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Review Article

HYDRODYNAMICALLY BALANCED SYSTEMS (HBS): INNOVATIVE APPROACH OF GASTRO RETENTION: A REVIEW

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ABSTRACT
The objective of writing this review on hydrodynamically balanced systems (HBS) was collection of the recent literature. The design of hydrodynamically balanced drug delivery system is base on prolong GI residence time of drug in an area of the GI tract to maximize drug reaching its absorption. Gastrointestinal transit time of orally administered dosage forms are controlled by using gastro retentive drug delivery systems (GRDDS). Need for GRDDS a controlled drug delivery system with prolonged residence time in the stomach. Floating drug delivery systems is one of the important approaches to achieve gastric retention to obtain sufficient drug bioavailability. This delivery system is desirable for drugs with an absorption window in the stomach or in the upper small intestine
KEYWORDS: Floating drug delivery systems, gastro retentive drug delivery systems (GRDDS), Gastrointestinal transit time ,Hydrodynamically balanced systems

INTRODUCTION

An ideal drug delivery system is one that transports the drug to its site of action and releases it in concentration that elicit optimal therapeutic response for as much time as is desired. Ideally, it should provide the drug only when and where it is needed and in the minimum dose level to elicit desired therapeutic effects. The Hydrodynamically balanced drug delivery system, in either capsule or tablet form, is designed to prolong GI residence time of drug in an area of the GI tract to maximize drug reaching its absorption. System is best suited for drugs having a better solubility in acidic environment and having specific site of absorption in the upper part of the small intestine. Gastrointestinal transit time of orally administered dosage forms are controlled by using gastro retentive drug delivery systems (GRDDS).

NEED FOR GRDDS

Need for GRDDS A controlled drug delivery system with prolonged residence time in the stomach is of particular interest for drugs which

- Are locally active in the stomach (misoprostol, antacids antibiotics against H. pylori).
- Have an absorption window in stomach or in the upper small intestine (L-dopa, P-amino benzoic acid, furosemide).
- Are unstable in the intestine or colonic environment (captopril).
- Exhibit low solubility at high pH values (diazepam, verapamil).
- Alter normal flora of the colon (antibiotics). Absorbed by transporter mechanism (paclitaxel).

Physiological Consideration of Gastrointestinal Tract

- The stomach having three anatomical regions: fundus, body and pylorus.
- The former two act as reservoir for ingested material whereas the latter is the major site for motions (gastric emptying).
- The gastric emptying process is variable from few minutes to few hours, depending on physiological state of the subject and the design of the formulation.
- The relatively brief gastric emptying time (GET) in humans, which normally averages 2-3 hours through the major absorption zones (stomach or upper part of the intestine) can result in incomplete drug release from the drug delivery systems leading to diminished efficacy of the administered dose.
- Thus, orally administered controlled release forms suffer from mainly two adversities: the short gastric retention time and unpredictable GET [1].

Stomach: Basic Anatomy, Physiology and Problems

Anatomy

The stomach lies between the oesophagus (proximally) and the duodenum (distally). It varies widely in size and shape depending on the person, the food content, and the posture of the body. It is J-shaped normally and the pyloric part lies horizontally or ascends to meet the proximal part of the duodenum.

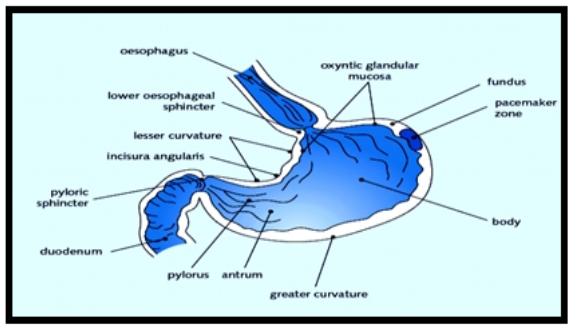


Fig1.1: Structure of Stomach

Anatomically, the stomach is divided into 3 parts (Figure.1.1)

- Fundus: the superior part of the stomach, this lies above the imaginary horizontal plane passing through the cardiac orifice.
- Body: this lies between the fundus and the antrum, and it is the largest part of the stomach.
- Antrum: this lies in the imaginary transpyloric plane and to the right of the angular notch (incisura angularis). It joins the pyloric canal on its right.

