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Pulsatile Drug Delivery System: An Systematic Review

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Abstract
Interest in drug delivery systems has grown over the past few decades due to developments in pharmaceutical technologies. Due to the inherent difficulties in the discovery and development process, pharmaceutical galenic research now concentrates on developing more effective drug delivery systems employing already-existing compounds rather than exploring novel drug discovery. The development of Pulsatile medication Delivery Systems is motivated by the need to treat disorders that require a periodic pulse of therapeutic concentration rather than constant medication levels. The market's pulsatile medication delivery systems. The following describes a number of commercial pulsatile drug delivery systems, including Pulsincap, Diffucap®, 3-Dimensional Printing®, CODAS®, OROS®, PULSYS, Diffutab, Orbexa, and Minitab: For illnesses that exhibit circadian rhythms or time-dependent symptom fluctuations, pulsatile medication delivery methods are particularly helpful. Asthma, heart problems, hormone abnormalities, and specific kinds of discomfort are a few examples. In these circumstances, pulsatile delivery can release medications at particular times when the disease is at its peak or when the body's normal cycles are upset. This tactic can improve medication effectiveness and lessen negative effects that are frequently brought on by continuous or non-specific drug release. In general, the targeted and time-controlled release of therapeutic medicines requires pulsatile drug delivery systems. Compared to traditional drug administration techniques, these systems have a number of advantages, including increased patient compliance, reduced adverse effects, and higher therapeutic efficacy. To properly enhance pulsatile systems and apply them to clinical practice, however, further research and development work is needed.

Keywords: Pulsatile Drug Delivery Systems, Galenic Research, Circadian Rhythms Time-Controlled Release, Therapeutic Efficacy

INTRODUCTION

Pulsatile systems are attracting significant interest Because they fully release the medication after a predetermined lag time, pulsatile devices are gaining a lot of attention. The pulsatile medication delivery system is a site- and time-specific technique that increases patient compliance by achieving customized and temporal delivery. It is described as the quick, brief release of a certain number of molecules that happens right after a predefined off-release interval.

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The field of chronopharmaceutics, which focuses on developing and accessing medication delivery methods, is relatively new. In order to treat a particular condition, these systems are designed to release a therapeutic chemical in a rhythm that best suits the biological requirements.[2]

The development of Pulsatile medication Delivery Systems is motivated by the need to treat disorders that require a periodic pulse of therapeutic concentration rather than constant medication levels.

These systems are distinguished by the quick and brief release of a predefined amount of drug molecules over a brief period of time, which happens right after an off-release interval. There are several methods for pulsatile delivery, including micro-flora activated systems, time-dependent systems, and pH-dependent systems. These can be created using the characteristics of the medicine molecule and the physiology of the illness. The methods of pulsatile medication delivery and the emerging technologies being used on an industrial scale are the main topics of this review.[3]

Such a novel drug delivery has been attempted for the following:[4]

1. The therapeutic strategy for illnesses whose pathophysiology displays circadian rhythms is chronopharmacotherapy.
2. This approach aims at avoiding the degradation of substances, such as proteins and peptides, in the upper gastrointestinal tract.

iii. Hormones and other medications, including isosorbide dinitrate, can be administered at predetermined times with this method. It is specifically utilized to prevent resistance from developing and to prevent hormone suppression, which could be impeded by continuous release from a traditional dosage form. Additionally, it is advantageous for:

Drugs that develop biological tolerance.

- Medications that have a high first-pass metabolism.
- Medications that target a particular intestinal tract location, such the colon

METHODOLOGIES FOR PULSATILE DRUG DELIVERY

Methodologies for the pulsatile drug delivery system can be broadly classified into three classes;

1. Time controlled
2. Stimuli induced
3. Externally regulated

1. Time Controlled Pulsatile Release System- Time-controlled drug delivery devices mimic the circadian rhythm by causing pulsatile release after a certain amount of time.Two parts are used in this kind of system: one for instantaneous release and the other for pulsed release. These time-controlled pulsatile release systems can be implemented using the different approaches listed below:[5]

