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A Review on Different Types of Pump used in Implantable Drug Delivery System

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ABSTARCT:

The cost-effective, cutting-edge implantable osmotic release pump is a medicine delivery method. This tiny implanted infusion pump may be used on mice, rats, and other lab animals for preclinical pharmacological research. Without the need for outside intervention, the mini-pump continuously and precisely distributes medications, hormones, and other test substances for durations of one day to one and a half months. The implanted pumps use osmosis to continuously inject laboratory animals that are uncontrolled.

KEY WORDS: Implantable Drug, Implantable pump, IDDS, ALZET osmotic pump, Rose and Nelson pump.

INTRODUCTION:

The most promising procedure-based method for regulated medication administration is osmotic pumps. Osmosis, which may be defined as the net flow of water molecules over a selectively permeable film caused by a difference in osmotic gradient over the layer, mediates the controlled drug delivery mechanism. Water can pass through the membrane because of the difference in solute concentration, however the majority of solute particles are rejected. To trigger the release of drugs from the pump, osmogens generate osmotic pressure.

Due to recent advancements and discoveries in the pharmaceutical sciences, such as pharmacokinetics, pharmacodynamics, and biopharmaceutics, drug delivery research has made significant strides during the past three decades. The study was motivated by controlled medication delivery and low development costs. In order to retain the optimal therapeutic dosage and efficacy, a major amount of the revolutionary drug delivery frameworks is updated so that the drug dose and dosing interval are decreased. These cutting-edge drug delivery systems were created to control medication release over a prolonged period of time. Additionally, recent developments have enabled the pace and amount of drug release to be independent of physiological parameters including the pH of the gastrointestinal tract, the presence of food, and nutritional status, as well as the physicochemical qualities of medications and excipients.

1) ALZET osmotic pump [1]

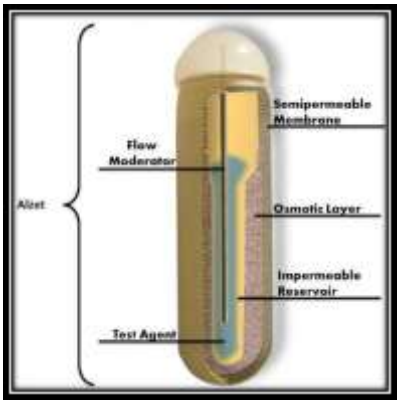

Figure : ALZET osmotic pump

Mechanism of Action :

- They consist of an osmotic agent, a semipermeable membrane, and a drug core (reservoir) (rate controller). After filling, a flow moderator is also put into the osmotic pump's body. It is a sort of implantable or insertable device where the active ingredient is a solution or suspension held in a cylindrical reservoir made of a synthetic, collapsible, impermeable elastomer wall (for example, polyester) and exposed to the outside world through a single aperture. (2)
- The water content in the tissue fluid will gradually pass through the semipermeable membrane once the osmotic pump is subcutaneously implanted at the targeted place in the body, dissolving the osmotically active substance. Osmotic pressure (compression of the flexible reservoir) is created in the small space between the stiff semipermeable compartment and the flexible reservoir wall. The reservoir progressively loses capacity, forcing the active agent's solution to depart via the flow moderator and allowing the medication to be delivered at a regulated rate.(3)

Advantages :

1. Release of zero orders
2. Regulated medication supply
3. Lessen the dosage frequency

Disadvantages :

1. 1.The pricey
2. Possibility of harmful effects from dosage dumping
3. Noncompliance by a patient (3)

Application :

- To continuously deliver hormones, drugs, and other test agents from one day to six weeks at predetermined rates
- including amino acids, anaesthetics, antibiotics, antibodies, anticancer agents, anticoagulants, antigens, hypertensives, anti-parasitic agents, anti-Parkinson agents, ascitic fluid, catechol amines, chelators, cholinergies, central nervous system acting agents, enzyme inhibitors, and analgesics.

