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Review Article

ATENOLOL IN EPISODIC MIGRAINE PROPHYLAXIS: A REVIEW

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ABSTRACT

Atenolol seems to reduce blood vessel dilation, which is known to contribute to migraine. It reduces electrical activity of nervous system and reduces it excitability. Atenolol is a β1-cardioselective beta-blocker that influences the heart circulation through veins and arteries. Primarily, it is used to treat high blood pressure and heart-related chest pain. It is also used as a supplement subsequent to a heart attack to lower the risk of death. Atenolol has shown efficacy in prevention of migraines and to treat certain irregularities in heartbeats. It can be taken orally or parentally. It reduces the heart rate and workload of cardiac muscles by blocking β1-adrenergic receptors in heart. It restricted blood flow in the brain by reducing blood vessel dilation and helpful in the treatment of migraine. It reduced the electrical activity of nervous system and made it less excitable. It also repressed the waves of electric currents that proved beneficial in the treatment of migraine aura.

Keywords: Atenolol, Migraine, Hypertension, Coronary artery, Asthmatic, Diabetic.

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INTRODUCTION

Migraine is a neurological stipulation with severe, intolerable headaches. Nausea, vomiting, difficulty speaking, numbness or tingling, and sensitivity to light and sound are the symptoms of migraine. It can impede with the daily life of affected person. Changes in lifestyle, medicines, and complementary remedies, etc., are abundant options of treatment.

Beta-blockers are one of the defensive medication choices for migraine. However, these types of drugs are mainly prescribed to treat heart conditions. However, research demonstrated that some beta-blockers may show efficacy in the treatment of migraine. Migraine is basically a type of headache with throbbing sensation of vary intensity in one particular area, usually accompanied by sensitivity to light and sound, so lying in a darkroom quietly has shown much relieves. Preventive and pain-relieving medication can help in managing migraine headaches [1-4]. Both β1 and β2 receptors are present on brain cells. A migraine occurrence is different from normal headache that generally occurs in phases and can stay for several days. It can disturb a person's working or studying ability.

A study conducted in 2018, discovered from trusted source that more than 15% of adults in the United States had undergone a migraine incident or a severe headache within 3 months. Data from the study conducted in 2015 confirmed that females are more affected than males from migraine. The ages of 18–44 years are more prone to migraine attack, but it can ensue at any moment, including during childhood [2-4].

Different possible triggers of migraine attack include hormonal changes (during menstruation), emotional elicit (anxiety, depression, excitement, and stress), dietary issue (alcohol, caffeine, cheese, chocolate, citrus fruits, and foods containing the additive tyramine), medications (hormone replacement therapy, sleeping pills, and some birth control pills), and environmental factors such as bright lights, flickering screens, loud noises, secondhand smoke, strong smells, stuffy rooms, and temperature changes.

Some other possible triggers are lack of sleep, physical overexertion, tiredness, poor posture, shoulder and neck tension, low blood sugar, irregular mealtimes, jet lag, and dehydration [3,4].

Beta-blockers are safe and most valuable antihypertensive drugs. Beta receptors are located in brain and in heart cells [5-8]. Adrenaline activates the beta receptors that ultimately augment the pressure and heart rate. Beta-blockers restrict the adrenaline to activate beta receptors present in blood vessels [9-13]. This action of beta-blockers is responsible for the relaxation of blood vessels, which leads to decrease in pressure and reduce migraine pain [14].

Atenolol is used unaided or in amalgamation to treat high blood pressure. Primarily, atenolol was launched in 1976 and got approval by the US FDA in August 1981 as antihypertensive drug and to treat other coronary artery disease [15,16]. Atenolol belongs to the class of beta-antagonist. This was a finding by accident that atenolol helped the patients with migraine. This ensued when patients who had been prescribed atenolol found that the drug also assuaged their migraine indications. The clear mechanism of atenolol to treat migraine is not known. Atenolol has shown its effects either by restricting the blood flow in the brain, by reducing nervous system electrical activity, by maintaining brain serotonin levels, by increasing activity in the hypothalamus, or by decreasing overall stress. Thus, beta-blockers are one of the first lines of treatment in migraine prevention, as it is generally effective and has relatively less side effects. In 2013, Edvardsson by his open-label 3 months study concluded atenolol seems to be a safe and effective treatment for chronic migraine.