Delivery systems with rupturable coating layer

These systems have an exterior coating that regulates release; it is porous, water-insoluble, and intended to experience a mechanically driven rupture phenomenon. A rupturable layer has recently been used in a number of systems based on hard gelatin capsules and tablet cores. By adding swelling, osmotic, or effervescent chemicals to the reservoir, the film might be ruptured. Drug release at a precise time interval can be achieved by system optimization.[6]

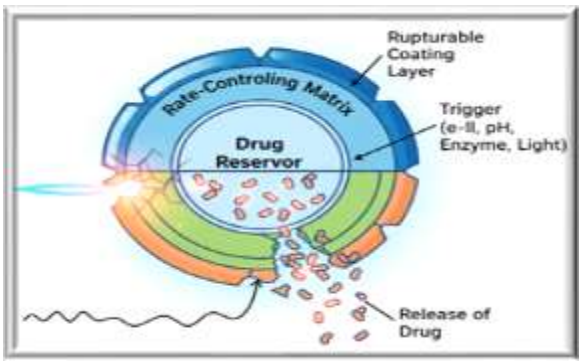

Fig.1 - Delivery Systems with Rupturable Coating Layer

Delivery systems provided with erodible coating layers: In this technique, drug release is contingent upon the outer layer applied to the drug-containing core dissolving or eroding. By optimizing the thickness of this outer coat, a time-dependent release of the active ingredient can be achieved.[7]

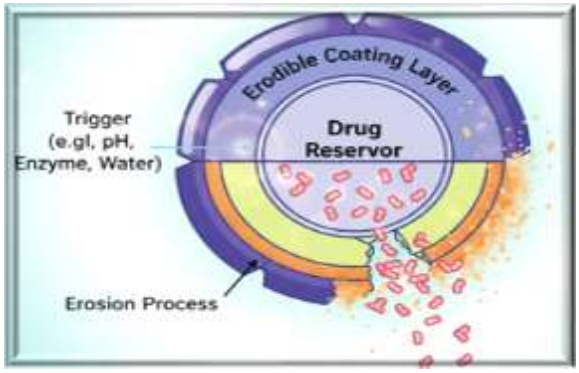

Fig. 2- Delivery Systems Provided with Erodible Coating Layers

Capsule shaped system provided with release controlling plug: The instant release compartment and the pulsed release compartment in these systems are separated by a release-controlling plug. The cap quickly dissolves when it comes into contact with aqueous fluids, releasing the instant release component first and then the pulsed release component. The lag time is provided by the plug, which is put into the body.[8]

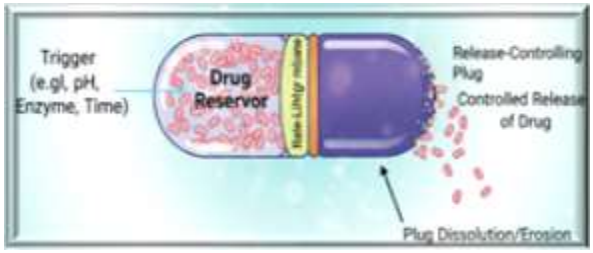

Fig.3 - Capsule Shaped System Provided with Release Controlling Plug

2. Stimuli Induced Pulsatile Systems: In these systems there is release of the drug after stimulation by any biological factor like temperature, or any other chemical stimuli.[9]

Temperature induced systems- Thermo-responsive hydrogels have been used to create pulsatile release devices. Drug release in the swollen state is modulated in these systems by the polymer's reaction to temperature, specifically passing through a swelling or deswelling phase. The reversible swelling characteristics of copolymers composed of N-isopropylacrylamide and butyrylacrylamide to develop an indomethacin pulsatile release pattern between 200C and 300C Additionally, thermosensitive polymeric micelles were created by Kataoka et al. as medication carriers for the treatment of cancer. End-functionalized poly(N-isopropylacrylamide) (PIPAAm), which showed hydration and dehydration behavior following temperature change, was used to create the micelle's corona.[10]

Chemical stimuli induced Pulsatile systems

Glucose-responsive insulin release devices Insulin must be administered at the appropriate time for diabetes mellitus due to the periodic rise in blood glucose levels. As a result, a number of systems that react to variations in glucose concentration have been created.

