people include viral myocarditis, long QT syndrome, Brugada syndrome, Catecholaminergic polymorphic ventricular tachycardia, hypertrophic cardiomyopathy and arrhythmogenic right ventricular dysplasia.

**Signs and symptoms:** The term cardiac arrhythmia covers a very large number of very different conditions. The most common symptom of an arrhythmia is an awareness of an abnormal heartbeat, called palpitations. These may be infrequent, frequent, or continuous. Some of these arrhythmias are harmless (though distracting for patients) but some of them predispose to adverse outcomes. Some arrhythmias do not cause symptoms, and are not associated with increased mortality. However, some asymptomatic arrhythmias are associated with adverse events. Examples include a higher risk of blood clotting within the heart and a higher risk of insufficient blood being transported to the heart because of weak heartbeat. Other increased risks are of embolisation and stroke, heart failure and sudden cardiac death. If an arrhythmia results in a heartbeat that is too fast, too slow or too weak to supply the body's needs, this manifests as a lower blood pressure and may cause lightheadedness or dizziness, or syncope (fainting). Some types of arrhythmia result in cardiac arrest, or sudden death. Medical assessment of the abnormality using an electrocardiogram is one way to diagnose and assess the risk of any given arrhythmia.

**DIAGNOSTIC APPROACH**

Cardiac arrhythmias are often first detected by simple but nonspecific means: auscultation of the heartbeat with a stethoscope, or feeling for peripheral pulses. These cannot usually diagnose specific arrhythmia but can give a general indication of the heart rate and whether it is regular or irregular. Not all the electrical impulses of the heart produce audible or palpable beats; in many cardiac arrhythmias, the premature or abnormal beats do not produce an effective pumping action and are experienced...
as "skipped" beats. The simplest specific diagnostic test for assessment of heart rhythm is the electrocardiogram (abbreviated ECG or EKG). A Holter monitor is an EKG recorded over a 24-hour period, to detect arrhythmias that may happen briefly and unpredictably throughout the day.

A more advanced study of the heart's electrical activity can be performed to assess the source of the aberrant heart beats. This can be accomplished in an electrophysiology study, an endovascular procedure that uses a catheter to "listen" to the electrical activity from within the heart, additionally if the source of the arrhythmias is found, often the abnormal cells can be ablated and the arrhythmia can be permanently corrected.

Transesophageal atrial stimulation (TAS) instead uses an electrode inserted through the esophagus to a part where the distance to the posterior wall of the left atrium is only approximately 5–6 mm (remaining constant in people of different age and weight). Transesophageal atrial stimulation can differentiate between atrial flutter, AV nodal re-entrant tachycardia and orthodromic atrioventricular re-entrant tachycardia. It can also evaluate the risk in people with Wolff–Parkinson-White syndrome, as well as terminate supraventricular tachycardia caused by re-entry.

**MANAGEMENT**

The method of cardiac rhythm management depends firstly on whether or not the affected person is stable or unstable. Treatments may include physical maneuvers, medications, electricity conversion, or electro or cryo-cautery. In the United States, people admitted to the hospital with cardiac arrhythmia and conduction disorders with and without complications were admitted to the intensive care unit more than half the time in 2011.

**Physical maneuvers:** A number of physical acts can increase parasympathetic nervous supply to the heart, resulting in blocking of electrical conduction through the AV node. This can slow down or stop a number of arrhythmias that originate above or at the AV node (see main article: supraventricular tachycardias). Parasympathetic nervous supply to the heart is via the vagus nerve, and these maneuvers are collectively known as vagal maneuvers.