Atenolol is available in tablet form with the brand name Tenormin to treat hypertension, migraine and angina pectoris, arrhythmias, and myocardial infarction [5,7]. Atenolol being a cardioselective beta-blocker can be given successfully to bronchial asthmatic and diabetic patients [9]. Patient compliance is better with atenolol because given once a day. It is also used to cure dysautonomia, migraine, anxiety, and hyperthyroidism [1,15-20].

STRUCTURE AND PROPERTIES

Chemically atenolol is 4-(2-hydroxy- 3-((1- methyl ethyl) amino) propoxy) benzeneacetamide (Fig. 1) [5-8]. Molecular weight of atenolol is 266.34. It is a hydrophilic compound having aqueous solubility 26.5 mg/ml at 37°C and log distribution coefficient 0.23. Atenolol is almost white powder. It is soluble in ethanol (~750 g/L), sparingly soluble in water, slightly soluble in dichloromethane [20,21].

LITERATURE

Atenolol is a selective β1-antagonist used widely to treat angina pectoris and high blood pressure [22-25]. Initially, atenolol was used to treat cardiac problems as it activates the beta receptors that ultimately augment blood pressure and heart rate. Beta-blockers restrict the adrenaline to activate beta receptors present in blood vessels and heart. This action of beta-blockers is responsible for the relaxation of blood vessels, which leads to decrease in blood pressure and reduce chest pain. They are used to manage the symptoms of hypertension by reducing oxygen requirement of heart. It can also be used in migraine prescription. As there is a connection between headaches and high blood pressure, but beta-blockers can thwart migraines still the person have only migraine symptoms. As a first line therapy for high blood pressure, β-antagonist reduced the mortality and morbidity [26] but in migraine, it restricts the dilation of blood vessels. Approximately 40–50% of administered atenolol is available in blood circulation. It has fewer tendencies (<5%) to bind with protein and approximately 90% of the absorbed drug excreted unchanged through renal route [27,28].

The optimum dose of atenolol is 100 mg once daily [29,30]. It is a hydrophilic compound and suitable to treat hypertension and migraine during pregnancy. The studies demonstrated that it can cross the placental barrier [31] but probable effects on fetus have not been estimated. Atenolol (Tenormin) and metoprolol (Toprol, Lopressor) were act selectively on beta-1 receptors in heart cells. They do not affect the beta-2 receptors in blood vessels and the lungs. Thus, cardioselective beta-blockers proved beneficial for people suffering from lung disorders.

The secretion of adrenaline into the bloodstream in response to anxiety, fear, or physical work out incontestably influences performance, a number of drugs are used by several athletes to modify performance that has their effects on the adrenergic system. Athletes attempt directly or indirectly to improve their performance using β-adrenergic drugs. Indirectly acting drugs affect the discharge and reuptake of noradrenaline and adrenaline and influencing all adrenaline receptors subtypes including the three β-adrenaline receptors. These agents produce an illusion of better performance due to its potent psychostimulant effects. β-adrenergic antagonists have ability to reduce heart rate and muscle tremor so used in sports to improve performance using steady and accurate dose. They have a venomous effect on stamina in sports because they reduce the load of maximum exercise and physical performance. Some drugs such as beta-blockers, the stimulant Ritalin, and drugs used in Parkinson's disease are now considered as smart drugs as the studies demonstrated that they can enhance alertness and improve test performance of students and sport participants. In 1991, a study was conducted on beta-blockers, to examine its effectiveness on SAT performance of 32 students who had test anxiety and outcomes of studies demonstrated that the students scored much higher than their drug-free previous round. β1 adrenoceptors present in different parts of body and responsible for various effects such as in heart arbitrate positive chronotropic and inotropic responses, in kidney manage release of renin from the juxtaglomerular apparatus, and in adipose tissue regulate lipolysis. In brain, β1-ARs regulate the discharge of melatonin from the pineal gland and influence the mood modifications [32,33].

Shamliyan reviewed pharmacologic treatment for episodic migraine and found that beta-blockers proved beneficial as they cause 50% decline in pain [34].

In the other meta-analysis, we found that beta-blockers were beneficial for migraine headaches [35].

The synergistic effect of atenolol and quercetin has shown improved protection to heart in ISO-induced animals, the free radical scavenging effect of quercetin responsible for their beneficial effects [36].