The main function of fundus and body is storage whereas that of antrum is mixing or grinding. The fundus adjusts to the increased volume during eating by relaxation of the fundal muscle fibers. The fundus also exerts a steady pressure on the gastric contents, pressing them towards the distal stomach. To pass through the pyloric valve into the small intestine, particles should be of the order of 1-2 mm. The antrum does this grinding. The stomach has limitation of short residence time [2].

Physiology

The physiology and disease state of stomach has a direct effect on design of controlled drug delivery system because drug is absorbed from and enters into site of action. Factors such as pH, nature and volume of gastric secretions, and gastric mucosa play an important role in drug release and absorption.

pH

Environmental pH affects the performance of orally administered drugs. A large volume of water administered with oral dosage form changes the pH of stomach to pH of water initially. This change occurs because stomach does not have enough time to produce sufficient quantity of acid before emptying of liquid from the stomach.

Volume

The resting volume of stomach is about 25-52ml. Gastric volume is important for dissolution of the dosage forms in vivo.

Gastric Secretion

Acids, pepsin, gastrin, mucus and some other enzymes are the secretions of the stomach. Normal adults produce a basal secretion up to 60ml with approximately 4mmol of hydrogen ions every hour. Other potent stimulators of gastric acid are the hormone gastrin, peptides, amino acids and gastric distention.

Effect of Food on Gastric Secretion

Type of meal and its caloric content, volume, viscosity and co-administered drugs affect gastric secretions and gastric emptying time. The rate of emptying primarily depends on caloric contents of the ingested meal. It does not differ for proteins, fats and carbohydrates as long as their caloric contents are the same. Generally gastric emptying is slowed down because of increased acidity, osmolarity and calorific values.

Gastric Motility

The complex anatomy and physiology of the GIT, including variations in acidity, bile salts, enzyme content, and the mucosal absorptive surface, significantly influence the release, dissolution, and absorption of orally administered dosage forms.

Two distinct patterns of gastrointestinal (GI) motility and secretion exist; corresponding to the fasted and fed states. As a result, the BA of orally administered drugs will vary depending on the state of feeding.

The fasted state is associated with various cyclic events, commonly referred to as the migrating motor complex (MMC), which regulates GI motility patterns.

The MMC is organized into alternating cycles of activity and quiescence and can be subdivided into basal (Phase I), pre-burst (Phase II), and burst (Phase III) intervals (Figure1.2).

- Phase I, the quiescent period, lasts from 30 to 60 min and is characterized by a lack of secretary, electrical, and contractile activity.
- Phase II exhibits intermittent action for 20–40 min, also to continuous gastric emptying through the pyloric sphincter in the fed state. This means that GRDDS must be functional quickly after administration and able to resist the onslaught of physiological events for the required period of time [3]
- Phase III (burst phase) lasts for 4 to 6 minutes. It includes intense and regular contractions for short period. It is due to this wave that all the undigested material is swept out of the stomach down to the small intestine. It is also known as the housekeeper wave.
- Phase IV lasts for 0 to 5 minutes and occurs between phases III and I of 2 consecutive cycles.

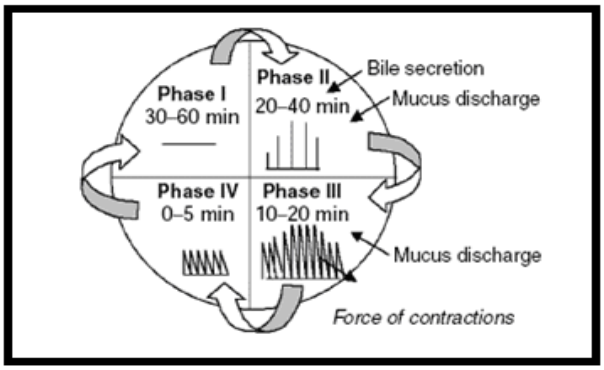


Figure 1.2: Motility patterns of the GIT in the fasted state.

