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Review Article

FLOATING DRUG DELIVERY SYSTEM: A NOVEL APPROACH

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ABSTRACT
Floating Drug Delivery System is a Novel drug delivery system used to achieve the gastric retention of dosage form which will leads to prolonged release and action of drugs. This delivery system retained in the stomach for a longer period of time and thereby improves the bioavailability of drugs. Several approaches are currently used in the prolongation of gastric residence time (GRT) including floating drug delivery system also called as hydrodynamically balanced system, swelling and expanding system, polymeric bioadhesive systems, high density systems etc. This review also contains current and recent advances in floating drug delivery systems.
Key words: Floating Drug Delivery System, Floating Systems, Effervescent Systems, Non-Effervescent Systems.

INTRODUCTION

A tablet is a pharmaceutical dosage form. It consist a mixture of active substances and excipients, usually in a powder form, and then pressed into a tablet. The excipients include diluents, binders, granulating agents, glidants (flow aids) and lubricants to ensure efficient tablet; disintegrants are used to promote tablet break-up in the digestive tract; sweeteners or flavors to enhance taste; and pigments to make the tablets visually attractive. A polymer coating is also applied to make the tablet smoother and easier to swallow. Oral drug delivery is the most useful form of drug delivery, having the highest degree of patient compliance, and still the preferred route of drug administration. Drugs that are easily absorbed from the gastrointestinal tract and having short biological half-life are eliminated quickly from the blood circulation. An incomplete release of the drug and shorter residence time of the dosage form in the upper gastro intestinal tract, will lead to lower bioavailability. Therefore, prolonged gastric retention is important in achieving control over the gastro retention time because this helps to retain the controlled release system in the stomach for a longer and predicted time. Drugs that require to be designed as gastro retentive systems are those,

1) Acting locally in stomach.
2) Primarily absorbed from the stomach.
3) Poorly soluble in alkaline pH.
4) Absorbed rapidly from the gastrointestinal tract, and that degrades in the colon.[1]

To formulate a successful gastro-retentive drug delivery system, several techniques are currently used such as hydrodynamically balanced systems (HBS)/ floating drug delivery system, low-density systems, raft systems incorporating alginate gels, bioadhesive or mucoadhesive systems, high density systems, superporous hydrogels, single and multiple unit gas generating systems, hollow microsphere, and magnetic systems.

There are three possible techniques to rendered drug floating,

- Gas contains floating systems:- Generation of co2 gas via chemical reaction between sodium bicarbonate and hydrochloric acid of gastric juice. The gas kept in the stomach ensures its floating
- Systems with low density core not subject to rapid chemical and physical changes, providing for the drug floatation.
- The core is coated with a gel or other polymeric shells from which drug are gradually released.[2]

Requirements for Gastric Retention:-

To achieve gastric retention, the dosage form must satisfy the following requirements,

a) The dosage form must be able to withstand the forces caused by peristaltic waves in the stomach and the constant contractions and grinding and churning mechanisms.
b) It must resist the premature gastric emptying.
c) Once its purpose has been served, the device should be removed from the stomach with ease.[1]

FLOATING DRUG DELIVERY SYSTEM (FDDS)

Floating systems, first described by Davis in 1968, FDDS have bulk density lower than that of the gastric fluid, and thus remain float in stomach for a prolong period. Sustained-release dosage forms gives prolonged action of a drug in the body. A floating drug-delivery system floats in the gastric juice without affecting the gastric emptying rate. It forms a cohesive gel barrier that serves as a reservoir and releases the drug over the desired period of time. This technique helps to increase the drug's gastric residence time and reduces the variability in bioavailability.[1] while the system is floating on the gastric contents the drug is released slowly at the desired rate. After release of drug, the system is eliminated from the stomach. This results in an increased GRT and a better control on fluctuations in plasma drug concentrations. The floating sustained release dosage forms exhibit most of the characteristics of hydrophilic matrices and are known as 'hydrodynamically balanced systems' (HBS) since they are able to maintain their low apparent density, while the polymer hydrates and builds a gel like barrier at the outer surface. The drug is released progressively from the swollen matrix, as in the case of conventional hydrophilic matrices. These forms are expected to remain buoyant (3–4 h) in the gastric contents without affecting the intrinsic rate of emptying because their bulk density is lower than that of the gastric fluid.

