



Anatomical and Physiological Characteristics of the Digestive Tract in Childhood

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Authors' contributions

The authors contributed equally in all stages of the elaboration of the article. Both authors read and approved the final manuscript.

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ABSTRACT

Nutrition is an act of fundamental survival in the human being's relational process with the environment. It is, instinctive in the first weeks of life and then becomes a learned behavior that counts on the participation of all organs and senses. The child needs nutrients in adequate quantity and quality during his growth and development, and depends on a system capable to receiving, metabolize, absorb and excrete the components of the diet. This article presents some characteristics of the child's digestive system that must be known to provide him with adequate food for his anatomical and physiological abilities.

Keywords: Child digestive tract; infant nutrition; children; infant physiology.

1. INTRODUCTION

The child is a human being inconsistent growth and development. Therefore, it is necessary to receive nutrients in adequate

quantity and quality for these processes to occur satisfactorily. Besides, the child needs a set of structures that can receive, process, absorb, take advantage of nutrients and excrete waste [1].

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The digestive system is the main structure involved in nutrition that has endocrine actions (responsible for the regulation of systemic levels of nutrients and food behavior) and protection, it also acts as a barrier that prevents the passage of non-essential substances to the body [2].

2. EMBRYOLOGY

At birth, the digestive tract is still immature and its development continues during the first year of life. The formation of the digestive system begins in the fourth week of intrauterine life from structures of the mesoderm and endoderm, with the dorsal part of the yolk sac giving rise to the primitive intestine that divides into the anterior, middle and posterior portions and forms the rest structures, evolving maturation in the cranio-caudal direction [3]. On that same occasion, the tongue starts to be formed from the floor of the pharynx and, in the following weeks, the palate begins to be molded from the maxillary processes, completing its fusion around the 12th week. Also, during the fourth week, the formation of the mandible and jaw begins, fundamental from the brachial cleft [4].

3. MOUTH

In term newborns the lips and orofacial musculature are suitable for suction. Eventually, newborns may have cleft lip and/or palate (congenital, partial or complete malformations of the face due to a failure in the fusion between the maxillary and frontonasal processes) that can be diagnosed even in the intrauterine period, from the 13th week of pregnancy and can compromise food intake [5].

All children have the taste and smell present at birth and can appreciate the different types of taste, evidently giving preference to breast milk and developing over time the ability to appreciate the nuances of flavors. About 75% of the taste buds in the oral cavity are located at the lingual papillae, which renew, on average, every two weeks [6].

The tongue is a muscular organ (involved in the movement of food, speech and swallowing) and sensory one that (detects taste, texture and temperature). Changes like ankyloglossia – a congenital condition when the inferior lingual frenulum is too short and is attached to the tips of the tongue limiting its movement - cause difficulties with sucking and swallowing [7-9].

The child born at term presents coordinated and repeated movements of sucking, swallowing, and breathing, and the strength and mobility of the tongue evolves with age. It is also an important factor for the development of the masticatory system and the face, appropriately allowing dental occlusion [10]. As from the sixth month of life, the sucking reflex is replaced by voluntary mouth movement, which will favor the feeding process. Between 6 and 8 months the child learns to make lateral and central movements in the mouth with food, keeping the lips closed, before swallowing. Around one year of age, when the jaw is more stabilized, it is possible to use a spoon to make meals [11].

The process of food digestion begins in the mouth, because enzymes such as lingual lipase (initiates the digestion of fats) and salivary amylase (acts on the hydrolysis of starch in dextrin and maltose) that can be found there in a small concentration and at a neutral pH. Since in the first days of life the infant produces a small amount of acid in the stomach [12]. The lingual lipase is secreted by lingual serous glands and hydrolyzes medium and long-chain triglycerides in the stomach. The child born produces small amounts of saliva that increases from with time to, produces between 50 mL and 150 mL a day. It is stimulated mainly by feeding and chewing movements. Mucus can be also found in the oral cavity and helps in the formation of the milk clot [13].

4. TEETH

The teeth are formed and calcified at different times beginning around 50 days of gestation. The rash begins between 6 and 8 months of age with the appearance of the lower two central incisors. Normally, four incisors, two canine, and four molars, milky white and partially mineralized, are present in the jaw and mandible and constitute a total of 20 primary teeth. The first dentition is completed between 24 and 30 months of life. At six to 8 years the deciduous teeth will begin to be lost in the same order they appeared and the permanent teeth begin to emerge [14].

The newborn's first chewing movements are irregular and uncoordinated, but in a few weeks, voluntary contractions of the buccinator and orbicularis muscles of the lips begin to help improve the movements of the oral cavity. During childhood, the masticatory force is small, increasing between 1.5 kg to 2.5 kg per year of

age, increasing to 40% at 6 years and 75% to 80% at 10 years and, only in adolescence, will reach its fullness [15].

