INTRODUCTION

Definition of normal stool pattern in neonates is not well developed and few studies describe bowel habits during the first months in healthy infants ***(Steer et al., 2009).***

The necessity for obtaining data concerning infants and young children is mandatory, not only to define normal bowel habits but also to recognize abnormal bowel habits such as constipation. Although the Rome III criteria defined functional constipation for children younger than 4 years, well-defined criteria for the youngest infants are lacking ***(Indrio et al., 2008).***

Although the patterns of defecation do not significantly differ among children all over the world, it has been stated that the effect of different feeding habits in different countries might change these patterns ***(Corazziari et al., 2005)***.

Defecation problems occur frequently in infants, and there is a risk of either underdiagnos is or overdiagnosis of constipation as information concerning the normal defecation pattern of young infants is scarce ***(Bulk-Bunschoten, 2002)***.

An infant's first bowel actions consist of meconium, which is greenish-black. After 24–48 hours the meconium changes – first to brownish 'transitional' stools and then, by the third or fourth day, to typical breastfed infants' stools, which are loose and mustard-yellow (sometimes with milk curds), although occasionally they are green or orange. None of these changes is significant in a healthy breastfed infant ***(Hertog et al., 2012)*.**

Constipation refers to the hard, dry consistency of the stools, not the frequency of bowel motions. Exclusively breastfed infants are rarely constipated. Many breastfed infants show signs of discomfort or distress before passing a motion. This is a normal response to body sensations they are not used to and it may not indicate constipation. Hard, dry bowel motions are more likely to occur after formula or solid foods have been introduced ***(Lee et al., 2012)***.

Gestational age, birth weight and time of first enteral feeding are significantly related to the time of first meconium passage. When there is delay in passage of meconium, we should consider close observation of other associated symptoms, to avoid extensive evaluation and intervention ***(Hye et al., 2006)***.

In a cohart study, ***Hertog et al. (2012)*** noticed that in breastfed infants, average daily defecation frequency decreased significantly during the first 3 months (from 3.65 to 1.88 times per day), whereas no significant changes were observed in infants fed standard formula or mixed feeding. At every age both the average and the range of defecation frequency of breastfed infants were higher than those of infants receiving formula feeding. Breastfed infants had softer faeces than formula-fed infants and the colour was more often yellow ***(Hertog et al., 2012)*.**

AIM OF THE WORK

To describe the normal stool pattern of healthy infant and factor associated with this pattern. To compare breastfed - and formula-fed normal newborns regarding stool pattern and time elapsed before passage of first meconium.

Chapter (1)

ANATOMY AND PHYSIOLOGY OF GIT

Development of gastrointestinal system

Formation of the gastrointestinal tract begins during the third and the fourth week after fertilization the ventral layer (endo- derm) rolls down to form the gut tube (primitive gut). This primitive gut is a single tube, fixed at both ends (the mouth and the anus) ***(Sadler, 2014)*.**

Development of the GI tract is largely dependent on the folding of the embryo during the first month intrauterine. At the beginning of the third week of gestation as a result of the neural plate development, the flat, trilaminar embryonic disc begins to fold in both a cephalic-caudal and a ventral direction, invaginating the dorsal portion of the yolk sac. By the fourth week this folding is complete, resulting in a horseshoe-shaped cylinder. This hollow tube is divided into three sections corresponding to the foregut, the midgut, and the hindgut ***(Thibodeau et al., 2012)*.**

- The foregut becomes the mouth, esophagus, stomach and duodenum until the bile duct (also the respiratory tract).
- The midgut becomes the duodenum after the bile duct, jejunum, ileum and proximal two thirds of the colon.

- The hindgut becomes the distal transverse, descending and sigmoid colon, rectum and anal canal (also the urinary bladder and urethra).

(Outteridge, 2015)

Foregut

The foregut forms part of the mouth, esophagus, stomach, proximal duodenum, pancreas, liver, and extra hepatic biliary system as well as the lower respiratory system. The most cranial area of the foregut is often known as the pharyngeal gut. Early in the fourth week of fetal life, a depression appears on the ventral surface of the head called the stomodeum or primitive mouth. At the same time that the mouth is formed, the rest of the foregut is also developing ***(Tortora et al., 2000)*.**