In one such system, glucose oxidase is immobilized within a pH-sensitive hydrogel. When the blood glucose concentration rises, glucose oxidase converts the glucose into gluconic acid, which, in turn, changes the system's pH. This pH shift induces swelling of the polymer, resulting in the release of insulin. Following its action, insulin lowers blood glucose, which in turn lowers gluconic acid. After that, the system goes back to the deswelling phase, which reduces the amount of insulin released.[11]

Drug release from intelligent gels responding to antibody concentration- There are many different types of bioactive substances in the body. New gels have recently been created that respond to variations in the concentration of these substances by changing their swelling/deswelling properties. Because of the extremely specialized character of this interaction, particular consideration has been given to the use of antigen-antibody complex formation as the cross-linking units within the gel. Reversible gel swelling/deswelling and drug permeability variations are achieved by taking advantage of the differential in association constants between polymerized antibodies and naturally formed antibodies toward particular antigens.[12]

pH sensitive drug delivery system- There are many different types of bioactive substances in the body. New gels have recently been created that respond to variations in the concentration of these substances by changing their swelling/deswelling properties. Because of the extremely specialized character of this interaction, particular consideration has been given to the use of antigen-antibody complex formation as the cross-linking units within the gel. Reversible gel swelling/deswelling and drug permeability variations are achieved by taking advantage of the differential in association constants between polymerized antibodies and naturally formed antibodies toward particular antigens.

Drug release can be accomplished at a particular site by choosing the right pH-dependent polymers. These polymers include sodium carboxymethylcellulose, polyacrylates, and cellulose acetate phthalate. To guarantee that the medication is released only in the small intestine, these polymers are widely used as enteric coating materials.[13]

3. Externally regulated systems- External stimuli including magnetism, ultrasound, electrical effects, and radiation can be used to program the release of drugs in externally regulated systems, which is another way to achieve pulsatile drug release. Magnetic beads inside the implant are used in magnetically controlled devices. The magnetic beads cause the release of drugs when a magnetic field is applied. The used alginate spheres to create a number of formulations for the in vitro magnetically induced release of insulin.[14]

Ultrasonic waves in ultrasonically modulated systems erode the polymeric matrix, which modifies the release of drugs. Miyazaki et al. looked at how ultrasonic affected the rates at which bovine insulin was released from reservoir-style drug delivery devices and ethylene-vinyl alcohol copolymer matrices. After applying ultrasonic waves, their results showed a significant decrease in blood glucose levels.[15]

DISEASES REQUIRING PULSATILE DRUG DELIVERY

Designing a pulsatile drug delivery system requires a deep comprehension of disease physiology. The pharmacokinetics and/or pharmacodynamics of medications are not constant over a 24-hour period for disorders when the body's rhythmic circadian organization plays a key role. This chronological behavior is seen in a number of diseases:

- One such condition that benefits from a pulsatile drug delivery system is asthma. Early in the morning is when normal lung function reaches its lowest point due to circadian fluctuations.
- Circadian rhythms affect a number of functions in cardiovascular illnesses, such as blood pressure, heart rate, stroke volume, cardiac output, and blood flow. For instance, vascular reactivity and capillary resistance are higher in the morning and lower later in the day. Additionally, there is a state of relative blood hypercoagulability in the morning due to an increase in platelet aggregability and a decrease in fibrinolytic activity.
- The therapeutic significance of circadian fluctuations in insulin and glucose for insulin replacement in Type 1 diabetes has been thoroughly investigated.
- In addition, a variety of circadian variations in lipid fractions in both patients and healthy individuals may result in modifications to the rhythmicity of other metabolisms and the blood coagulation system, which could cause a number of issues.[16]