**Antiarrhythmic drugs:** Symptomatic tachycardia and premature beats may be treated with a variety of antiarrhythmic drugs. These may be given intravenously in an emergency situation or orally for long-term treatment. These drugs either suppress the abnormal firing of pacemaker tissue or depress the transmission of impulses in tissues that either conduct too rapidly or participate in re-entry. In patients with atrial fibrillation, a blood thinner (anticoagulant or antiplatelet) is usually added to reduce the risk of blood clots and stroke. Learn more about A Fib medications. When tachycardia’s or premature beats occur often, the effectiveness of antiarrhythmic drug therapy may be gauged by electrocardiographic monitoring in a hospital, by using a 24-hour Holter monitor or by serial drug evaluation with electrophysiological testing. The relative simplicity of antiarrhythmic drug therapy must be balanced against two disadvantages. One is that the drugs must be taken daily and indefinitely. The other is the risk of side effects. While side effects are a risk of all medication, those associated with antiarrhythmic drugs can be very hard to manage. They include proarrhythmia, the more-frequent occurrence of pre-existing arrhythmias or the appearance of new arrhythmias as bad as or worse than those being treated.

**Calcium channel blockers:** Calcium channel blockers, also known as "calcium antagonists," work by interrupting the movement of calcium into heart and blood vessel tissue. Besides being used to treat high blood pressure, they're also used to treat angina (chest pain) and/or some arrhythmias (abnormal heart rhythms).

**Beta-blockers:** Beta-blockers decrease the heart rate and cardiac output, which lowers blood pressure by blocking the effects of adrenalin. They're also used with therapy for cardiac arrhythmias and in treating angina pectoris.

**Anticoagulants:** Anticoagulants (blood thinners) work by making it harder for the blood to clot, or coagulate. They aren't designed to dissolve existing blood clots. They prevent new clots from forming or existing clots from getting larger. Because a common type of stroke is caused by a blood clot obstructing blood flow to the brain, anticoagulants are often prescribed for people with certain conditions to prevent the occurrence of a first stroke or to prevent the recurrence if the patient has already had a stroke. Anticoagulants are also given to certain people at risk for forming blood clots, such as those with artificial heart valves or who have atrial fibrillation.

**Side Effects Associated With Antiarrhythmics**

- Worsening arrhythmias
- Allergic reaction
- Chest pain
- Fainting
- Swelling of the feet or legs
- Blurred vision
- Shortness of breath
- Abnormally fast heartbeat
- Abnormally slow heartbeat
- Dizziness or light-headedness
- Cough
- Other potential side effects you should discuss with your doctor if you experience them include:
  - Bitter or metallic taste or change in taste
  - Loss of appetite
  - Increased sensitivity to sunlight
  - Diarrhoea or constipation

When first taking antiarrhythmics, avoid operating heavy machinery (for example, driving) until you know how...
the medication will affect you. Ask your doctor for advice about what to avoid doing and when you can resume.

**Electricity:** Arrhythmias may also be treated electrically, by applying a shock across the heart either externally to the chest wall, or internally to the heart via implanted electrodes. Cardioversion is either achieved pharmacologically or via the application of a shock synchronised to the underlying heartbeat. It is used for treatment of supraventricular tachycardias. In elective cardioversion, the recipient is usually sedated or lightly anaesthetized for the procedure. Defibrillation differs in that the shock is not synchronised. It is needed for the chaotic rhythm of ventricular fibrillation and is also used for pulse less ventricular tachycardia. Often, more electricity is required for defibrillation than for cardioversion. In most defibrillation, the recipient has lost consciousness so there is no need for sedation. Defibrillation or cardioversion may be accomplished by an implantable cardioverter-defibrillator (ICD). Electrical treatment of arrhythmias also includes cardiac pacing. Temporary pacing may be necessary for reversible causes of very slow heartbeats, or bradycardia, or when the heart is working hard and also show how well the heart's chambers and valves are working.

**Chest pain** is common:

- **Cathyothrosis:** is a procedure to treat atrial fibrillation (A Fib), a type of irregular heartbeat. It can help keep your heartbeat in a normal rhythm. Ablation usually uses long, flexible tubes (catheters) inserted through a vein in your groin and threaded to your heart to correct structural problems in your heart that cause an arrhythmia. It works by destroying tissue in the heart that triggers an abnormal heart rhythm. In some cases, ablation prevents abnormal electrical signals from traveling through the heart and, thus, stops the arrhythmia. Cardiac ablation is sometimes done through open-heart surgery, but it’s often done using catheters, making the procedure less invasive and shortening recovery times.