The pediatric patients with long QT syndrome administered atenolol twice a day for effective and valid treatment [37].

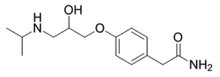

Fig. 1: Chemical structure of atenolol

Rausova *et al*. investigated the pharmacodynamic relationship between atenolol and valsartan using mathematical model by estimating their effects on systolic blood pressure, diastolic blood pressure, and heart rate [38].

Edvardsson performed an open-label study to investigate the worth and acceptability of atenolol in prevention of chronic migraine and concluded that atenolol is a safe and effective treatment for chronic migraine [39,40].

Shirsand *et al*., 2012, prepared sustained release mucoadhesive buccal tablets containing atenolol to study the unidirectional release of medicine in buccal cavity for extended period to improve the bioavailability and patient compliance by reducing dose frequency [41].

Anepu *et al*., 2016, used melt granulation technique to prepare sustained release gastroretentive floating matrix tablets of atenolol with polymers such as hydroxy propyl methyl cellulose (HPMC), K100M beeswax, HPMC K4M with ethyl cellulose, and glyceryl monostearate, evaluated them, and compared liberation of drug amid glyceryl monostearate and beeswax [42].

El-Zahry prepared silver nanoparticles chemically by reduction of silver nitrate. They used hydroxylamine HCl in medium having alkaline pH to estimate the mixture of atenolol and amiloride in both pharmaceutical dosage forms and in biological samples simultaneously [43].

Satyanarayana and Sandeepthi, 2018, formulated and evaluated floating microspheres of atenolol tartrate by emulsification solvent diffusion technique to avoid the side effects [44].

Adhikari and Panda, 2017, developed and evaluated the buccal patches of atenolol using fenugreek seed mucilage with hydroxypropyl methyl cellulose (HPMC K4M) and a backing membrane of ethyl cellulose (5% w/v) and found that buccal patches have been proved beneficial over the conventional drug delivery systems to decrease the dosing frequency and enhance patient compliance [45].

Parashar and Singh, 2018, prepared tablet of atenolol having double layer to improve its bioavailability and absorption in the lower portion of gastrointestinal tract by biphasic liberation of drug. Sodium starch glycolate, croscarmellose sodium, and crospovidone were used for immediate release portion of formulation and gum acacia, different grade HPMC K4M, hydroxy HPMC K15M, gum tragacanth, guar gum, and ethyl cellulose were used for continued release portion [46].

Hasanah *et al*., 2019, developed a separation method to detect and monitor the level of atenolol in the body. The method includes molecular modeling interaction between atenolol and itaconic acid then spectrophotometry to determine the binding constants, precipitation polymerization to synthesize the polymer, and then characterization and application of polymers to take out atenolol in serum [47].

Salam *et al*., 2020, synthesized different tin complexes containing atenolol moieties and investigated their photostabilizing effect on PVC. They concluded that atenolol-tin complexes as additives to PVC provided stability to polymeric films against light. Morphological investigation through infrared spectroscopy and weight loss studies evidenced that the triphenyltin complex is most effective to enhance photostability of blends [48].

MECHANISM OF ACTION

Atenolol is a cardioselective beta-antagonist. It acts selectively on β1 receptor and produces cardioselective effect exclusive of membrane

stabilizing or inherent sympathomimetic actions [49]. It inhibited the action of epinephrine, a natural chemical present on heart, and blood vessels in our body, and reduced blood pressure and sprain on heart and controlled the heart rate.

Atenolol diminished the chest pain and sternness of heart attacks. It influenced the response of cardiac nerve impulses. It maintained the heart beats and controlled blood pressure.

For the treatment of migraine, it acts by several mechanisms like (Fig. 2):

- It altered the electrical activity of the brain to avert the slothful brain activity associated with migraine (in early stages).
- It acts directly on the brain blood vessels and decreases cerebral (brain) blood flow.
- It improves the activity of hypothalamus.

It observed that a combination of these effects is accountable for its consequence in migraine; but it is not completely clear which effect has come first and proved more beneficial to treat migraine [50].