When the embryo is approximately 4 weeks old, the respiratory diverticulum (lung bud) appears at the ventral wall of the foregut at the border with the pharyngeal gut. The tracheoesophageal septum gradually partitions this diverticulum from the dorsal part of the foregut. In this manner the foregut divides into a ventral portion, the respiratory primordium, and a dorsal portion, the esophagus. The esophagus elongates over a 2- to 3-week period to allow the development of the lungs, heart, and neck ***(Sadler, 2014)*.**

The stomach, first appearing as a dilation of the foregut, begins to grow with the dorsal aspect outpacing the ventral aspect, thus forming the greater curvature. As the esophagus grows, the stomach initially in the region of the neck descends and rotates 90° on its longitudinal axis until it reaches its final position ***(Singh, 2012)*.**

The duodenum develops from two sources (dual origin): (a) proximal half is derived from foregut and (b) distal half is derived from midgut. Around the fifth or sixth week, villi grow and temporarily occlude the lumen until the ninth or tenth week of gestation. Several other buds on the foregut also form the liver, gallbladder, bile ducts, and pancreas ***(Berseth et al., 2005)*.**

Midgut:

The midgut consists of the distal duodenum, jejunum, ileum, cecum, appendix, ascending colon, and the right two thirds of the transverse colon. Blood is supplied by the superior mesenteric artery. By the sixth week of gestation, the rate of growth causes the tube to bend ventrally. Simultaneously, rapid growth of the liver quickly limits space within the abdominal cavity. Consequently, around 7 weeks gestation, loops of intestine begin to protrude into the umbilical cord. The duodenum is the short retroperitoneal portion of the GI tract that connects the foregut to the midgut. At its proximal end, it connects to the outlet of the stomach, the pylorus, and it ends a short distance later at the ligament of Treitz, where the GI tract becomes an intraperitoneal organ once again and becomes the jejunum ***(Robert, 2015)*.**

The small intestine is the major digestive and absorptive portion of the GI tract. The small intestine is well developed after its extracorporeal migration into the umbilical cord. Rapid epithelial proliferation occludes the small-intestinal lumen early in development, but the lumen becomes patent at 12 weeks' gestation ***(Berseth et al., 2005).***

As the midgut herniates, it rotates in a counterclockwise fashion approximately 90° around an axis formed by the superior mesenteric artery. At around 10 weeks, when the abdominal cavity has expanded sufficiently and the growth of the liver has slowed, reduction of the midgut herniation occurs. As the loops of intestine are retracted into the abdomen they rotate another 180°, resulting in a full rotation of 270°. This counterclockwise rotation allows the transverse colon to pass in front of the duodenum and places the cecum and appendix in the right lower quadrant of the abdomen. Once the intestine has rotated into proper placement, the mesentery attaches to the posterior abdominal wall ***(Montrowl, 2014).***

Hindgut:

The GI components of the hindgut include the left one-third of the transverse colon, the descending colon, ascending colon, sigmoid colon, rectum, and superior portion of the anal canal. Blood is supplied from the inferior mesenteric artery. The major developmental changes occur in the terminal hindgut known as the cloaca and involve formation of the anus. The hindgut initially ends at the cloacal membrane, which separates it from the anal pit or proctodeum ***(Singh, 2012).***

Around the fourth week of gestation, the urorectal septum forms and by the sixth week divides the cloaca into a ventral urogenital sinus and a dorsal anorectal canal. By the eighth week of gestation, the anal membrane has moved inferior and is found at the bottom of the proctodeum. In the ninth week this membrane ruptures, completing patency of the GI tract ***(Singh, 2012)***.

Physiology of the GI tract

The human gastrointestinal (GI) tract is a complex combination of organs whose primary function is to digest and absorb nutrients. Many important secondary functions are also performed, such as the endocrine function of the pancreas. In fact, what was once considered a simple system of digestion and absorption is now recognized as something much more complex and dynamic ***(Tortora et al., 2000)***.

Structure:

The wall of the GI tract from the lower esophagus to the anal canal has the same basic, four-layered arrangement of tissues. The four layers of the tract, from deep to superficial, are the mucosa, submucosa, muscularis, and serosa ***(Chamley et al., 2005)***.