Among the different hydrocolloids recommended for floating form formulations, cellulose ether polymers are the most popular, especially hydroxypropylmethylcellulose (HPMC). Fatty material with a bulk density lower than one may be added to the formulation to decrease the water intake rate and increase buoyancy. In parallel with formulation studies, investigations have been undertaken in animals and humans to evaluate the intragastric retention performance of floating. These assessments were carried out either indirectly through

pharmacokinetic studies with a drug tracer, or directly by means of X-ray and gamma scintigraphic monitoring of the transit through the GI tract. When a floating capsule is administered to subjects who have consumed a fat and protein meal, it remains buoyant at the surface of the gastric contents in the upper part of the stomach and moves to the lower region progressively as the meal empties from the stomach. The reported gastric retention times range from 4 to 10 h. Pharmacokinetic and bioavailability evaluation studies confirm the favorable effect of this prolonged gastric residence time.[2]

MECHANISM OF FLOATING SYSTEMS

Various attempts have been made to retain the dosage form in the stomach as a way of increasing the retention time. These attempts include introducing floating dosage forms (gas-generating systems and swelling or expanding systems), Floating drug delivery systems (FDDS) have a bulk density less than gastric fluids and so remain buoyant in the stomach without affecting the gastric emptying rate for a prolonged period of time. While the system is floating on the gastric contents (given in the Figure 1 (a)), the drug is released slowly at the desired rate from the system. After release of drug, the residual system is emptied from the stomach. This results in an increased GRT and a better control on the fluctuations in plasma drug concentration. However, besides a minimal gastric content needed to allow the proper achievement of the buoyancy retention principle, a minimal level of floating force (F) is also required to keep the dosage form reliably buoyant on the surface of the meal. To measure the floating force kinetics, a novel apparatus for determination of resultant weight has been reported in the literature. The apparatus operates by measuring continuously the force equivalent to F (as a function of time) that is required to maintain the submerged object. The object floats better if F is on the higher positive side (Figure 1(b)). This apparatus helps in optimizing FDDS with respect to stability and durability of floating forces produced in order to prevent the drawbacks of unforeseeable intragastric buoyancy capability variations.[3]

F = F buoyancy - F gravity = (Df - Ds) gv

Where, F= total vertical force,
Df = fluid density,
Ds = object density,
v = volume and
g = acceleration due to gravity [3, 4]

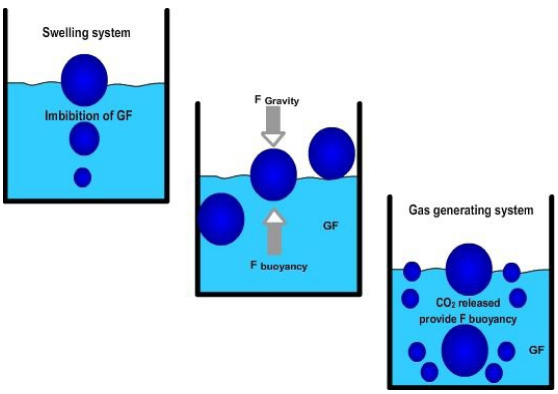

FIG. 1 MECHANISM OF FLOATING DRUG DELIVERY SYSTEM[4]

CLASSIFICATION OF FDDS BASED ON MECHANISM OF BUOYANCY

A. Single Unit Floating Dosage Systems
  a) Effervescent Systems (Gas generating system)
  b) Non-effervescent Systems
B. Multiple Unit Floating Dosage Systems
  a) Non-effervescent Systems
  b)Effervescent Systems
  c) Hollow Microspheres
C. Raft Forming Systems
D. Expandable, Unfoldable, and Swellable systems.
E. Mucoadhesive or Bioadhesive systems.