**EKG** (electrocardiogram) - This simple, painless test records the heart's electrical activity. The test shows how fast the heart is beating and its rhythm. An EKG also records the strength and timing of electrical signals as they pass through your heart. Echocardiography - This is a painless test that uses sound waves to create an image of the heart.

**Defibrillation or cardioversion** is either achieved pharmacologically or via the application of a shock synchronised to the underlying heartbeat. It is used for treatment of supraventricular tachycardias. In elective cardioversion, the recipient is usually sedated or lightly anaesthetized for the procedure. Defibrillation differs in that the shock is not synchronised. It is needed for the chaotic rhythm of ventricular fibrillation and is also used for pulse less ventricular tachycardia. Often, more electricity is required for defibrillation than for cardioversion. In most defibrillation, the recipient has lost consciousness so there is no need for sedation. Defibrillation or cardioversion may be accomplished by an implantable cardioverter-defibrillator (ICD). Electrical treatment of arrhythmias also includes cardiac pacing. Temporary pacing may be necessary for reversible causes of very slow heartbeats, or bradycardia, or when the heart is working hard.

**People have Catheter Ablation**

Special cells in the heart create electrical signals that travel along pathways to the chambers of your heart. These signals make the hearts upper and lower chambers beat in the proper sequence. Abnormal cells may create disorganized electrical signals that cause irregular or rapid heartbeats called arrhythmias. When this happens, the heart may not pump blood effectively and you may feel faint, short of breath and weak. Medicines to treat rapid and irregular heartbeats work very well for most people. But they don’t work for everyone, and they may cause side effects in some people. In these cases, doctors may suggest catheter ablation. The procedure is used most often to treat a condition called supraventricular tachycardia, which occurs because of abnormal conduction fibers in the heart. Catheter ablation is also used to help control other heart rhythm problems such as atrial flutter and atrial fibrillation. Catheter ablation destroys the abnormal tissue without damaging the rest of the heart.

**Before AF Ablation**

An EKG (electrocardiogram) - This simple, painless test records the heart's electrical activity. The test shows how fast the heart is beating and its rhythm. An EKG also records the strength and timing of electrical signals as they pass through your heart. Echocardiography - This is a painless test that uses sound waves to create an image of the heart & also show how well the heart's chambers and valves are working. Stress testing - Some heart problems are easier to diagnose when the heart is working hard and beating fast.

**Expect After AF Ablation**

Chest pain is common: A majority of patients have chest pain for a few days after the procedure. The severity of the pain varies a lot. Most often, it hurts to take a deep breath or cough. Some patients say their chest feels tight. These symptoms are likely due to irritation of the lining of the heart, called the pericardium. It’s hard to predict who will get post-procedural chest pain.

**Arrhythmia:** Isolate pulmonary veins can irritate the heart, which in turn may cause arrhythmia. Other
possible disruptions to the rhythm include prolonged bed rest, effects of anesthesia, and pain.

**Resting heart rate changes:** The resting heart rate can increase in the weeks or months after ablation. The increase is usually 10-20 beats per minute more than pre-procedure levels. This phenomenon usually resolves.

**Digestive problems:** Patients have trouble moving food through their GI tract after ablation. Symptoms include reflux, feeling bloated, and intolerance of big meals, while signs may include distention of the abdomen. Ablation in the left atrium may transiently damage nerves that control motility of the GI tract.

**SIGNS & SYMPTOMS**

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<td>Dizziness</td>
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<td>Fainting [syncope] or near – fainting spells</td>
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<td>Smoking or alcohol consumption or caffeine drug abuse</td>
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<td>Rapid heartbeat or pounding</td>
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<td>7.</td>
<td>Chest pain</td>
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<td>Stress</td>
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<td>8.</td>
<td>In extreme cases, sudden cardiac arrest</td>
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<td>Diabetes</td>
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**TYPES OF ABLATION**

**NON-SURGICAL ABLATION**

Used for many types of arrhythmias. During this procedure a catheter is inserted into a specific area of the heart. A special machine directs energy through the catheter to small areas of the heart muscle that causes the abnormal heart rhythm. This energy “disconnects” the pathway of the abnormal rhythm.