Mucosa

The mucosa, or inner lining of the GI tract, is a mucous membrane. It is composed of (1) a layer of epithelium in direct contact with the contents of the GI tract, (2) a layer of connective tissue called the lamina propria, and (3) a thin layer of smooth muscle (muscularis mucosae):

1. The epithelium in the mouth, pharynx, esophagus, and anal canal is mainly nonkeratinized stratified squamous epithelium that serves a protective function. Simple columnar epithelium, which functions in secretion and absorption, lines the stomach and intestines. The tight junctions that firmly seal neighboring simple columnar epithelial cells to one another restrict leakage between the cells. The rate of renewal of GI tract epithelial cells is rapid: Every 5 to 7 days they slough off and are replaced by new cells. Located among the epithelial cells are exocrine cells that secrete mucus and fluid into the lumen of the tract, and several types of endocrine cells, collectively called enteroendocrine cells, that secrete hormones ***(Gerard and Bryan, 2009)*.**

2. The lamina propria (*lamina*-thin, flat plate; *propria*-one's own) is areolar connective tissue containing many blood and lymphatic vessels, which are the routes by which nutrients absorbed into the GI tract reach the other tissues of the body.

This layer supports the epithelium and binds it to the muscularis mucosae (discussed next). The lamina propria also contains the majority of the cells of the mucosa-associated lymphatic tissue **(Gerard and Bryan, 2009).**

3. A thin layer of smooth muscle fibers called the muscularis mucosae throws the mucous membrane of the stomach and small intestine into many small folds, which increase the surface area for digestion and absorption. Movements of the muscularis mucosae ensure that all absorptive cells are fully exposed to the contents of the GI tract.

(Schroeder et al., 2000)

Submucosa

The **submucosa** consists of areolar connective tissue that binds the mucosa to the muscularis. It contains many blood and lymphatic vessels that receive absorbed food molecules. Also located in the submucosa is an extensive network of neurons known as the submucosal plexus. The submucosa may also contain glands and lymphatic tissue ***(Barrett and Keely, 2000).***

Muscularis

The **muscularis** of the mouth, pharynx, and superior and middle parts of the esophagus contains *skeletal muscle* that produces voluntary swallowing. Skeletal muscle also forms the external anal sphincter, which permits voluntary control of defecation. Throughout the rest of the tract, the muscularis consists of *smooth muscle* that is generally found in two sheets: an inner sheet of circular fibers and an outer sheet of longitudinal fibers. Involuntary contractions of the smooth muscle help break down food, mix it with digestive secretions, and propel it along the tract. Between the layers of the muscularis is a second plexus of neurons-the myenteric plexus ***(Chamley et al., 2005)*.**

Serosa

Those portions of the GI tract that are suspended in the abdominopelvic cavity have a superficial layer called the serosa. As its name implies, the serosa is a serous membrane composed of areolar connective tissue and simple squamous epithelium (mesothelium). The serosa is also called the visceral peritoneum because it forms a portion of the peritoneum, which we examine in detail shortly. The esophagus lacks a serosa; instead only a single layer of areolar connective tissue called the adventitia forms the superficial layer of this organ ***(Clancy et al., 2009)*.**