Effervescent Systems/ Gas-generating Systems:-

These buoyant systems use matrices prepared with swellable polymers like HPMC, polysaccharides like chitosan, effervescent components like sodium bicarbonate, citric acid and tartaric acid or chambers containing a liquid that becomes a gas at body temperature. The optimal stoichiometric ratio of citric acid and sodium bicarbonate for gas generation is reported to be 0.76: 1. The common approach for preparing these systems involves resin beads loaded with bicarbonate and coated with ethyl cellulose. The coating, which is insoluble but permeable, allows permeation of water. Thus, carbon dioxide is released, causing the beads to float in the stomach .

Other approaches and materials that have been reported are highly swellable hydrocolloids and light mineral oils, a mixture of sodium alginate and sodium bicarbonate, multiple unit floating pills that generate carbon dioxide (co2) when ingested [1, 2]

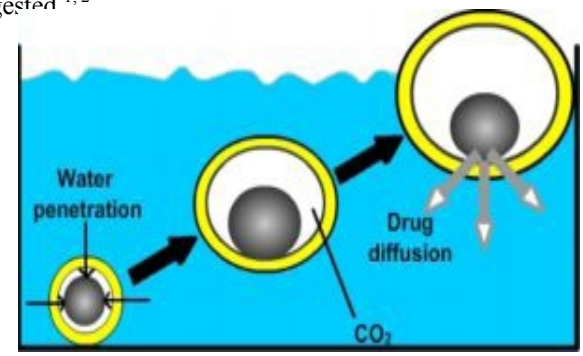

FIG.2 Mechanism of floatation via CO2 generation.[4]

Non-effervescent systems :-

Colloidal gel barrier system

Such systems contains drug with gel forming hydrocolloids meant to remain buoyant on stomach contents. This system incorporates a high level of one or more gel forming highly swellable cellulose type hydrocolloids. e.g. HEC, HPMC, NaCMC, Polysacchacarides and matrix forming polymer such as polycarbophil, polyacrylates and polystyrene etc. when coming in contact with gastric fluid, the hydrocolloid in the system hydrates and forms a colloidal gel barrier around the gel surface. The air trapped by the swollen polymer maintains a density less than unity and confers buoyancy to these dosage forms.

Microporous Compartment System:

This technology is based on the encapsulation of drug reservoir inside a Microporous compartment with aperture along its top and bottom wall. The peripheral walls of the drug reservoir compartment are completely sealed to prevent any direct contact of the gastric mucosal surface with the undissolved drug. In stomach the floatation chamber containing entrapped air causes the delivery system to float over the gastric contents. Gastric fluid enters through the apertures, dissolves the drug, and carries the dissolve drug for continuous transport across the intestine for absorption.

Alginate beads

Multiple unit floating dosage forms have been developed from freeze-dried calcium alginate. Spherical beads of approximately 2.5 mm in diameter can be prepared by dropping a sodium alginate solution in to aqueous solutions of calcium chloride, causing precipitation of calcium alginate. The beads are then separated snap and frozen in liquid nitrogen, and freeze dried at -40°C for 24 hours, leading to the formation of porous system, which can maintain a floating over a 12 hours.[1,4,5]

Hollow microspheres

Hollow microspheres (microballons), loaded with drug in their outer polymer shells were prepared by a novel emulsion-solvent diffusion method. The ethanol : dichloromethane solution of the drug and an enteric acrylic polymer was poured in to an agitated aqueous solution of PVA that was thermally controlled at 40° C.The gas phase generated in dispersed polymer droplet by evaporation of dichloromethane formed in internal cavity in microspheres of the polymer with drug. The microballons floated continuously over the surface of acidic dissolution media containing surfactant for greater than 12 hours in vitro.[5]

Raft Forming system

Raft forming systems have received much attention for the delivery of antacids and drug delivery for gastrointestinal infections and other disorders. The mechanism involved in the raft formation includes the formation of a viscous cohesive gel in contact with gastric fluids, wherein each portion of the liquid swells forming a continuous layer called a raft. This raft floats on gastric fluid because of the low bulk density created by the formation of CO2. Usually, the system contains a gel forming agent and alkaline bicarbonates or carbonates responsible for the formation of CO2 to make the system less dense and able to float on the gastric fluids. It is used for the treatment of Helicobacter pylori (H. pylori) infections in the GIT.[2]