Table No- 1 Diseases Requiring Pulsatile Drug Delivery

□ Disease	⏰ Chronological Rhythms (Why it Matters)	💊 Drugs Used (Class/Examples)	🎯 Rationale for Timing
Peptic Ulcer Disease	Late afternoon and nighttime are the times when stomach acid secretion is at its highest (usually between 10 PM and 2 AM).	H2 blockers, such as ranitidine and cimetidine	given at night in order to inhibit the nocturnal acid surge, which is the most important aspect of ulcer healing.
Asthma	A natural decrease in cortisol and adrenaline during the night and early morning hours exacerbates bronchoconstriction	Antihistamines and beta_2 Agonists, such as salbutamol	throughout order to cover the time of greatest danger (4:00 AM to 6:00 AM), long-acting beta-2 agonists are frequently administered

□ Disease	⏰ Chronological Rhythms (Why it Matters)	💊 Drugs Used (Class/Examples)	🎯 Rationale for Timing
	and airway inflammation.		throughout the evening.
Cardiovascular Diseases (e.g., Hypertension, Angina, Myocardial Infarction)	Blood pressure is at its lowest when you're sleeping and rises sharply and dangerously when you wake up (morning rise). Additionally, platelet aggregation peaks in the morning.	Calcium channel blockers, beta blockers, and ACE inhibitors	To reduce the risk of morning cardiovascular events, dosage should guarantee maximum medication concentration either before or during the early morning hours.
Arthritis (Rheumatoid)	Pain and stiffness are worse in the morning due to peak inflammatory cytokine (e.g., IL-6) release happening throughout the night.	NSAIDs, Glucocorticoids (e.g., Prednisone)	In order to offset the inflammatory surge before the patient awakens, delayed-release or evening-dosed glucocorticoids are timed to peak in the early morning.
Hypercholesterolemia	The dark/night cycle, when the liver is at rest and breaking down lipids, is when cholesterol synthesis is at its highest.	HMG-CoA Reductase Inhibitors (Statins) (e.g., Simvastatin)	In order to align with the peak activity of the synthesis enzyme (HMG-CoA reductase), shorter-acting statins are best administered in the evening or right before bed.
Diabetes Mellitus	Due to delayed insulin action and carbohydrate consumption, postprandial (after-meal) blood sugar levels rise.	Sulfonylurea, Insulin, Biguanides (e.g., Metformin)	Dosing is timed to coincide with the rise in blood glucose, particularly for oral secretagogues and rapid-acting insulin.

□ Disease	⏰ Chronological Rhythms (Why it Matters)	💊 Drugs Used (Class/Examples)	🎯 Rationale for Timing
Attention Deficit Syndrome (ADS/ADHD)	The objective is to control dopamine and norepinephrine levels in the brain to maintain concentration during critical learning times.	Methylphenidate (a psychostimulant)	Formulations are made with a second dose to address needs in the afternoon (when DOPA levels might be lower) and are intended for timed release to cover the working or school day.

Need of pulsatile drug delivery systems- For illnesses that exhibit circadian rhythms or time-dependent symptom fluctuations, pulsatile medication delivery methods are particularly helpful. Asthma, heart problems, hormone abnormalities, and specific kinds of discomfort are a few examples. In these circumstances, pulsatile delivery can release medications at particular times when the disease is at its peak or when the body's normal cycles are upset. This tactic can improve medication effectiveness and lessen negative effects that are frequently brought on by continuous or non-specific drug release. In general, the targeted and time-controlled release of therapeutic medicines requires pulsatile drug delivery systems. Compared to traditional drug administration techniques, these systems have a number of advantages, including increased patient compliance, reduced adverse effects, and higher therapeutic efficacy. To properly enhance pulsatile systems and apply them to clinical practice, however, further research and development work is needed.[17]

Pulsatile drug delivery system mechanism[18]:

There are mainly three mechanisms by which drug release occurs from a pulsatile drug delivery system:

1. **Diffusion:** This happens when a medication solution diffuses from the inside to the outside of the system as a result of water diffusing into the drug particles upon contact with a liquid in the gastrointestinal tract.
2. **Osmosis:** Under some circumstances, the osmotic pressure that results from water entering the drug particles can rise. The medication is subsequently forced out of the body by this internal pressure.
3. **Erosion:** Certain formulation blocks are made expressly to erode gradually over time, releasing the medication that is contained within the particles.