2) ROSE AND NELSON PUMP :

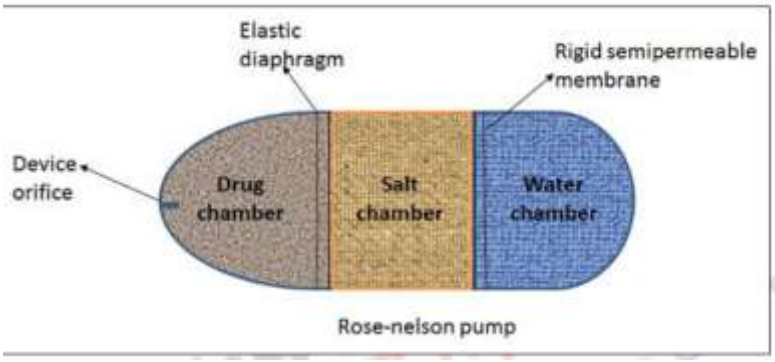

Figure : Rose and Nelson pump

Mechanism of Action :

- One of the earliest osmotic devices was the Rose-Nelson pump. It consists of a reservoir for drugs, a salt chamber, and a water chamber. Between the salt and water chambers is a stiff semipermeable membrane, and between the salt and drug chambers is an elastic diaphragm. Water enters the salt chamber as a result of the formation of an osmotic pressure differential across the semipermeable membrane (from lower concentration to the higher concentration of solute). This expands the salt chamber's size. At the same time, the elastic diaphragm expands to force the medication out of the apparatus. This pump's structure and workings are similar to the push-pull osmotic pump. The fact that the water chamber has to be charged before usage is this pump's main drawback..(4)

Advantages :

1. Release of zero orders.
2. Managed medication administration.
3. Lower the dosage frequency.

Disadvantages :

1. 1.Expensive.
2. The risk of toxicity brought on by dosage dumping.
3. 3.Rapid tolerance development There might be a hypersensitivity response.
4. It's challenging to be honest and reliable.

Application :

- To continuously deliver hormones, drugs, and other test agents from one day to six weeks at predetermined rates
- including amino acids, anaesthetics, antibiotics, antibodies, anticancer agents, anticoagulants, antigens, hypertensives, anti-parasitic agents, anti-Parkinson agents, ascitic fluid, catechol amines, chelators, cholinergies, central nervous system acting agents, enzyme inhibitors, and analgesics. (5,6)

3) HIGUCHI LEEPER PUMP :

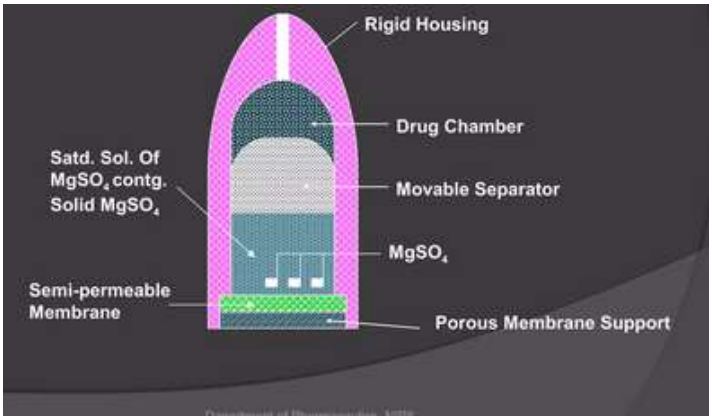

Figure: Higuchi leeper pump

Mechanism of Action :

- The Rose-Nelson pump is not like this device since it lacks an internal water chamber. Water enters the device from the rear through a porous support for the semipermeable membrane that is supported by a stiff casing. Saline solution is present in the salt chamber. The Higuchi-Leeper pump operates on the theory of water imbibition from the environment. The pump is activated when the device is ingested or implanted in the body, which causes the surrounding biological fluid to seep into the device through the porous semipermeable membrane. This fluid influx dissolves the salt, generating osmotic pressure that pushes the moveable separator toward the drug chamber to keep the substance inside the device out of the device. This kind of pump is frequently used in veterinary medicine to give animals antibiotics or growth hormones. The lack of an internal water chamber makes this device less prone to microbial contamination. Consequently, it may be kept for a longer period of time before usage.(7)

Advantages :

1. Osmotic systems can achieve the best possible delivery rate, which is zero-order.
2. Simple administration.
3. Better success in the treatment of chronic illnesses.
4. If desired, delivery can be delayed or pulsed.
5. Because of the special qualities of the semipermeable membrane (SPM) used in coating osmotic formulations, medication release for oral osmotic systems is independent of stomach pH and hydrodynamic circumstances.
6. Boost bioavailability (8)

Disadvantages:

1. Non-compliance by the patient
2. It is necessary to have trained and educated personnel.
3. Costly.
4. Possibility of toxicity owing to dosage.
5. Rapid development of tolerance.
6. Possibility of hypersensitivity reaction.