PHARMACOKINETICS

Atenolol is a hydrophilic, cardioselective β1 antagonist [7]. It acts by inhibiting sympathetic stimulation of β1 adrenergic receptors on vascular smooth muscle and in heart, by competing with catecholamines [51] and for prophylaxis of migraine by restricting the blood flow in the brain, by reducing nervous system electrical activity, by maintaining brain serotonin levels, by increasing activity in the hypothalamus, or by decreasing overall stress. Thus, it seems to be one of the first line treatments in migraine prevention. Reduction in plasma rennin activity and free fatty acid levels are endocrine and metabolic actions of atenolol. Plasma half-life of atenolol is 6–8 h [8-10]. Insulin-induced hypoglycemic action of atenolol is less than non-selective beta-blockers. As atenolol is hydrophilic, very less concentration is found in brain tissue. The oral bioavailability of atenolol is about 50–60%. It absorbs incompletely from gastrointestinal tract and bounds insignificantly to plasma proteins, only minute fraction of an administered dose penetrate into brain. It has limited tendency (<5%) to bind with plasma protein. The apparent volume of the distribution of atenolol is about 50–75 L, thus, distributes extensively in body. Approximately 95% of absorbed dose of atenolol is excreted unchanged through kidneys through urine [5-11,52-54]. About 6–16% of atenolol bounds in human serum albumin [55].

Very less amount of atenolol is metabolized in liver by hydroxylation reaction and glucuronide conjugation. These metabolites form 5–8% and 2% of total renally excreted dose and rest is excreted unchanged. The hydroxylated metabolite has shown 1/10th the beta-blocking activity of atenolol [56].

Atenolol has ability to cross umbilical cord, placenta, and maternal serum levels, so to be avoided during pregnancy. In renal dysfunction, eradication of atenolol is prolonged, so dosage reduced accordingly, otherwise, patients with less glomerular filtration rate may show accretion [57].

PHARMACODYNAMICS

Atenolol is a β1-cardioselective beta-blocker seems to be one of the first-line treatments in migraine prevention [5,7]. It can be given cautiously to asthmatic patients taking bronchodilator drug. It antagonized the effect of norepinephrine in peripheral nervous system by averting increase in heart rate, electrical conductivity, and contractility in the heart [58]. It can restrict the blood flow in the brain, reduce electrical activity of nervous system, maintain serotonin levels in brain, increase activity hypothalamus activity in brain, and decrease the overall stress. Thus, it proves beneficial in the migraine treatment. Atenolol has shown side effects related to CNS such as depression, fatigue, and sleep disturbances such as insomnia or nightmares. It abridged both diastolic and systolic blood pressures in hypertensive patients [11]. It has shown its maximum therapeutic efficacy on the 3rd day of its treatment. In population suffering with coronary artery disease, atenolol reduces myocardial oxygen consumption and produces change in myocardial blood flow; it decreases regional myocardial blood flow in both normal and slightly more in post-stenotic areas [12]. It increases the length of sinus cycle, atrial refractoriness, sinus node recovery time, and AV conduction time [7-8,59]. Olesen *et al*., 2006, supported the efficacy of atenolol (50–200 mg/day) in episodic migraine prophylaxis [60]. The dilation of blood vessels contributes to migraine and beta-blockers condense this dilation which seems beneficial for migraine treatment. They reduced the excitability of nervous system by reducing the electrical activity. They also repress impression of electric currents that are responsible for migraine aura.

DOSAGE [29]

The dosages of atenolol [23,24] in different conditions are shown in Table 1.

Dosage forms

Tenormin tablets: 25, 50, and 100 mg.

Vials: The composition of atenolol in vials is 5 mg/10 ml of citrate-buffered solution for intravenous injection. The solution should be delivered only by trained staff. The standard dose of atenolol as tablet instigated at 25 mg once or twice a day and modified according to patient's response toward medication [9-12].

THERAPEUTIC TRIALS

Initially, atenolol was intended to use in patients with hypertension in controlled trials or exercise-related angina pectoris. Some clinical trials on atenolol are given in Table 2.