Expandable, Unfoldable, and Swellable Systems

The dosage form must be small enough to be swallowed and must not cause gastric obstruction either singly or by accumulation. Thus, their configurations are required to develop expandable system to prolong gastric retention time (GRT). Thus, gastroretentivity is improved by the combination of substantial dimension with high rigidity of dosage form to withstand peristalsis and mechanical contractility of the stomach. Unfoldable and swellable systems are used to develop an effective gastro retentive drug delivery. Unfoldable systems are made of biodegradable polymers. They are available in different geometric forms like tetrahedron, ring or planner membrane of biodegradable polymer compressed within a capsule which extends in the stomach.

Swellable systems are also retaining in the gastro intestinal tract (GIT) due to their mechanical properties. The swelling is usually results from osmotic absorption of water. Expandable systems have some drawbacks like problematic storage of much easily hydrolysable, biodegradable polymers.[3]

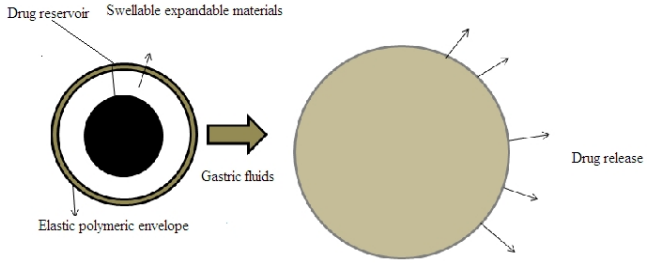

FIG 3. DRUG RELEASE FROM SWELLABLE SYSTEMS.[3]

Mucoadhesive or Bioadhesive Systems

The basis of mucoadhesion is that a dosage form can stick to mucosal\ surface by different mechanisms. Different theories to explain these mechanisms are,

1. Mucoadhesion take place by attractive electrostatic forces between the glycoprotein mucin network and the bioadhesive material.
2. Adsorption theory- Bioadhesion is due to secondary forces as Vander Waals forces and hydrogen bonding.
3. Wetting theory- Based on the ability of bioadhesive polymers to spread and develop intimate contact with mucus layers.
4. Diffusion theory- Physical entanglement of mucin strands and the flexible polymer chains, or an interpenetration of mucin strands into the porous structure of polymer substrate.[3]

FACTORS AFFECTING GASTRIC RETENTION:

Density

Density of the dosage form is inversely proportional to the gastric retention.

Density of the dosage form should be less than the gastric content density. (1.004 gm/ml)

Size and Shape

Dosage form unit with a diameter of more than 7.5 mm are reported to have an increased GRT competed to with those with a diameter of 9.9 mm.

The dosage form with a shape tetrahedron and ring shape devises with a flexural modulus of 48 and 22.5 kilopond per square inch (KSI) are reported to have better GIT @ 90 to 100 % retention at 24 hours compared with other shapes.[6]

Fed or Unfed State

Under fasting conditions, the GI motility is characterized by periods of strong motor activity or the migrating myoelectric complexes (MMC) that occurs every 1.5 to 2 hours. The MMC sweeps undigested material from the stomach and if the timing of administration of the formulation coincides with that of the MMC, the GRT of the unit can be expected to be very short. However, in the fed state, MMC is delayed and GRT is considerably longer.

Nature of the meal

Feeding of indigestible polymers of fatty acid salts can change the motility pattern of the stomach to a fed state, thus decreasing the gastric emptying rate and prolonging the drug release.[6]

Caloric Content

GRT can be increased between 4 to 10 hours with a meal that is high in proteins and fats.

Frequency of feed

The GRT can increase by over 400 minutes when successive meals are given compared with a single meal due to the low frequency of MMC.

Age
Elderly people, especially those over 70 years have a significantly longer GRT.

Posture
GRT can vary between supine and upright ambulatory states of patient.[8]

Concomitant drug administration
Anticholinergic like atropine and propentheline Opiates like codeine and prokinetic agents like metoclopramide and cisapride.