Gastric Emptying

Particle size and feeding state strongly affect the residence time of particles in stomach. Some other factors affecting gastric emptying are as follows: type of meal and its caloric content, volume, viscosity and co-administered drugs. The rate of gastric emptying primarily depends on the caloric contents of the ingested meal. Generally an increase in acidity, osmolarity and calorific value slows down gastric emptying. Stress increases gastric emptying rate whereas depression slows it down. Gastric emptying of dosage forms is different in fasted and fed conditions.

Liquid in fasted and fed conditions

Volumes of liquids affect gastric emptying of liquids. Liquid empties exponentially; that is, larger the volume, faster the emptying. Gastric emptying of small volumes like 100 ml or less is governed by the MMC cycle whereas large volumes of liquids 200 ml or more are emptied out immediately after administration.

Solid in fasted and fed conditions

The stomach treats tablets and capsules as an indigestible material. The gastric residence time of such units is highly variable in the fasted condition. Gastric emptying of such units depends on MMC. Park et al. have shown that gastric emptying of tablets was not affected by the physical properties of tablets. It is known that particle smaller than 2 mm in size are emptied from the stomach quickly.

In the fed state, the stomach handles particles of different sizes in different ways. The average time required for a dosage unit to traverse the GIT is 3–4 h, although slight variations exist among various dosage forms (Table.1.1) [4].

Table 1.1: Transit Time of various dosage forms across the segments of the GIT

Dosage form	Transit time (hours)		
	Stomach	Small intestine	Total
Tablets	2.7±1.5	3.1±0.4	5.8
Pellets	1.2±1.3	3.4±1.0	4.6
Capsules	0.8±1.2	3.2±0.8	4.0
Solution	0.3±0.07	4.1±0.5	4.4

Factors Controlling Gastric Retention of Dosage Forms

The stomach anatomy and physiology contain parameters to be considered in the development of gastro retentive dosage forms. To pass through the pyloric valve in to the small

intestine the particle size should be in the range of 1 to 2 mm. The most important parameters controlling the gastric retention time (GRT) of oral dosage forms include: density, size and shape of the dosage form, food intake and its nature, caloric content and frequency of intake, posture, gender, age, sex, sleep, body mass index, physical activity and diseased states of the individual (e.g. chronic disease, diabetes etc.) and administration of drugs with impact on gastrointestinal transit time. The molecular weight and lipophilicity of the drug depending on its ionization state are also important parameters [5, 6, 7].

- **Density of dosage forms**
  The density of a dosage form affects the gastric emptying rate and determines the location of the system in the stomach. Dosage forms having a density lower than the gastric contents can float to the surface, while high density systems sink to bottom of the stomach. A density of <1.0 gm/cm^3 is required to exhibit floating property [8, 9].
- **Shape and size of the dosage form**
  Shape and size of the dosage forms are important in designing indigestible single unit solid dosage forms.
  In most cases, the larger the dosage form the greater will be the gastric retention time (GRT) due to the larger size of the dosage form would not allow this to quickly pass through the pyloric antrum into the intestine. Dosage forms having a diameter of more than 7.5 mm show a better gastric residence time compared with one having 9.9 mm. Ring-shaped and tetrahedron-shaped devices have a better gastric residence time as compared with other shapes [9, 10, 11].
- **Food intake and its nature**
  Food intake, viscosity and volume of food, caloric value and frequency of feeding have a profound effect on the gastric retention of dosage forms. The presence or absence of food in the gastrointestinal tract (GIT) influences the gastric retention time (GRT) of the dosage form. Usually the presence of food in the gastrointestinal tract (GIT) improves the gastric retention time (GRT) of the dosage form and thus, the drugs absorption increases by allowing its stay at the absorption site for a longer period. Again, increase in acidity and caloric value shows down gastric emptying time (GET), which can improve the gastric retention of dosage forms [12].
- **Effect of gender, posture and age**
  Generally females have slower gastric emptying rates than male. The effect of posture does not have any significant difference in the mean gastric retention time (GRT) for individuals in upright, ambulatory and supine state. In case of elderly persons, gastric emptying is slowed down [13].