The latest technology used in the pulsatile drug delivery system:

The market's pulsatile medication delivery systems The following describes a number of commercial pulsatile drug delivery systems, including Pulsincap, Diffucap®, 3-Dimensional Printing®, CODAS®, OROS®, PULSYS, Diffutab, Orbexa, and Minitab:

Pulsincap Technology- R.R. Scherer International Corporation (Michigan) created the Pulsincap device, which is made up of an insoluble semi-capsule body that is sealed at the open end by a hydrogel cap that is covered in a water-soluble cap. To get rid of problems with inconsistent stomach emptying, an enteric polymer is applied to the entire device. The hydrogel expands as the capsule comes into contact with digestive fluid, eventually forcing the plug out of the capsule and causing the medication to release quickly.

Beads or granules with four layers—a core, the medication, bulking agents (such sodium aminoglycate or sodium carboxymethyl cellulose), and an insoluble outer membrane (composed of an aqueous polymer, like ethylcellulose, Eudragit® RL)—were used in another formulation technique. The bulking agents expand when the outer membrane is penetrated by gastrointestinal fluids. The medication is released quickly as a result of the membrane being damaged by the stress caused by this swelling force.

Polymers with varying viscosity classes, such as hydroxypropylmethylcellulose, polymethyl methacrylates, polyvinylacetate, and polyethylene oxide, were used in the hydrogel capsules.

Enteric-coated extended-release pills (ETP tablets) were another novel strategy. These were created by transforming an enteric polymer into sustained-release enteric tablets with a hydroxypropyl cellulose outer layer and a tablet core that contained the model medication diltiazem hydrochloride.[19,20]

The study's goal was to investigate the Pulsincap system's controlled release of the medication Diclofenac sodium as a function of time and pH.[21]

The DIFFUCAPS technology:

The solubility and absorption of some medications are affected by variations in the pH of the gastrointestinal system. This pH dependence can be problematic, especially when creating formulations with controlled or sustained release. Even though the intestine is the best location for active drug absorption, medications like carvedilol and dipyridamole are particularly problematic because they are soluble in the acidic circumstances of the stomach but insoluble in the neutral/slightly alkaline conditions of the intestine. Particularly concerning are weak and basic medicinal molecules that become insoluble at pH levels higher than five. The development and marketing of innovative controlled delivery systems for the once-or twice-daily administration of single pharmaceuticals or combinations with highly pH-dependent and/or poorly soluble drug profiles in physiological fluids is made easier by Eurand's Diffucaps® technology. This exclusive technique was created especially for simple and weak medications. It entails covering these drug-coated beads with functional polymers after adding an inhibitor polymer, a crystallization inhibitor, or a pharmaceutically acceptable organic acid to inert cores. By employing an acidic core, the final formulation guarantees that the medication is continuously surrounded by an acidic environment, which makes the drug soluble in vivo in a setting where it would not otherwise be.[22]

Compatibility with medications that are poorly soluble in low intestinal pH environments, environments with a pH above 8.0, or physiological fluids is one of this multiparticulate system's benefits. It allows for the achievement of the necessary pharmacokinetic profile and dose flexibility. In addition to minimizing the impact of food, this approach can offer the best release profiles for both single drugs and drug combos Additionally, the Diffucaps® drug delivery system can be used with other Eurand technologies to improve the gastrointestinal tract's ability to absorb medications.[23,24]

Three-dimensional printing-

Complex pharmaceutical devices have been made using three-dimensional printing (3DP), a novel solid

freeform manufacturing method and a kind of rapid prototyping (RP) technology. Using liquid bonding materials and powder techniques, prototyping entails building certain layers.

The many advantages of the 3DP system over alternative ways for improving pharmaceutical applications—such as new techniques for creating, developing, producing, and promoting different kinds of solid dosage forms—are highlighted in literature studies. For example, the versatility of 3DP technology enables its implementation in:

- Linear drug delivery systems
- Enteric delivery systems
- Rapid dissolution oral delivery systems
- Floating, timed, and pulsatile systems
- Dosage forms with multiphase release properties
- Implantable drug delivery systems (PDDS)

Furthermore, the delivery of very poisonous and strong medications, peptides, proteins, and poorly water-soluble pharmaceuticals, as well as the controlled release of several drugs in one form, can all be addressed by 3DP technology.