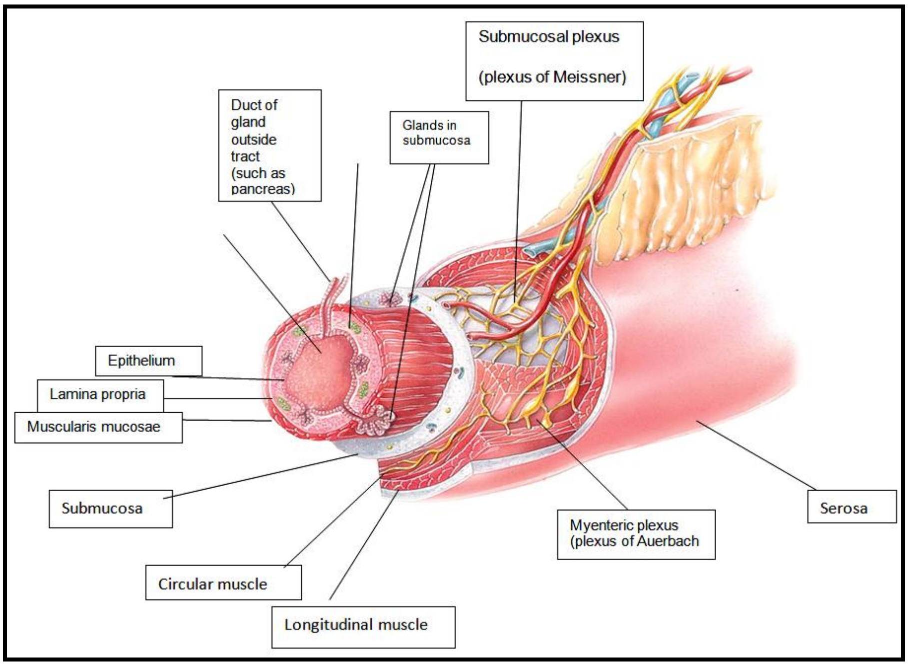

Figure (1): Anatomy of the intestinal wall **(Gerard and Bryan, 2009).**

Circulation

After birth, the intestine is a site for intense metabolic activity. Blood flow significantly increases from days 1 to 3, then plateaus until day 12, and declines progressively until day 30. Introduction of feedings causes vasodilation and increased oxygen delivery (postprandial hyperemic response) from capillary to cell to meet increased demand for digestion. Changes in flow are mediated by nitric oxide (NO), a vasodilator, myogenic response, and endothelin (ET-1), which provide vasoconstriction. Infants have altered capacity to respond to systemic circulatory problems such as decreased arterial pressure and hypoxemia ***(Reber et al., 2002)*.**

Motility

Different regions of the gastrointestinal tract play different roles in the breakdown of food and uptake of nutrients, and hence the food, or partly or fully broken down food particles, must be transported from the mouth to the anal region ***(Wood, 2008)*.**

The esophageal phase

This stage of swallowing begins once the bolus enters the esophagus. During this phase, peristalsis (a progression of coordinated contractions and relaxations of the circular and longitudinal layers of the muscularis, pushes the bolus onward in the esophagus it is controlled by the medulla oblongata.) In the section of the esophagus just superior to the bolus, the circular muscle fibers contract, constricting the esophageal wall and squeezing the bolus toward the stomach. Meanwhile, longitudinal fibers inferior to the bolus also contract, which shortens this inferior section and pushes its walls outward so it can receive the bolus. The contractions are repeated in waves that push the food toward the stomach. As the bolus approaches the end of the esophagus, the lower esophageal sphincter relaxes and the bolus moves into the stomach. Mucus secreted by esophageal glands lubricates the bolus and reduces friction. The passage of solid or semisolid food from the mouth to the stomach takes 4 to 8 seconds; very soft foods and liquids pass through in about 1 second ***(Peter et al., 2009)*.**

The peristaltic waves initiated by impulses from autonomic nerves, specifically the enteric nervous system (ENS), and coordinated by the swallowing center in the medulla. The ENS is regulated by a series of genes that influence receptor sites, transcription, and translation of neuronal signals ***(Bates et al., 2006)*****.**

Although this sphincter is anatomically indistinct from the remainder of the esophagus, it normally remains contracted so that the contents of the stomach, which are under relatively higher internal pressure in relation to that experienced in the esophagus, do not reflux ***(Coad and Dunstall, 2005)*****.**

Gastric phase

Peristaltic waves spread across the stomach as it fills with food toward the small intestine. These contractions are no longer mediated by the medulla but by the nerve plexuses and the effect of smooth muscle stretching.

The muscle layers of the stomach are thicker in the distal portion (antrum) in comparison with the relatively thin layer surrounding the upper portion (fundus), resulting in the most powerful and intense contractions in the antrum. These strong antral contractions are the primary force acting to break up the gastric contents and mix them with enzymes to form a semifluid mixture called chyme. In addition, they force the chyme past the pyloric sphincter into the duodenum. Although the rate of gastric emptying is normally controlled by the chemical composition and amount of chyme, gastric motility may actually be decreased by stomach distention, increased caloric density, or high loads of carbohydrate, fat, or acid, to provide more time for digestion and absorption in the small intestine. In general, formula empties more slowly than breast milk. Right lateral positioning increases gastric emptying, but is associated with increased occurrence of gastric esophageal reflux (GER) as compared to left lateral positioning ***(Omari et al., 2004)*.**

Intestinal phase

The two types of movements of the small intestine—segmentations and a type of peristalsis called migrating motility complexes-are governed mainly by the myenteric plexus ***(Wood, 2008)*.**

Segmentations are localized, mixing contractions that occur in portions of intestine distended by a large volume of chyme. Segmentations mix chyme with the digestive juices and bring the particles of food into contact with the mucosa for absorption; they do not push the intestinal contents along the tract. Segmentation starts with the contractions of circular muscle fibers in a portion of the small intestine. Next, muscle fibers that encircle the middle of each segment also contract, dividing each segment again. Finally, the fibers that first contracted relax, so that large segments are formed again. As