Potential Drug Candidates for Gastro retentive Drug Delivery Systems

- Drugs those are locally active in the stomach e.g. antacids etc.
- Drugs that have narrow absorption window in gastrointestinal tract (GIT) e.g. L-DOPA, para aminobenzoic acid, etc.
- Drugs those are unstable in the intestinal or colonic environment e.g. captopril, ranitidine HCl, metronidazole.
- Drugs that disturb normal colonic microbes e.g. antibiotics against Helicobacter pylori.
- Drugs that exhibit low solubility at high pH values e.g. diazepam, chlordiazepoxide and verapamil HCl [14].

Drugs those are unsuitable for Gastro retentive Drug Delivery Systems

- Drugs that have very limited acid solubility e.g. phenytoin etc.
- Drugs that suffer instability in the gastric environment e.g. erythromycin etc.
- Drugs intended for selective release in the colon e.g. 5-amino salicylic acid and corticosteroids etc [15].

Advantages of Gastro retentive Drug Delivery Systems

- The bioavailability of therapeutic agents can be significantly enhanced especially for those which get metabolized in the upper GIT by this gastro retentive drug delivery approach in comparison to the administration of nongastroretentive drug delivery.
- For drugs with relatively short half life, sustained release may result in a flip- flop pharmacokinetics and also enable reduced frequency of dosing with improved patient compliance.
- It can be used to overcome the adversities of the gastric retention time (GRT) as well as the gastric emptying time (GET). As these systems are expected to remain buoyant on the gastric fluid without affecting the intrinsic rate of employing because their bulk density is lower than that of the gastric fluids.
- Gastro retentive drug delivery can produce prolong and sustain release of drugs from dosage forms which avail local therapy in the stomach and small intestine. Hence they are useful in the treatment of disorders related to stomach and small intestine.
- The controlled, slow delivery of drug form gastro retentive dosage form provides sufficient local action at the diseased site, thus minimizing or eliminating systemic exposure of drugs. This site-specific drug delivery reduces undesirable effects of side effects.
- Gastroretentive dosage forms minimize the fluctuation of drug concentrations and effects. This feature is of special importance for drug with a narrow therapeutic index.
- Gastroretentive drug delivery can minimize the counter activity of the body leading to higher drug efficiency.

Prolonged gastric retention can be achieved by using various approaches

To formulate a site-specific orally administered controlled release dosage form, it is desirable to achieve prolong gastric residence time by the drug delivery. Prolonged gastric retention improves bioavailability, increases the duration of drug release, reduces drug waste, and improves the drug solubility that are less soluble in a high pH environment .

Prolonged gastric retention time (GRT) in the stomach could be advantageous for local action in the upper part of the small intestine e.g. treatment of peptic ulcer, etc. Over the last few decades, several stomach specific or gastro retentive drug delivery approaches being designed and developed, including

- High-density systems
- Bioadhesive or Mucoadhesive systems
- Swelling and Expanding Systems
- Magnetic Systems
- Superporous Hydrogels
- Incorporation of Passage Delaying Food Agents
- Ion Exchange Resins

- Bioadhesive Uposomal Systems
- Floating systems
  - Raft-forming systems
  - Gas-generating systems
  - Low-density systems
  - Hydrodynamically Balanced Systems (HBS)

High Density Systems

These systems (Figure 1.3), which have a density of ~3 g/cm^3, are retained in the rugae of the stomach and are capable of withstanding its peristaltic movements. Above a threshold density of 2.4–2.8 g/cm^3, such systems can be retained in the lower part of the stomach. These formulations are prepared by coating drug on a heavy core or mixed with inert materials such as iron powder, barium Sulphate (density = 4.9), zinc oxide and titanium oxide etc. The materials increase density by up to 1.5- 2.4 gm/cm3. A density close to threshold density seems necessary for significant prolongation of gastric residence time. But, effectiveness of this system in human beings was not observed and no system has been marketed [16, 17, 18].