For the creation of solid drug delivery systems (DDS), 3DP technology has a number of benefits over traditional compression and other RP technologies because of its adaptable and highly repeatable manufacturing process. This opens the door for 3DP technology to advance in pharmaceutical applications.

The system's continued use is now limited by a few problems, such as the pharmacotechnical characteristics of 3DP products and the choice of appropriate excipients. Therefore, in order to properly integrate 3DP systems with traditional pharmaceuticals, more advancements are required to solve these issues.[25]

Dual and zero-order release forms were created using a surface degradation/erosion method based on HPMC, lactose, and Eudragit RL100. The release from tablets with a non-uniform drug distribution was modeled using the erosion rate constants. Diclofenac and chlorpheniramine dual-release tablets were designed with three separate drug areas, and the model tracked the tablet's two-sided disintegration.[26]

Diclofenac was sustained in three formulations for one to seven hours (9.6 mg/h), one to fifteen hours (6.8 mg/h), and one to thirty-six hours (2.5 mg/h). It has been extensively researched. [27]

CODAS (Chrono therapeutic Oral Absorption Drug System) :-

Sometimes the drug's immediate release is not what's wanted. It may be important to postpone the drug's action for a number of reasons. One example of a drug release that is scheduled to happen after a long lag time after injection is chronotherapy. To accomplish this extended delay, Elan Drug Technologies created the CODAS® technology.

The various benefits of the CODAS® system include:

- A release profile designed to complement the patient's biological rhythm.
- Controlled onset of action.
- A sustained release mechanism.
- A release rate that is largely independent of pH, position, and diet.
- A "sprinkle" dose, in which the contents of the capsule can be opened and added to meals.
- Reducing the effective daily dose and drug exposure.
- Targeting the gastrointestinal tract for a local effect.

- Reducing exposure in a methodical manner to reach a desired profile.[28,29]

A combination of water-soluble and water-insoluble polymers makes up the release control polymer. The medicine can diffuse through the resultant pores in the coating when water from the gastrointestinal tract comes into touch with the polymer-coated beads because the water-soluble polymer eventually degrades. The drug's regulated release is maintained by the water-insoluble polymer's ongoing barrier function. The release rate is mostly unaffected by diet, location, and pH. It has been shown that multiparticulate systems, including Verelan® PM, are not dependent on gastrointestinal motility.[30]

OROS technology : OROS delivery devices are authorized for use with medications that dissolve poorly in water. A bi-layer or tri-layer tablet core with a push layer and one or more drug layers is used in the push-pull system. Osmotic agents, suspending agents, and poorly soluble medications are all found in the drug layer. Water-swellable polymers and an osmotic agent are among the constituents of the push layer. The tablet core is encased in a semi-permeable membrane. The push-pull system, which is essentially a pulsatile drug delivery system, is an example of the present and future methods for administering medications to treat particular illnesses. When compared to first-order or zero-order drug delivery methods, pulsatile drug delivery shows great promise. By utilizing various polymer layers and adjusting the drug coating's thickness, pulsatile drug release can be produced.

Procardia XL®, DitropanXL®, and Concerta® are notable examples of the numerous OROS® (ALZA Corp.) systems that have been created. To promote compliance and therapeutic impact, the recently developed L-OROS® SOFTCAP administration system combines the features of a regulated delivery method with enhanced bioavailability.[31,32]

PULSYS: PULSYS, a delivery method created by Middle Brooks Pharmaceuticals, Inc., allows for the pulsatile or quick release of specific drugs. Additionally, a drug's continuous release and absorption are made possible by this technology. Among the company's PULSYS products are MOXATAG (Amoxicillin Extended Release) 775 mg Tablets, which are intended to treat pharyngitis/tonsillitis secondary to Streptococcus pyogenes (often known as strep throat) in adults and children 12 years of age and older. One immediate-release component and two delayed-release components make up the once-daily MOXATAG extended-release tablet. To prolong the release of amoxicillin in MOXATAG in comparison to regular amoxicillin, these three ingredients are mixed in a certain ratio utilizing PULSYS technology.[33,34]