In the first four months of life, children may still not have a well-developed tongue movement that pushes food to the back of the mouth, preparing it to be swallowed. In this phase, the tongue tends to project the food out of the mouth, making it difficult to swallow pasty foods, which is called the extrusion reflex, which disappears around 4 months of life [16].

5. SWALLOWING

Swallowing is an automatic reflex for the first three months of life until the muscles in the throat establish cerebral connection [6]. It starts between 16 and 17 weeks of intrauterine life when the foetus swallowing small amounts of amniotic fluid. Is a dynamic process that requires more than 30 muscles and six cranial nerves in coordination of the lips, tongue, palate, pharynx, larynx and esophagus, acting on the bolus and preparing it for the digestion process. Children are estimated to swallow 600 - 1000 times a day [16].

The swallowing occurs in three phases [17,18]:

- a) Oral (conscious and voluntary): triggering of the swallowing reflex efusing the transportation of the bolus towards the pharynx;
- b) Pharyngeal (conscious and involuntary): transportation of the bolus through the pharynx;
- c) Esophageal (unconscious and involuntary): transportation of the bolus through the esophagus to the stomach.

Later, the oral phase comes under voluntary control as the central nervous system develops.

6. ESOPHAGUS

The esophagus begins forming during the fourth week of gestation and is composed of striated muscle in the upper third and smooth muscle in the lower two thirds. There are upper and low sphincters at the ends which prevent the retrograde passage of food and fluids because the transition to the stomach is weak and almost non-existent, in addition to the obtuse gastric esophagus angle [4]. Thus, the child has some anti-reflux mechanisms such as:

- a) Lower esophageal sphincter that matures during the first year of life;
- b) Hiss angle that is formed between the abdominal esophagus and the gastric fundus and which must be acute;
- c) Phenoesophageal ligament that serves to prevent the lower esophageal sphincter from being subjected to negative pressure;
- d) Crural diaphragm: a gap formed by the fibers of the diaphragm;
- e) Gastric rosette: a concentric folds of the gastric mucosa existing in the transition between the esophagus and stomach.

The peristaltic movements are initiated with distention of the upper esophagus region and are coordinated by the medullary neural reflexes and the vagus nerve in the upper one third [4].

7. STOMACH

The stomach has its formation started in the fourth week of gestation. At birth, its capacity is of approximately 10 mL and walls with little tonicity. The capacity increases to 90 mL at the end of the first month, 150 mL in the 3rd month and, up to two years old can accommodate about 30 mL/kg of body weight. There are no peristaltic contractions in the stomach in the first 2 - 4 days of life and gastric receptive relaxation is absent in newborn [19].

The stomach normally holds food for 4 to 6 hours and the gastric emptying time varies according to some factors such as volume, composition and temperature of the diet, pH and osmolality, which stimulate harmonious movements and coordinated with the intestinal activity. Fundic smooth muscle relaxes when a meal enters in the stomach [20].

Many substances, components of gastric juice, are secreted into the ingested food such as mucus to protect the stomach lining, hydrochloric acid which helps to kill the ingested bacteria and activate other digestion processes, and the intrinsic factor which allows absorption of iron and pepsin plus renin commence the chemical digestion of proteins. Hydrochloric acid starts to be produced after the 19th week, is present in stomach at birth, but the stomach pH is nearly neutral due to swallowing of the alkaline amniotic fluid. In the first 8 hours of life gastric secretion of acid commence and acidity increases in the first 24 hours [21].

8. INTESTINE, DIGESTION AND ABSORPTION

The intestine is the first barrier for nutrients and luminal components and its macro and micro anatomical developments are complete in the 6th fetal month. Most of the phenomena of digestion and absorption occur in the duodenum and jejunum that use segmentation and propulsion movements, although a little immature in the first days of life, to propel the bolus through its length of approximately 200 cm and with more than one million villi in the first weeks of life. The permanence time of the bolus in the infant's intestine is approximately 5 hours and the total emptying can take up to 8 hours [22].

9. DIGESTIVE ENZYMES

The brush border exists already from the 6th fetal week and from this time digestive enzymes start to be produced. From the eighth week of gestation, lingual lipase and gastric lipase can be detected in the fetus, which together with the lipases of breast milk, act on lipid metabolism at the beginning of life, since pancreatic lipase will begin to be produced after 22nd week and, in the first weeks of life, it still shows little lipolytic activity [23].

From the 12th week of gestation, the enzymes responsible for the digestion of carbohydrates (lactase, sucrase -isomaltase, and maltase) appear, while pancreatic amylase will start to be produced in the 22nd week [24]. After the 16th fetal week, the pancreas has already formed granules of zymogen (trypsinogen and chymotrypsinogen) that start to perform triptych activity after the 28th week [25,26].

At birth, the child has a full capacity of the enzymes lactase, sucrase-isomaltase, maltase, trypsin, and chymotrypsin. During the first months of life, the other enzymes will continue to evolve until reaching concentrations equal to those of adults, around one year of age [27].