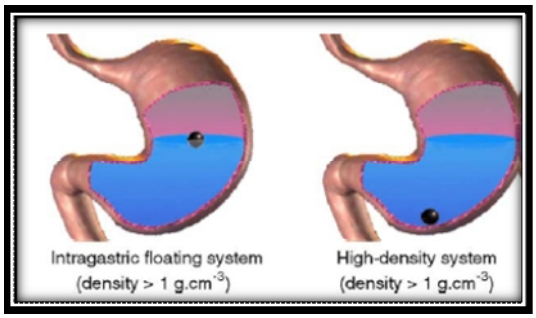


Figure 1.3 Schematic localization of an intragastric floating system and high density system in the stomach.

Bio/Muco-Adhesive Systems

The term 'Mucoadhesion' is commonly used to describe an interaction between the mucin layer that lines the entire GIT and a bioadhesive polymer (Figure 1.4). Bioadhesive drug delivery systems are used as a delivery device within the lumen and cavity of the body to enhance drug absorption in a site-specific manner. In this approach, bio adhesive polymers are used and they can adhere to the epithelial surface in the stomach. Thus, they improve the prolongation of gastric retention. The basis of adhesion in that a dosage form can stick to the mucosal surface by different mechanism. Different theories are invoked to explain these mechanisms are:

- The absorption theory, suggests that bioadhesion is due to secondary forces such as Vander Waal forces and hydrogen bonding.
- The electron theory, which proposes attractive electrostatic forces between the glycoprotein mucin net work and the bio adhesive material.
- The wetting theory, which is based on the ability of bioadhesive polymers to spread and develop intimate contact with the mucous layers, and finally, the diffusion theory, proposes physical entanglement of mucin strands and the flexible polymer chains, or an interpenetration of mucin strands into the porous structure of the polymer substrate.
- The diffusion theory, which proposes physical entanglement of mucin strands the flexible polymer chains, or an interpenetration of mucin strands into the porous structure of the polymer substrate.

Materials commonly used for bioadhesion are poly acrylic acid, Chitosan, cholestyramine, sodium alginate, hydroxypropyl methylcellulose (HPMC), sucralfate, tragacanth, dextrin, polyethylene glycol (PEG) and polylactic acids etc. Even though some of these polymers are effective at producing bioadhesive, it is very difficult to maintain it effectively because of the rapid turnover of mucus in the gastrointestinal tract (GIT).

The main disadvantage of such systems is their susceptibility to adhere to various particles (food, mucosa, etc.) in the stomach. Additional complication is related to the pH-dependent behavior of bioadhesive materials: reduced acidity of the gastric juice may significantly decrease the adhesive properties and, hence, the gastro retentive effect of the system [19, 20, 21].

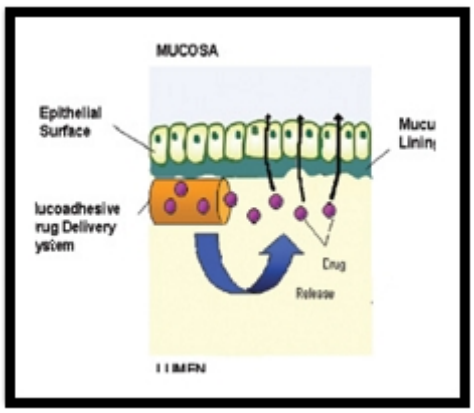


Figure 1.4: Bioadhesive system

Swelling and Expanding Systems

Swelling and expanding systems are dosage forms that, after swallowing, swell to an extent that prevents their exit from the pylorus (Figure 1.5). As a result, the dosage form is retained in the stomach for a long period. These systems may be called 'plug type systems', since they exhibit a tendency to be logged at the pyloric sphincter. Swelling and controlled release of the drug may be achieved on contact of the drug delivery system with gastric fluid; the polymer imbibes water and swells. Extensive swelling of the polymer is the result of the presence of physical-chemical crosslink in the hydrophilic polymer network. This cross-link prevents dissolution of the polymer and thus maintains the physical integrity of the dosage form. The bulk enables gastric retention and maintains the stomach in a 'fed' state, suppressing housekeeper waves. Medicated polymer sheets or swelling balloon hydrogels are examples of such delivery systems. A balance between the rate and extent of swelling and the rate of erosion of the polymer is crucial to achieve optimum benefit and to avoid adverse effects [22, 23].