Application :

- When a lengthy time of regulated release is necessary for the treatment of chronic disorders, this technique is frequently utilised.
- to continually provide test chemicals, such as hormones and medicines, at predetermined rates..(9)

4) MINI OSMOTIC PUMP :

- Alza Corp. first created the mini osmotic implanted pump for use in research involving animal models. These pumps' ability to function depends on the osmotic pressure differential between a compartment within the pump (the salt sleeve) and the tissue environment in which the pump is located. layer of osmosis (10)

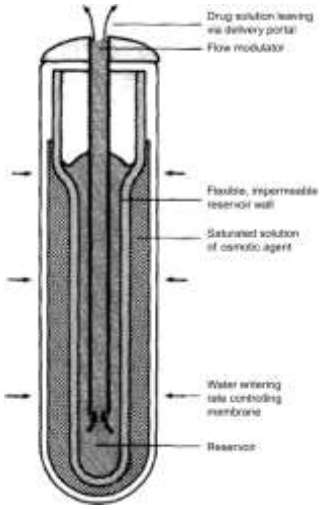

Figure : **MINI OSMOTIC PUMP**

Mechanism of action :

- Water enters the pump through a semi-permeable membrane that makes up the pump's outer surface because of the high osmolality of the salt sleeve. Water flows into the salt sleeve, compressing the flexible reservoir. This continues to remove the test solution from the pump at a regulated, pre-set rate. Because it is not feasible to refill the compressed reservoir, little osmotic pumps are only intended for single use. (11)

Advantages :

1. Release of zero orders.
2. Managed medication administration.
3. Lower the dosage frequency.

Disadvantages :

1. Expensive.
2. Possibility of harmful effects from dosage dumping.
3. Tolerance is developed quickly There might be a hypersensitivity response.
4. It's hard to maintain integrity and consistency.

Application:

- Osmotic pumps are tiny infusion pumps used to provide medications to lab animals continuously.These tiny pumps give scientists a way to deliver regulated, continuous agents in vivo.
- Osmotic pumps can be placed subcutaneously or intraperitoneally and utilised for systemic delivery.

5) SANDWICHED OSMOTIC PUMP:

Sandwiched osmotic tablets have two delivery orifices with a semi-permeable membrane covering and a polymeric push layer sandwiched between two drug layers.(11)

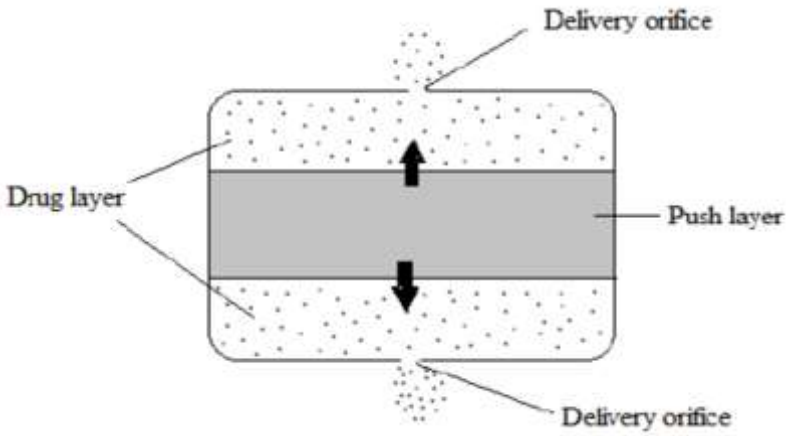

Figure : SANDWICHED OSMOTIC PUMP

Mechanism of action :

- The middle push layer, which contains the swelling agents, imbibes water from the surroundings through the semi-permeable membrane when the device is exposed to an aqueous environment. As a consequence, the medication is delivered through the two orifices located on the tablet's opposing sides. So, medicines that might induce localised irritation of the stomach mucosa are best treated with SOTS (12,13)

Advantages:

1. Osmotic systems can achieve the best possible delivery rate, which is zero-order.
2. Simple administration.
3. Better success in the treatment of chronic illnesses.
4. If desired, delivery can be delayed or pulsed.
5. Because of the special qualities of the semipermeable membrane (SPM) used in coating osmotic formulations, medication release for oral osmotic systems is independent of stomach pH and hydrodynamic circumstances.
6. Boost bioavailability

Disadvantages:

1. Non-compliance by the patient
2. It is necessary to have trained and educated personnel.
3. Expensive.
4. Risk of harm brought on by dosage
5. Quickly increasing tolerance

Applications:

- A 24-hour continuous delivery of a water-insoluble medication is possible using a sandwiched osmotic pump tablet.
- Drug release is seldom affected by release media or agitation level.(13)

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