ADVANTAGES OF FLOATING DRUG DELIVERY SYSTEAM:

Floating drug delivery systems have numerous advantages listed below:

- Acidic substances like aspirin cause irritation on the stomach wall when come in contact with it. Hence, HBS formulation may be useful for the administration of aspirin and other similar drugs.
- The FDDS are useful for drugs which are absorbed through the stomach. E.g. Ferrous salts and for drugs meant for local action in the stomach and treatment of peptic ulcer disease e.g. Antacids.
- When there is vigorous intestinal movement and short transit time as might occur in certain type of diarrhea, poor absorption is expected. Under such circumstances it may be advantageous to keep the drug floating condition in stomach to get a relatively better response.
- This method is also effective with medicaments which are absorbed from the intestine. E.g. Clorpheniramine maleate
- Drugs which has narrow absorption window in the small intestinal region, that are formulated as Floating drug delivery system (FDDS).
- Certain types of drugs can benefit from using FDDS , these includes,

a) Drugs acting locally in the stomach.
b) Drugs those are primarily absorbed in stomach.
c) Drugs those are poorly soluble in alkaline pH.
d) Drugs with narrow absorption window.
e) Drugs those are degrade in the colon.

- FDD minimizes the counter activity of the body leading to higher drug efficiency.
- FDDS minimizes the fluctuations of drug concentration and effects. Therefore, the concentration dependant adverse effects that are associated with peak concentration can be presented. This feature is of special importance for drugs with narrow therapeutic index.

DISADVANTAGES OF FLOATING DRUG DELIVERY SYSTEMS

- There are certain situations where gastric retention is not desirable. Aspirin and non-steroidal anti-inflammatory drugs are known to cause gastric lesions, and slow release of such drugs in the stomach is unwanted.
- Thus, drugs that may irritate the stomach lining or are unstable in its acidic environment should not be formulated in gastroretentive system.
- Other drugs, such as isosorbide dinitrate, that are absorbed equally well throughout the GI tract will not benefit from incorporation into a gastric retention system.
- Not suitable for drugs that have solubility or stability problem in GIT.
- Drugs such as nifedipine which is well absorbed along the entire GIT and which undergoes first pass metabolism, may not be desirable.
- Not suitable for drugs that have solubility or stability problem in GIT.[1, 3, 10, 11]

EVALUATION PARAMETERS OF FDDS

Weight variation: Uniformity of Weight according to Indian pharmacopoeia, 20 tablets were selected at random, weight together and individually for the determination of weight of tablets. The mean and standard deviations were calculated.

Hardness : Hardness or tablet crushing strength (fc), the force required to break a tablet in a diametric Compression was measured using Monsanto tablet hardness tester. It is expressed in kg/cm2.

Friability: Friability The friability test was carried out in Roche Friabilator. Ten tablets were weighted (Wo) initially and put in a rotating drum. Then the tablets were subjected to 100 falls of 6 in. height. After completion of rotation, the tablets were again weighted (W).

$$\% \text{ Weight loss or friability (f)} = (1 - w/ w0) \times 100$$

Disintegration time: In vitro disintegration time was determined using disintegration test apparatus. For this, a tablet was placed in each of the six tubes of the apparatus and one disc was added to each tube. The time taken for complete disintegration of the tablet with no palpable mass remaining in the apparatus was measured.

Buoyancy time (Floating time) : A tablet was introduces in to beaker containing 100ml of 0.1N HCL. The time taken by the tablet to come up to the surface and floated was taken as the buoyancy time. An average of three determinations was taken for the floating forms.

Drug release: Dissolution tests are performed using the dissolution apparatus. Samples are withdrawn periodically from the dissolution medium with replacement and then analyzed for their drug content after an appropriate dilution.

Content uniformity: The drug content in each formulation was determined by triturating 20 tablets and powder equivalent to average weight was added in 100ml of solvent, followed by stirring for 30 minutes. The solution was filtered through a 0.45µ membrane filter, diluted suitably and the absorbance of resultant solution was measured spectrophotometrically in UV.