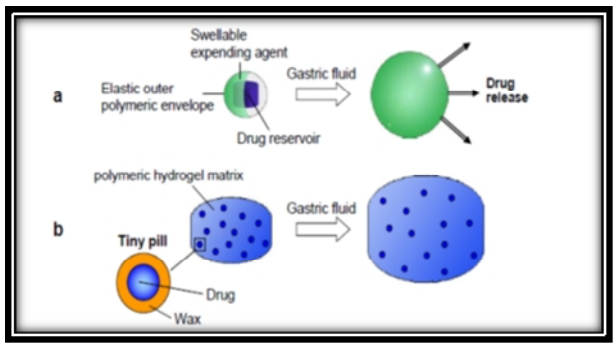


Figure 1.5: Swelling system

Magnetic Systems

This approach to enhance the gastric retention time (GRT) is based on the simple principle that the dosage form contains a small internal magnet, and a magnet placed on the abdomen over the position of the stomach. Groning et al. developed a method for determining gastrointestinal transit of magnetic dosage forms under the influence of an extracorporeal magnet, using a pH telemetering capsule (Heidelberg capsule). Small magnets were attached to the capsule and administered to humans. Using an extracorporeal magnet, gastric residence time of the dosage form was found to be >6 hours compared with 2.5 hours for the control. Although magnetic systems seem to work, the external magnet must he positioned with a degree of precision that might compromise patient compliance [24, 25].

Superporous Hydrogels

In this approach to improve gastric retention time (GRT) super porous hydrogels of average pore size >100 micro miter, swell to equilibrium size within a minute due to rapid water uptake by capillary wetting through numerous interconnected open pores (Figure 1.6). They swell to a large size (swelling ratio: 100 or more) and are intended to have sufficient mechanical strength to withstand pressure by gastric contraction.

This is achieved by co-formulation with a hydrophilic particulate material, croscarmellose sodium. This forms a dispersed phase within the continuous polymer matrix during the synthesis ('superporous hydrogel composites').

The super porous hydrogel composites stay in the human stomach for >24 hours. Recent advances in the field have led to 'superporous hydrogel hybrids", which are prepared by adding a water-soluble or water dispersible polymer that can be cross-linked after the superporous hydrogel is formed. Examples of hybrid agents include polysaccharides such as sodium alginate. Pectin and Chitosan[26, 27, 28].

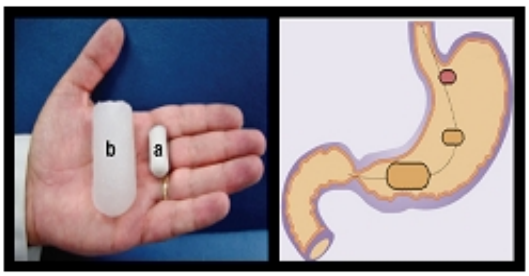


Figure1.6: On the left, superporous hydrogel in its dry (a) and water-swollen (b) state.
On the right, schematic illustration of the transit of superporous hydrogel.

Incorporation of passage delaying food agents

The food excipients like fatty acids, e.g. salts of myrestic acid change and modify the pattern of the stomach to a fed state, thereby decreasing gastric emptying rate and permitting considerable prolongation of release. The delay in the gastric emptying after meals rich in fats is largely caused by saturated fatty acids with chain length of C_{10}-C_{14} [29, 30].

Ion Exchange Resin

A coated ion exchange resin bead formulation has been shown to have gastric retentive properties, which was loaded with bicarbonates. Ion exchange resins are loaded with bicarbonate and a negatively charged drug is bound to the resin, resultant beads were then encapsulated in a semi permeable membrane to overcome the rapid loss of carbon dioxide. Upon arrival in the acidic environment of the stomach and exchange of chloride and bicarbonate ions take place. As a result of this reaction carbon dioxide was released and trapped in a membrane thereby carrying beads towards the top of gastric content and producing a floating layer of resin beads in contrast the uncoated beads, which will sink quickly [31,32].