*EX: 1.RF ablation 2.cryoablation*

**SURGICAL ABLATION**

Used for treating atrial fibrillation can be "minimally invasive" or traditional "open" surgery and may be combined with other surgical therapies such as bypass surgery, valve repair, or valve replacement.

*EX: 1.The Maze procedure 2.Minimally invasive surgical ablation*

**ATRIAL FIBRILLATION (AF)**

Atrial fibrillation (AF) affects proximately 10 million patients in China, undoubtedly the largest demographic group in the world. Catheter ablation targeting pulmonary vein isolation (PVI) has been evolved over the past decade and has become the common treatment for AF, but it often requires repeated procedures, and is associated with serious, although infrequent, complications. It is the most common type of serious arrhythmia, occurs when the electrical impulses that control the heart become erratic. When the electrical impulses become irregular, they interfere with the atria’s ability to effectively pump blood from the heart. The heartbeat may become very fast, sometimes exceeding 200 beats per minute. Because the heart is not pumping blood effectively, blood can pool and form clots in the upper chambers of the heart. For people with AF, clots are most likely to occur in a part of the left atrium called the left atrial appendage. These blood clots may travel to the brain and cause a stroke.\(^2\)
SURGICAL METHOD FOR ATRIAL FIBRILLATION

Open- heart maze procedure: Maze heart surgery is a complex procedure in which a surgeon creates small cuts in the upper part of the heart. The cuts are then stitched together and scar tissue forms. The scars interfere with the transmission of electrical impulses that can cause AFib. Normal heart beat is then restored. [25]

Robotically assisted and minimally invasive surgery to treat isolated fibrillation: Surgical approaches for isolated atrial fibrillation include robotically assisted & key hole surgery. The robotically assisted maze procedure includes creation of lines of conduction block that block the abnormal impulses that cause atrial fibrillation, enabling restoration of normal sinus rhythm. The lines of conduction block are created using cryothermy or RF energy. Robotically assisted surgical ablation also includes exclusion of the left atrial appendage, the primary source of strokes in patients with atrial fibrillation. The robotically assisted maze procedure is appropriate for patients with highly symptomatic atrial fibrillation, patients in whom catheter ablation has failed, & patients who have a history of stroke or other blood clots. The success rate is approximately 80% to 90%, varying with patient characteristics. [26, 27]

Complications: Several factors may contribute to the development of complications in AF ablation. Important contributors include a variety of patient factors related to the extent of structural heart disease, procedural factors, and physician and centre experience. In experienced centres, the risk of a major complication is < 1%–2%. Catheter ablation of AF is a challenging and complex invasive procedure, which is associated with a risk of major complications. An international survey in 2005 reported a 6% incidence of major complications (tamponade, stroke, pulmonary vein stenosis, or death) there is more recent data suggesting that the complication rate of AF ablation is decreasing. A recent consecutive series of patients undergoing AF ablation reported a major complication rate of 0.8%, with no instances of death, stroke, atrio-oesophageal fistula, or pulmonary vein stenosis. [28, 29]

CONCLUSIONS

The expert consensus is that ablation of AF is an increasingly used strategy, predominantly in symptomatic patients. Pulmonary vein isolation remains the cornerstone of the strategy employed. The best results are obtained in patients with paroxysmal AF, no structural heart disease and smaller atria. The mechanisms of AF are very complex and even somewhat mysterious. While it may not be easy to attain a greater understanding of the mechanism of AF or to discover clearer guidance on catheter ablation, research on AF nonetheless leads to a better understanding of other cardiac and non-cardiac diseases because AF develops multifactorially in association with various underlying systemic pathophysiologies. To understand AF is to understand the whole body. It is our goal and hope as a next step to promote catheter ablation as a first-line therapy in more patients with AF based on definitive evidence that the procedure reduces mortality and morbidity.

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