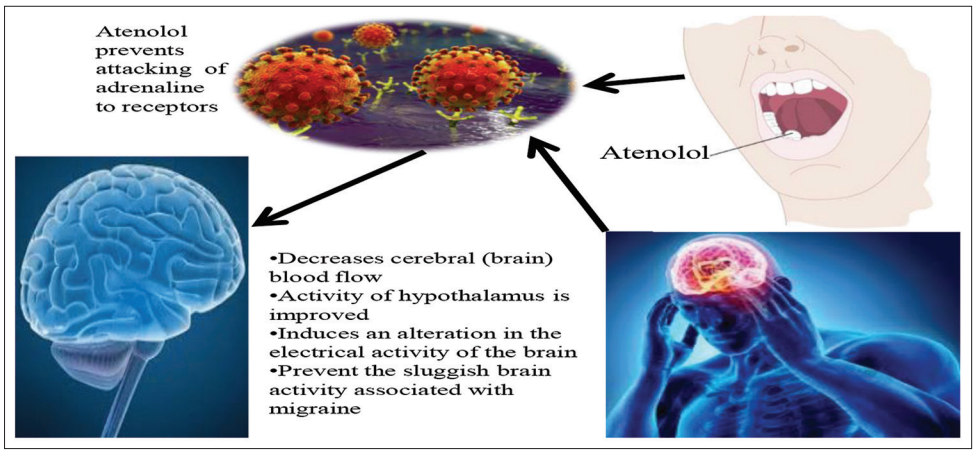

Fig. 2: Mechanism of the action of atenolol for migraine treatment

Table 1: Dosages of atenolol

Conditions	Dose		
	Pediatric	**Adult**	**Geriatric**
Hypertension	0.5–1 mg/kg/day orally; not more than 2 mg/kg/day or 100 mg/day [8-10]	25–50 mg/day orally initially; not more than 100 mg/day orally [8-10]	25 mg/day orally initially; not more than 100 mg/day orally [8-10]
Angina pectoris	-	Begin with 50 mg/day orally and increased up to 100–200 mg/day orally [9]	Begin with 25 mg/day orally and increased up to 100–200 mg/day [9]
Post-myocardial infarction	-	Initially 100 mg/day orally and after myocardial infarction continued for 6–9 days twice a day [10-12]	100 mg/day orally and after MI continued for 6–9 days twice a day [10-12]
Alcohol withdrawal syndrome (off-label)	50–100 mg/day orally [12-14]		
Migraine	50–250 mg/day		
Supraventricular arrhythmias (off-label)	Before surgery begin with 50 mg/day orally up to 3 days and continued till 7 days after surgery with increased dose up to 100 mg/day [10,11]		
Thyrotoxicosis (off-label)	25–100 mg/day orally [9]		

Table 2: Some clinical trials on atenolol are given in table [62]

CTID	Phase, date	Title	Results
NCT04224675	N/A, January 13, 2020	Captopril versus atenolol to prevent expansion rate of thoracic aortic aneurysms	This study demonstrated that ACEIs are performed better than BB therapy in lowering the intensification of TAAs, during aortic surgical treatment or intervention, aortic burst or dissection, and death.
NCT01719367	N/A, June 17, 2019	Genetically determined response to atenolol in patients with persistent atrial fibrillation	This study concluded that these agents manage heart rate, thus thwarting symptoms related to systolic heart failure associated with increased heart rate due to a quick ventricular response to AF.
NCT00669279	Phase 4, October 5, 2017	Effect of carvedilol controlled release and atenolol on central blood pressure	The objective behind this study is to investigate whether controlled release carvedilol or atenolol decrease blood pressure effectively in body like in arm.
NCT01251146	Phase 4, March 8, 2017	A randomized controlled study to assess the effects of bisoprolol and atenolol on resting heart rate and sympathetic nervous system's activity in subjects with essential hypertension	In this study, both bisoprolol and atenolol was administered to subjects with essential hypertension to compare their effects on sympathetic nervous system's activity and resting heart rate.

In angina pectoris patients, atenolol in dosage 50–400 mg daily was successful in plummeting the incidence or sternness of angina attacks and declining requirement of glyceryl trinitrate. It also improved ST segment dejection and exercise potential [14].

In hypertension placebo-controlled studies, 100–200 mg/day dose of atenolol reduced standing, lying, or exercise-induced blood pressures up to 15–20%. Studies demonstrated that atenolol seems to be more effective in reducing diastolic blood pressure than non-selective β-blockers [61].