X-ray/gamma scintigraphy

X-ray/gamma scintigraphy is currently a very popular method for evaluating parameters for floating dosage forms. It helps to locate the dosage form in the GIT and it can be used to predict and correlate the gastric emptying time and the passage of the dosage form in the GIT. Here, the inclusion of a radio-opaque material into a solid dosage form enables it to be visualized by X- rays. Similarly, the inclusion of a γ-emitting radio-nuclide in a formulation allows indirect external observation using a γ-camera or scintiscanner. In case of γ-scintigraphy, the γ-rays emitted by the radio-nuclide are focused on a camera, which helps to monitor the location of the dosage form in the GI tract.

RECENT ADVANCES IN FLOATING DRUG DELIVERY SYSTEM

Ninan Ma *et al* developed a type of multi-unit floating alginate (Alg) microspheres by the ionotropic gelation method with calcium carbonate (CaCO3) being used as gas-forming agent. Attempts were made to enhance the drug encapsulation efficiency and delay the drug release by adding

chitosan (Cs) into the gelation medium and by coating with Eudragit, respectively. The gastrointestinal transit of optimized floating sustainedrelease microspheres was compared with that of the nonfloating system manufactured from identical material using the technique of gamma-scintigraphy in healthy human volunteers. It was found that the drug encapsulation efficiency of Cs–Alg microspheres was much higher than that of the Ca–Alg microspheres, and coating the microspheres with Eudragit RS could extend the drug release significantly. Both uncoating and coating microspheres were able to continuously float over the simulated gastric fluid (SGF) for 24 h *in vitro*. Prolonged gastricretention time (GRT) of over 5 h was achieved in the volunteer for the optimized coating floating microspheres (FM). In contrast, non-floating system (NFM) could be emptied within 2.5 h.

Sungthongjeen *et al* have prepared a floating multilayer coated tablets based on gas formation. The system consists of a drug-containing core tablet coated with a protective layer (hydroxypropyl methylcellulose), a gas forming layer (sodium bicarbonate) and a gas-entrapped membrane, respectively. Eudragit® RL 30D was chosen as a gas-entrapped membrane due to its high flexibility and high water permeability. The obtained tablets enabled to float due to the CO2-gas formation and the gas entrapment by polymeric membrane. The effect of formulation variables on floating properties and drug release was investigated. The floating tablets using direct-compressed cores had shorter time to float and faster drug release than those using wet-granulated cores. The increased amount of a gas forming agent did not affect time to float but increased the drug release from the floating tablets while increasing coating level of gasentrappe membrane increased time to float (more then 8 hours) and slightly retarded but sustained drug release.

Rajnikanth and Mishra have developed a floating in situ gelling system of clarithromycin (FIGC) using gellan as gelling polymer and calcium carbonate as floating agent for potentially treating gastric ulcers, associated with Helicobacter pylori. Gellan based FIGC was prepared by dissolving varying concentrations of gellan in deionized water to which varying concentrations of drug and sucralfate were dispersed well. The addition of sucralfate to the formulation significantly suppressed the degradation of clarithromycin at low pH. FIGC showed a significant anti-H. pylori effect than that of clarithromycin suspension. The in situ gel formulation with sucralfate cleared H.pylori more effectively than that of formulation without sucralfate. In addition, the required amount of clarithromycin for eradication of H. pylori was found to be less from FIGC than from the corresponding clarithromycin suspension. It was concluded that prolonged gastrointestinal residence time and enhanced clarithromycin stability resulting from the floating in situ gel of clarithromycin might contribute better for complete clearance of H. pylori.[2, 4]

DRUGS USED IN THE FORMULATIONS OF FLOATING DOSAGE FORMS

Floating microspheres – Aspirin, Griseofulvin, p-nitroaniline, Ibuprofen, Ketoprofen, Piroxicam, Verapamil, Cholestyramine, Theophylline, Nifedipine, Nicardipine, Dipyridamol, Tranilast and Terfinadine ·

Floating granules - Diclofenac sodium, Indomethacin and Prednisolone

Films – Cinnarizine , Albendazole

Floating tablets and Pills – Acetaminophen Acetylsalicylic acid, Ampicillin, Amoxycillin trihydrate, Atenolol, Fluorouracil, Isosorbide mononitrate , Para- aminobenzoic acid, Piretanide , Theophylline, Verapamil hydrochloride, Chlorpheniramine maleate, Aspirin, Calcium Carbonate, Fluorouracil, Prednisolone, Sotalol, pentoxyfilline and Diltiazem HCl.