Bioadhesive liposomal Systems

Mucoadhesive liposomal systems are developed by using a polymer coating technique to facilitate enteral absorption of poorly absorbed drugs. Liposomes are generally coated with Mucoadhesive polymers such as chitosan, carbopol, Carboxymethyl chitin and Carboxymethyl Chitosan. The Mucoadhesion of the resultant Liposome leads to an enhanced gastro retentive time of the dosage form [33, 34].

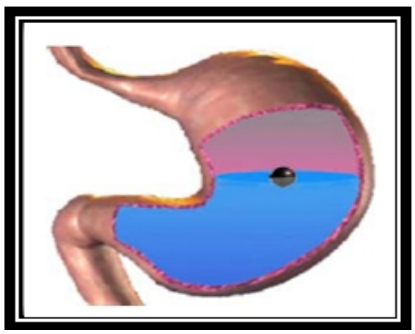
Floating drug delivery systems

Floating drug delivery systems is one of the important approaches to achieve gastric retention to obtain sufficient drug bioavailability. This delivery system is desirable for drugs with an absorption window in the stomach or in the upper small intestine. These systems have a bulk density lower than gastric fluids (Figure 1.7) and thus remain buoyant in the stomach without affecting the gastric emptying rate for a prolonged period of time. While the system is floating in the gastric contents, the drug is released slowly at a desired rate from the system. After the release of the drug, the residual system is emptied from the stomach. This results in an increase in the gastric retention time and a better control of fluctuations in plasma drug concentration.

The major requirements for floating drug delivery system are:

- It must maintain specific gravity lower than gastric contents (1.004 gm/cm3).
- It must form a cohesive gel barrier.
- It should release contents slowly to serve as a reservoir.

Depending upon the mechanism of buoyancy, two different types of systems have been used, i.e. effervescent and non-effervescent. The three approaches used in designing Intragastric floating drug delivery systems will now be described [35, 36].



Low-density systems (<1 g/cm3)

Figure 1.7: Schematic localization of an intragastric floating system.

Raft-forming systems

Raft forming systems have received much attention for the drug delivery for gastrointestinal infections and disorders. The mechanism involved in the raft formation (Figure 1.8) includes the formation of viscous cohesive gel in contact with gastric fluids, where in each portion of the liquid swells forming a continuous layer called a raft. This raft floats on gastric fluids because of low bulk density created by the formation of CO_2. Usually, the system ingredients includes a gel forming agent and alkaline bicarbonates or carbonates responsible for the formation of CO_2 to make the system less

dense and float on the gastric fluids . Jorgen *et al* described an antacid raft forming floating system. The system contains a gel forming agent (e.g. sodium alginate), sodium bicarbonate and acid neutralizer, which forms a foaming sodium alginate gel (raft), which when comes in contact with gastric fluids, the raft floats on the gastric fluids and prevents the reflux of the gastric contents (i.e. gastric acid) into the esophagus by acting as a barrier between the stomach and esophagus [37,38].

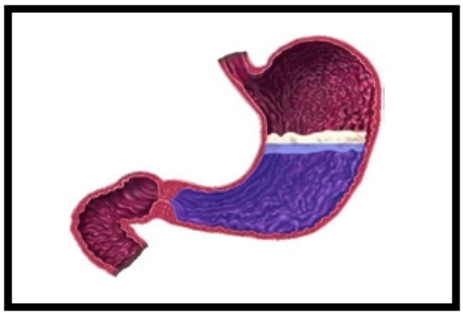


Figure 1.8: Schematic illustration of the barrier formed by a raft-forming system.

Gas-generating systems

In this system floatability can be achieved by the generation of gas bubbles (Figure 1.9). Carbon dioxide can be generated in situ by incorporation of carbonates or bicarbonates, which react with acid either natural gastric acid or co-formulated citric or tartaric acid in single unit systems, such as capsules or tablets. Effervescent substances are incorporated in a hydrophilic polymer and carbon dioxide bubbles are trapped in the swollen matrix. In vitro, the lag time before the unit floats is <l minute and buoyancy is prolonged for 8-10 hours. Bilayer or multilayer systems have also been designed in which drug and excipients can be formulated independently, and the gas generating unit can be incorporated into any of the layers of multiple unit systems, which avoids the 'all-or-nothing' emptying process encountered in single unit systems [39, 40].