Patented formulations of Atenolol

Various formulations prepared from atenolol have been patented. Some patented formulations are enlisted in Table 3 and explained as:

Table 3: Some examples of patented formulations of atenolol

Type of formulations	Patent	Patentees	References
Bilayer tablets	WO2008001311A2	*Verma et al.*	[63]
Nanoemulsion	CN102631428A	*Wuqing et al.*	[64]
Compound double-layer tablet	CN103211816A	*Huang et al.*	[65]
Powder	CN103739512A	*Dingqiang i.*	[66]
Freeze-dried tablet	CN104434771A	*Lei et al.*	[67]
Medicinal composition	CN105582327A	*Ren*	[68]
Nanoparticles	US10053531B2	*Zhang et al.*	[69]

Verma *et al*. patented a pharmaceutical composition containing an amalgamation of atenolol and isosorbide mononitrate in preset dose and their method of preparation. The composition provides atenolol immediately and isosorbide mononitrate comprehensively. As compared to the monotherapy, this combination has shown synergistic effect.

Wuqing *et al*. patented nanoemulsion form of atenolol and demonstrated that atenolol in nanoemulsion has shown increased blood brain barrier transmission capacity, bioavailability of technical material, half-life of drug, dissolution, infiltration capacity, and stability of atenolol.

Huang *et al*. patented a compound double-layer tablet containing atenolol and amlodipine. In tablet, atenolol is present as first layer in dose of 25 mg and amlodipine in dose of 2.5 mg as second layer. The tablet has shown good stability and low incidence of adverse responses.

Dingqiang *et al*. patented the method for preparing S-atenolol which includes following steps: (1) p-hydroxyphenylacetamide react with R-epoxy chloropropane, and gives S-4-((2-epoxyethyl) methoxy)phenylacetamide and (2) S-4-((2-epoxyethyl) methoxy) phenylacetamide reacts with dimethylamine and gives S-atenolol. Therefore, S-atenolol can be effectively prepared.

Lei *et al*. patented the composition and method of preparation of freeze-dried atenolol tablet. They demonstrated that freeze-dried tablet of

atenolol has shown improved bioavailability of tablet and helped to overcome disadvantages of common atenolol tablet.

Ren patented a medicinal composition of atenolol along with Hainan ervatamia roots, *Cycas revoluta* Thunb., *Cunninghamia lanceolata* (Lamb.) Hook, and herba lagotis to reduce side effects associated with atenolol.

Zhang *et al*. patented the molecularly imprinted polymer nanoparticles of atenolol and their method of preparation. These nanoparticles have shown applications in analysis of biological sample, biomimetic sensors, food, and environmental monitoring.

SIDE EFFECTS

Almost patients endured atenolol comfortably [1-14,70,71]. The side effects associated with atenolol are shown in Fig. 3.

Interactions

Atenolol in pregnancy

As atenolol caused harm to unborn child when used during pregnancy, so according to FDA, it is placed under category D medication for pregnancy [68]. Atenolol passes the placental barrier which depicts the fetus to probable unenthusiastic effects. Some studies demonstrated that during the second trimester of pregnancy, atenolol decreases the gestational age and results in lower birth weight of infants. During the last trimester, revelation to atenolol increases risk to infant such as bradycardia, hypoglycemia, and hypotension immediately or several hours after labor [72-75].

Atenolol is not suggested for lactating women as this medication is leached out in mother milk and can cause redundant effects on lactating baby.

Food interactions

Atenolol has shown following interactions with different food.

- Grapefruit juice: Ingestion of grapefruit juice with atenolol may supplement blood level of atenolol because the juice of grapefruit inhibited liver enzymes to inactivate several drugs.
- Sodium-rich foods: The hypotensive consequence of atenolol is diminished by foods containing sodium content.
- Citrus fruit juice: Orange juices reasonably impede the gastrointestinal absorption of atenolol [76].
- Atenolol interactions with alcohol: The synergistic effect of atenolol with alcohol may make the person drowsy or feel sleepier and amplify the risk of orthostatic hypotension.

Drug interactions

Atenolol has shown interactions with various drugs [23,77,78]. These are depicted in Fig. 4.

Atenolol disease interactions

There are 18 diseases that show interactions with atenolol [79-81], as shown in Fig. 5.

APPLICATION

Atenolol has application in the treatment of various diseases, as shown in Fig. 6 [77].