Table 1 shows the time of appearance of digestive enzymes and hormones produced in the digestive tract during the period of intrauterine life.

The synthesis of bile acids begins in the 14th week of intrauterine life and is mature after birth. However, the small efficiency of the enterohepatic circulation at the beginning of life leads to fecal loss of bile salts and small capacity

for the formation of cholates and deoxycholates, in addition to a lesser capacity to absorb fats. The concentration of bile acids in the duodenal juice is also low in the first months of life [26].

Table 1. Age of onset of enzyme and hormone production in the digestive tract

Enzyme	Weeks of gestation
Lingual lipase	8
Gastric lipase	8
Lactase	12
Sacrase-isomaltase	12
Pancreatic lipase	22
Pancreatic amylase	22
Enterokinase	24
Pepsin	34
Hormone	
Gastrin	8
Secretin	8
Motilin	8
Gastric inhibitor peptide	8
Cholecystokinin	10

10. SPHINCTER CONTROL

The start of swallowing and the arrival of food in the stomach trigger the so-called gastrocolic reflex, which may be exacerbated in some children in the first weeks of life, to promote evacuation after each feeding. The evacuation process begins with the distension of the rectal ampulla that triggers a medullar reflex that consists of the contraction of the entire colon, aided by contractions of the diaphragm and abdominal wall, in addition to the relaxation of the perianal muscles located in the region of the pelvis floor and the anal sphincter. The control of the conscious inhibition of this reflex and the evacuation act occurs after two years of age [28].

11. DEFENSE MECHANISMS OF THE DIGESTIVE SYSTEM

The digestive system epithelium is the first line of defense that prevents the penetration of living or inert substances into the circulation. In addition to it, there are non-immunological mechanisms such as the gastric barrier (acidic pH and the digestive action of pepsin), gastrointestinal motility, mucins (glycoproteins and glycolipids produced by goblet cells), normal intestinal flora that has a competitive effect and elaboration of antibacterial catabolites such as acid and butyric acids, and other substances with antibacterial properties such as bile salts and lysozymes [29].

The immune defense mechanisms are mainly due to the secretory immunoglobulin A, which is produced by cells located below the epithelial layer and resistant to the action of enzymes, which acts by making it difficult for antigens to adhere to the mucosal surface and the opsonization of viruses. Class G and M immunoglobulins also play an important defense role, as they reach the child's small intestine intact due to the low proteolytic activity of the newborn's stomach [30].

12. MICROBIOTA

The neonatal intestinal microbiota is a complex ecosystem composed of numerous strains of bacteria, protozoa, and fungi which performs a variety of activities metabolic, nutritive, and protective that affect the intestinal physiology and the body metabolism and immunity [31,32].

Although intestinal bacterial colonization begins when the fetus is in the uterus, the gastrointestinal tract is considered sterile until birth. On the first day of life, rapid colonization of the newborn's intestine occurs with maternal and environmental microorganisms, mainly *E coli* and other *Enterobacteriaceae* [33].

Some days after birth, when these organisms depleted the initial oxygen supplies, the gut becomes an anaerobic environment favoring the development anaerobic bacteria such as *Bifidobacterium*, *Clostridium*, *Bacteroides*, and *Ruminococcus*. During lactation there is a predominance of *Bifidobacterium* and some lactic acid bacteria that will be maintained until the introduction of other foods [34,35].

After weaning Bifidus flora is out-competed by adult-type microorganisms, represented by bacteria in the genera *Bacteroides*, *Prevotella*, *Ruminococcus*, *Clostridium*, and *Veillonella* which colonize the children's intestine. The establishment of gut microbiota is affected by [36,37]:

- a) Delivery mode: cesarean (predominance of *Staphylococcus*, *Corynebacterium*, and *Propionibacterium*) or vaginally (predominance of *Lactobacillus* and *Prevotella*);
- b) Type of milk: breastfeeding (probiotic effect of oligosaccharides stimulates the development of *Bifidobacterium*) or formula (favors the growth of *Clostridium difficile*);

- c) Antibiotics usage: shift the composition of the but microbiota towards a high of *Proteus* bacteria and low *Actinobacteria* populations, decrease the overall diversity of microorganisms, and selects for drug-resistant bacteria;
- d) Introduction of solid foods: stimulates the growth of *Bacteroidetes* and *Firmicutes*;
- e) Geographic, cultural, and economic conditions that favor contact with several other strains of microorganisms.

13. CONCLUSION

The term newborn is prepared to take full advantage of the nutritional qualities of breast milk being able to suck, swallow, metabolize, absorb and eliminate the few residues that remain in the intestine. And exclusive breastfeeding should preferably be maintained during the first six months of life [38]. Thereafter, or when breast milk is not possible to be offered, other foods must be introduced into the child's diet, observing their physiological characteristics so that they are fully utilized, respecting the capacity of the structures and cultural conditions and economic costs related to food.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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