

Topographoanatomical characteristics of the gastroduodenal junction in fetuses and newborns

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Abstract

It has been established through means of anatomical investigations that the muscular tunic of the gastroduodenal junction in late fetuses and newborns are permeated by connective tissue bands whose thickness is the greatest within the limits of the syntopic field of the pancreas. According to ultrasonic examinations of the diameter of the pyloric canal and the pyloric ostium, the thickness of the pyloric walls is larger in infants than in newborns, and the distinction is greater in males than in females.

Key words: gastroduodenal junction, anatomy, fetus, newborns, children.

Топографоанатомические особенности гастродуоденального перехода у плодов и новорожденных

С помощью анатомического исследования установлено, что у поздних плодов и новорожденных мышечная оболочка гастродуоденального перехода пронизана соединительнотканными тяжами, толщина которых наибольшая в области синтопического поля поджелудочной железы. По данным ультразвукографического исследования, у детей грудного возраста диаметры пилорического канала и пилорического отверстия и толщина стенки пилоруса больше, чем у новорожденных, а у мальчиков данные параметры выше, чем у девочек.

Ключевые слова: гастродуоденальный переход, анатомия, плод, новорожденный, дети.

Introduction

The anatomofunctional significance of the pylorus is confirmed in practice, in this connection of pyloropreserving and pyloromodeling operations, various kinds of valvular and closed gastroduodenoanastomoses [1, 2] are widely introduced. The microsurgical anatomy of the gastroduodenal junction (GDJ) is actively elaborated; however, the micro macroscopic anatomy of this segment in fetuses and newborns is described only in isolated papers [3]. The interest of researchers in the gastroduodenal segment from the anatomical point of view is stipulated by a possibility of examining it in practical medicine – roentgenologically, tomographically, endoscopically, and ultrasonographically.

The object of the research: to study the specific structure characteristics of the gastroduodenal junction (GDJ) and the chronological order of forming anatomical interrelations of the GDJ during the fetal and early neonatal period of ontogenesis.

Material and methods

The research was carried out on 78 human autopsied specimens without external signs of anatomical deviations or anomalies. This was performed in accordance with the methodological recommendations “Observance of ethical and legislative norms and demands, when performing scientific and morphological investigations” [4]. The age of the fetuses was determined on the basis of measuring the parietococcygal and parietocalcaneal lengths. The form, location of the stomach and the upper portion of the duodenum were also

determined. The macroscopy of the GDJ and the adjacent structures belonging to the fetuses aged 4-5 months were carried out by means of a stereoscopic microscope – MBC-10. Segments of the digestive tract with the adjacent structures were excised from the pylorus and they were rinsed under running water during a 24-hour period.

The segments were dehydrated by passing them through a battery of spirits of the initial concentration. A series of histotopographic sections, 10 mm in width, were prepared from paraffin blocks. The specimens were cut with the help of a microtome, stained with hematoxylin and eosin. Upon Canada balsam fixation, the microscopic specimens were studied under a light mono- and binocular microscopes in the macro/microscopic field of vision (from a 3 x to 45 x magnification), that is in the range of magnifying a stereoscopic microscope, a surgical magnifying glass, or a surgical microscope [5].

GDJ skeletopy, holotopy, and syntopy were studied by means of the method of a radioanatomic investigation. The duodenum and the stomach were filled retrogradely with a radio opaque mixture on the red lead base. The angle between the longitudinal axes of the pyloric portion and the body of the stomach was measured. For this purpose, arbitrary lines were drawn along the body and the pyloric portion in the middle between the lesser and greater curvatures of the stomach and parallel to them. The diameters of the pylorus and the pyloric canal of the stomach, the duodenal ampulla, and the length of the pyloric canal were measured with the aid of IIII-1 sliding caliper. The diameter of the gastric pylorus was measured

within the range of the narrowest segment of the GDJ, the diameter of the pyloric canal – in the middle between the pylorus and the angular notch of the stomach, the diameter of the duodenal ampulla – at the level of the broadest segment of this upper portion. The length of the pyloric canal was measured along the lesser and greater curvature of the stomach. The thickness of the tissue membranes of the digestive wall was measured on GDJ microscopic slides by means of a fine adjustable screw. Statistical organometric data processing was carried out using Microsoft Office – Excel software.