Floating Capsules - Chlordiazepoxide hydrogen chloride, Diazepam, Furosemide, Misoprostol, L-Dopa, Benserazide, Ursodeoxycholic acid and Pepstatin, and Propranolol.[2, 4]

MARKETED PRODUCTS OF FDDS

Some of the marketed formulations are listed as follows:-

Table. 1. GASTRORETENTIVE PRODUCTS AVAILABLE IN THE MARKET.[3, 5]

BRAND NAME	DELIVERY SYSTEAM	DRUG (DOSE)	COMPANY NAME
Val release @	Floating Capsule	Diazepam (15mg)	Hoffmann-LaRoche
Topalkan@	Floating liquid alginate preparation	Al—Mg Antacid	Pierre Fabre Drug, France
Conviron®	Colloidal gel forming FDDS	Ferrous sulphate	Ranbaxy, India
Cytotech®	Bilayer floating capsule	Misoprostol (100µg/200µg	Pharmacia, USA
Cifran OD®	Gas-generating floating form Effervescent Floating liquid alginate preparations	Ciprofloxacin (1gm)	Ranbaxy, India
Liquid Gaviscon®	Floating CR capsule	Al hydroxide (95 mg), Mg Carbonate (358 mg)	GlaxoSmithKline, India
Madopar HBS		Levodopa & benserazide	Roche product, USA.

APPLICATIONS OF FLOATING DRUG DELIVERY SYSTEMS

Floating drug delivery offers several applications for drugs having poor bioavailability because of the narrow absorption window in the upper part of the gastrointestinal tract. It retains the dosage form at the site of absorption and thus enhances the bioavailability.

Sustained Drug Delivery :-

HBS systems can remain in the stomach for long periods and hence can release the drug over a prolonged period of time. The problem of short gastric residence time encountered with an oral CR formulation hence can be overcome with these systems. These systems have a bulk density of <1 as a result of which they can float on the gastric contents. These systems are relatively large in size and passing from the pyloric opening is prohibited

E.g. Sustained release floating capsules of nicardipine hydrochloride were developed and were evaluated in vivo. The formulation compared with commercially available MICARD capsules using rabbits. Plasma concentration time curves showed a longer duration for administration (16 hours) in the sustained release floating capsules as compared with conventional MICARD capsules (8 hours).

Site-Specific Drug Delivery :-

These systems are particularly advantageous for drugs that are specifically absorbed from stomach or the proximal part of the small intestine, e.g., riboflavin and furosemide.

E.g. Furosemide is primarily absorbed from the stomach followed by the duodenum. It has been reported that a monolithic floating dosage form with prolonged gastric residence time was developed and the bioavailability was increased. AUC obtained with the floating tablets was approximately 1.8 times those of conventional furosemide tablets.

Absorption Enhancement

Drugs that have poor bioavailability because of site-specific absorption from the upper part of the gastrointestinal tract are potential candidates to be formulated as floating drug delivery systems, thereby maximizing their absorption.

E.g. A significantly increase in the bioavailability of floating dosage forms(42.9%) could be achieved as compared with commercially available LASIX tablets (33.4%) and enteric coated LASIX-long product (29.5%).[10, 12]

CONCLUSION

Gastroretentive floating drug delivery systems have emerged as an efficient means of enhancing the bioavailability and controlled delivery of many drugs. The increasing sophistication of delivery technology will ensure the development of increase number of gastroretentive drug delivery system which has the high absorption window and therapeutic index. The FDDS become an additional advantage for drugs that are absorbed primarily in the upper part of GI tract, i.e., the stomach, duodenum, and jejunum.

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