- Acute MI: Atenolol is used to reduce cardiovascular mortality in the treatment of hemodynamically stable patients who suffer from acute MI [82,83].
- Coronary atherosclerosis-associated angina pectoris: Atenolol is used in long-term management of patients with angina pectoris [82,84].
- Migraine: Atenolol with other beta-blockers is prime option in episodic migraine prophylaxis. Edvardsson demonstrated that

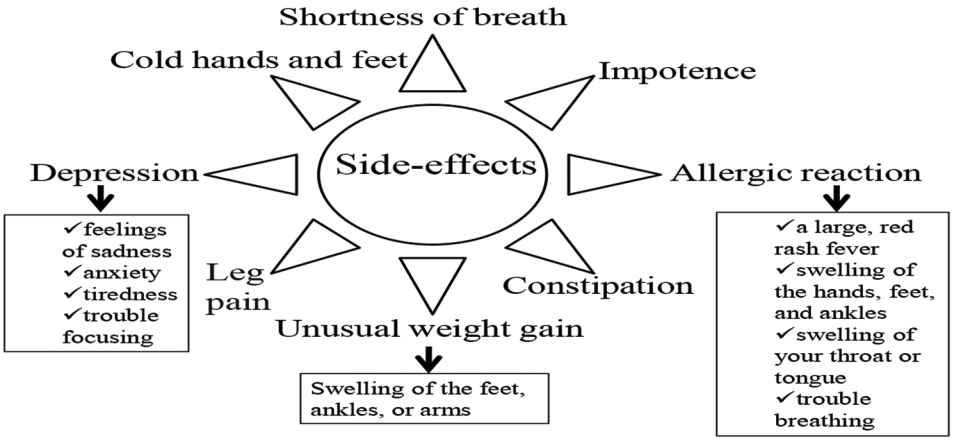

Fig. 3: Side effects of atenolol

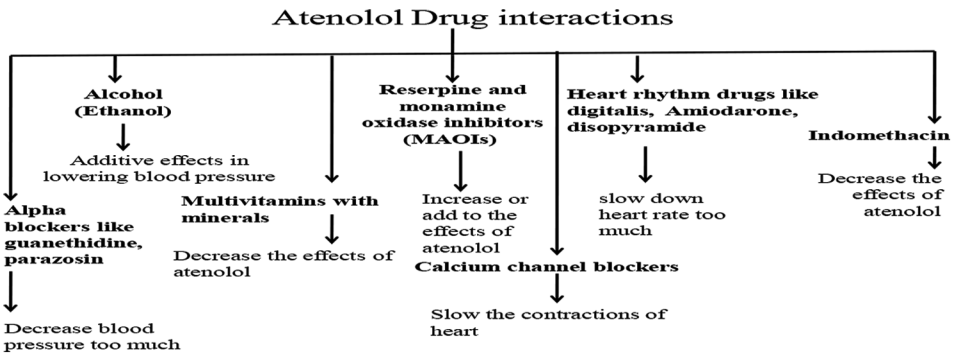

Fig. 4: Drug interactions with atenolol

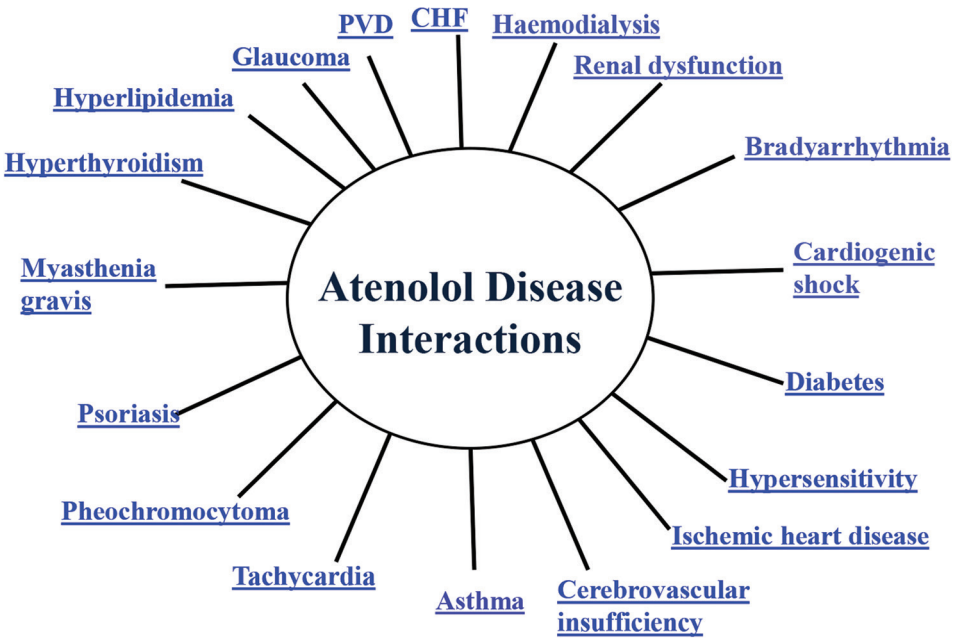

Fig. 5: Interactions of atenolol with diseases

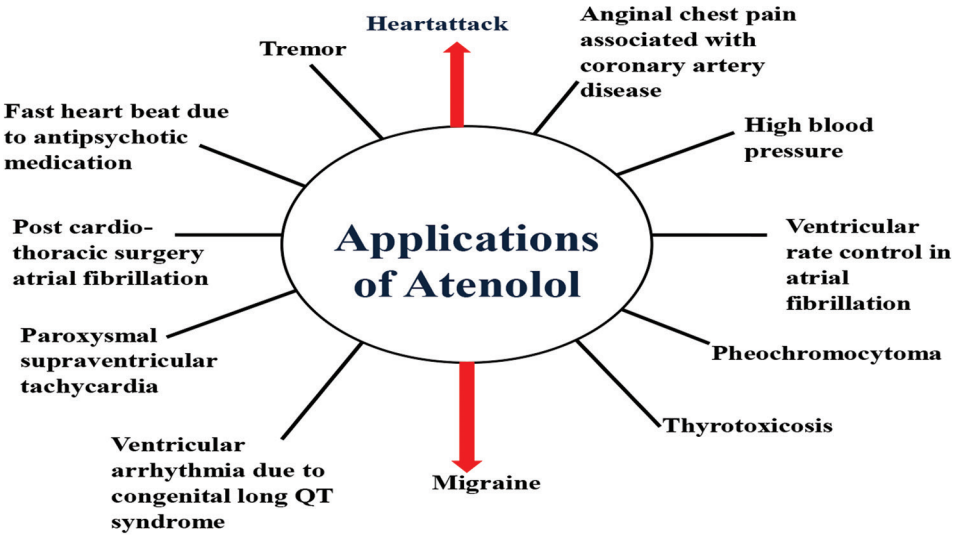

Fig. 6: Applications of atenolol

50–200 mg/day dose of atenolol is effective in migraine prophylaxis. Atenolol decreases the dilation of blood vessels that are responsible for migraine. It reduces electrical activity of nervous system and reduces it excitability. It restrains the electric currents waves that are responsible for migraine [38,39].

- Photostabilizer: Salam *et al*. synthesized different tin complexes containing atenolol moieties and investigated their photostabilizing effect on PVC. They concluded that as additives to PVC, the atenolol-tin complexes provided significant photostabilization to polymeric films [48].
- Cancer: Atenolol and aspirin both enhanced the anticancer activity of metformin, they drastically reduced endothelial cell component of tumor vessels. They potentiated the antineoplastic activity of metformin against breast cancer by targeting cancer cells [21].
- Atrial fibrillation (rate control): Atenolol is suggested for patients with paroxysmal, atrial flutter, persistent, or permanent atrial fibrillation and symptomatic supraventricular tachycardias for ventricular rate control [85].
- Thyrotoxicosis: Atenolol is also recommended effectively to treat symptomatic thyrotoxicosis and in asymptomatic patients with higher risk of hyperthyroidism [86-88].
- Hypertension: Atenolol is also recommended to treat hypertension. Careful monitoring of blood pressure of patient is mandatory before administering next dose [89].
- Ventricular arrhythmias: Data from observational studies conducted by American College of Cardiology/American Heart Association/ Heart Rhythm Society, demonstrated that atenolol may be useful for reducing ventricular arrhythmias in patients suffering from arrhythmogenic right ventricular cardiomyopathy [89].
- As performance booster in sports: Beta-blockers can prevent the increase in heart rate during exercise. Thus, delay the targeted heart rate to approach; otherwise, very hard exercise must be needed to control heart rate for the enhancement of performance in sports [90].

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AUTHORS' CONTRIBUTIONS

Data collection.

CONFLICTS OF INTEREST

The authors authenticate that the contents of this article have no conflicts of interest.

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Declared none.

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