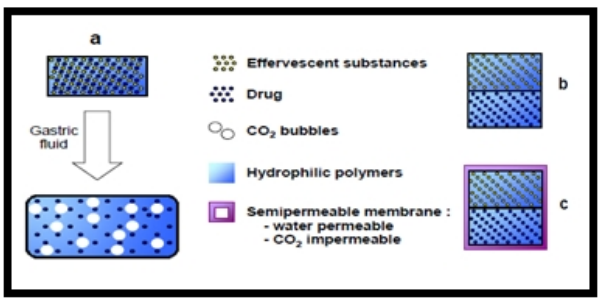


Figure 1.9: Gas-generating systems. (a) Bilayer gas-generating systems, with (c) or without (b) semi permeable membrane.

Low-density systems

Gas-generating systems inevitably have a lag time before floating on the stomach contents, during which the dosage form may undergo premature evacuation through the pyloric sphincter. Low density systems (<1 g/cm^3) with immediate buoyancy have therefore been developed. They are made of low-density materials entrapping oil or air. Most examples are multiple unit systems such as hollow microspheres (microballoons), hollow beads, micro particles, emulgel beads or floating pellets. At present, hollow microspheres (figure 1.10) are considered to be one of the most promising buoyancy systems because they combine the advantages of multiple unit systems and good floating properties. However, like all floating systems, their efficacy is dependent on the presence of enough liquid in the stomach, requiring frequent water [41, 42].

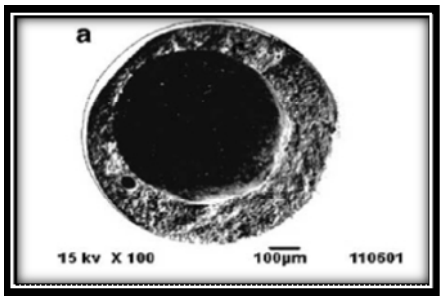


Figure 1.10: Hollow microspheres/Microballoons

Hydrodynamically balanced systems

Hydrodynamically balance systems are best suited for drugs having a better solubility in acidic environment and also for the drugs having specific site of absorption in the upper part of the small intestine. To remain in the stomach for a prolonged period of time the dosage form must have a bulk density of less than 1. It should stay in the stomach, maintain its structural integrity, and release drug constantly from the dosage form.

These are single-unit dosage forms, containing one or more gel-forming hydrophilic polymers. The polymer is mixed with drug and usually administered in a gelatin capsule. The capsule rapidly dissolves in the gastric fluid at body temperature, and hydration and swelling of the surface polymers produces a floating mass. Drug release is controlled by the formation of a hydrated boundary at the surface. Continuous erosion of the surface allows water penetration to the inner layers, maintaining surface hydration and buoyancy (Figure 1.11) Incorporation of fatty excipients gives low-density formulations and reduced penetration of water, reducing the erosion.

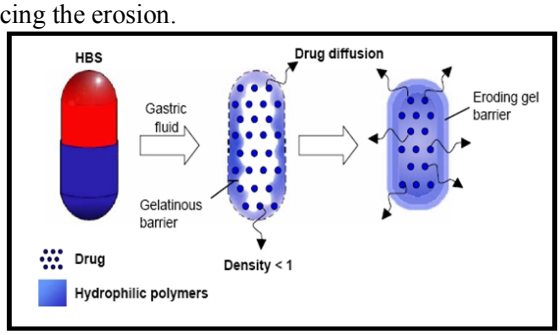


Figure 1.11: Hydrodynamically Balanced System (HBS)

CONCLUSION

The Hydrodynamically balanced systems (HBS) are very effective system because it is designed to prolong GI residence time of drug in an area of the GI tract and it maximizes drug absorption. There are many factors which effect the gastric retention time. There are so many problems occur to found prolong gastric retention so use many approaches to achieved it. Floating Drug Delivery Systems (FDDS) or Hydro dynamically Balanced Systems (HBS) have been developed in order to increase the gastric residence time (GRT).

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