Diffutab: Custom release profiles and region-specific releases are made possible by Diffutab technology. This method uses a combination of hydrophilic polymers and waxes to regulate medication release through tablet matrix erosion and diffusion. Diffutabs are particularly useful for high-dose goods and drugs that need to be taken once daily or with prolonged release. This method has been effectively used by Eurand for both soluble and insoluble materials. Because the matrix tablets combine the active medication with water-soluble particles, Diffutabs have a high drug load, support for prolonged release, and once-daily administration.[35,36]

Minitabs: Eurand Minitabs include gelling excipients that regulate the drug's release rate. To further control the discharge rate, further membranes may be added. Because these tablets are packaged into capsules, numerous medicines and/or release profiles can be combined into a single dosage form. Before applying any further coating, Eurand Minitabs can be prepared as matrix tablets. They can also be added to cuisine as a sprinkle. Eurand Minitabs combines the complexity of multiparticulate systems with the ease of tablet composition. Because of this, they can be used as a sprinkle for elderly and pediatric patients who have trouble swallowing pills, as well as for high medication loading.[37,38]

Artificial intelligence in PDDS

A smart control system, site-specific distribution, sustained release, and dose adjustment are some of the factors that must be taken into account while developing implantable drug delivery systems. Ultrasound, a micropump mechanism, and site-specific administration using microrobots are some of the drug delivery techniques employed. One possible technique for creating a drug delivery system loaded with microparticles or nanoparticles is the microfluidic system. Electronic devices, wireless hardware, and a power source have been integrated into a microchip implant (MicroCHIPS, Inc.) to enable programmable drug release, which offers pulsatile drug release for six months.[39,40,41]

Table No- 2 The latest technology used in the pulsatile drug delivery system

Technology/Brand	Type of Control	Core Mechanism	Primary Application
Pulsincap	Time-Controlled (Capsule)	When the outer cap melts, a swollen hydrogel plug releases the medication.	Chronotherapy (e.g., morning anti-arthritics).
ODAS	Time-Controlled (Coated Tablet)	The lag time is determined by the thick, slowly dissolving polymer film covering the drug core.	Simple, robust delayed release.
PULSYS	Time-Controlled (Multiparticulate)	Drug pellets with a time-delay barrier that has been programmed.	Reduced dose dumping; flexible lag times.
CODAS	Time-Controlled (Multiparticulate)	Hydrophilic and hydrophobic coating combination for a regulated extended lag period.	Chronotherapy for cardiovascular drugs.
OROS	Osmotic-Controlled	The drug is forced out of an orifice by osmotic pressure that develops inside a	Precise, zero-order release after delay (e.g., ADHD).

Technology/Brand	Type of Control	Core Mechanism	Primary Application
		semi-permeable membrane.	
PH	Site-Controlled Sensitive	An osmotic system's pH-sensitive membrane only dissolves in the colon.	Colon-specific delivery (e.g., Crohn's disease).

Future Scope of Pulsatile Drug Delivery Systems:

For many disorders, the pulsatile medication delivery system is thought to be the best option both now and in the future. When compared to first-order and zero-order drug delivery methods, it exhibits considerable promise. By using a different polymer layer and adjusting the coating's thickness, pulsatile drug release can be produced.[42]

Conclusion:

Although prolonged drug release and controlled drug delivery systems have been very successful in the pharmaceutical industry, they are unable to release or administer medications in accordance with the body's circadian rhythm. Because it delivers the medication in time with this rhythm, the pulsatile drug delivery system (PDDS) has grown in popularity. While maintaining the intended efficacy and lowering the risk of adverse effects, PDDS has decreased overdose incidents and dose frequency when compared to alternative controlled or prolonged drug delivery systems. There are numerous methods on the market, including temperature-induced PDDS, chemical-based PDDS, externally regulated systems, frangible coating layers, abrasive coating layers, and stimuli-stimulated PDDS. The pulsatile drug delivery system is anticipated to be a promising future, and these are helpful in treating a variety of disorders.

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