An examination of the digestive organs without the pathology of 16 neonates, aged 5-7 days, and 16 nurslings aged 8-10 months, equally distributed between males and females, were carried out on the base of the Khmelnyts'kyi Municipal Children's Clinical Hospital (jointly with physician H.O. Lobintseva). This was possible with the aid of the "Sonoline G 60 S" apparatus ("Siemens", Germany), using a high-density linear-array transducer 7.5 MHz.

During supersonic scanning, the diameter of the lumen and the length of the pyloric canal, the thickness of the pyloric wall, and the diameter of the pyloric ostium were determined. The obtained results were processed according to Wilcoxon's criterion for independent samplings [6].

The results of the investigation and their analysis

It has been established that starting from the fourth month of intrauterine development a subtle narrowing is observed between the stomach and the duodenum. The position of the stomach is horizontal, corresponding to the projection of the left upper quadrant of the abdomen. Four parts are identified in the duodenum. A broader area – the duodenal ampulla is observed in the upper portion of the duodenum. The hardly narrowed area of the digestive tube corresponds to the pylorus of the stomach, whereas the broader area – to the pyloric canal and the duodenal ampulla.

The pyloric canal is directed from left to right, from above to downwards, and from behind to the front, the upper part of the duodenum – from left to right, from below to upwards, and from the front backwards. The duodenal projection corresponds with the epigastric region proper. The projection of the pylorus on the anterior abdominal wall in relation to the anatomical midsagittal or median plane determined is regarded to be practically important. There are three types of interrelations of the gastric pylorus with the median plane: 1) the pylorus is identified on the right from the median plane; 2) at the level of the median plane; 3) on the left from the median plane. In all the age-related groups, the pylorus is more frequently identified to the right of the median plane and less frequently to the left of it.

The angle between the longitudinal axes of the pyloric portion and the body of the stomach in the first half of the fetal period changes from obtuse (93.4° – in the 4th month) to acute (78.8° – in the 6th month). With an increase of the term of the prenatal development, the angular value diminishes henceforth. Throughout the second and third trimesters, the angular value reduces 1.7 times and makes up 54.4° in newborns.

In the beginning of the fetal period, during 4th-5th months, the folds of the mucus membrane are observed only on the boundary of the pyloric portion and the body of stomach; however, they have no clear orientation. At the end of the second trimester, marked folds of the mucous membrane are barely detected without a clear cut orientation within the limits of the pyloric canal of the stomach.

The circular fold within the range of the duodenum proper along with the muscular ring of the pylorus are directed into the lumen of the duodenum, which gives every reason to differentiate the duodenal surface of the gastric pylorus from this stage of morphogenesis. The formation of the duodenal recess is observed between the walls of the duodenum and duodenal surface of the gastric pylorus. During the 7th month of gestation, the folds of the mucous tunic of the pyloric part of the stomach acquire a longitudinal oblique or transverse orientation. At the end of the 3rd trimester (months 8-9) and at an early stage of the neonatal period, the longitudinal plicae of the mucous coat are differentiated within the limits of the pyloric canal, whereas at the border of the pyloric portion and the body of the stomach - longitudinal oblique ones and plicae without a clear-cut orientation. It should be noted that a marked duodenal recess is observed during the neonatal period owing to an orientation of the pylorus towards the duodenum. Taking into consideration the results of our own research, we share the warnings of the specialists [7] to the effect that it is not advisable to dissect the serous muscular layer of the pylorus as far as the aboral edge during pyloromyotomy in order to avoid a dissection of the duodenal wall within the limits of the duodenal recess.

The organometric parameters of the GDJ increase more intensively in the 2nd trimester of the intrauterine development. During the 4-6 months, the diameter of the pylorus increases 1.8 times and from the 7th month till the moment of birth – 1.2 times; respectively the diameter of the pyloric canal increases 1.7 and 1.2 times, the diameter of the duodenal ampulla – 1.6 and 1.2 times. The pyloric canal has the largest diameter, whereas the gastric pylorus has the smallest diameter in newborns. An analysis of the findings indicates that the greatest intensity of the growth of the GDJ organometric parameters is observed in the 5th, 6th, and 9th months. As is generally known, the absolute figures of the thickness of the muscular layer of the pyloric portion of the stomach diminish in the last month of the intrauterine development [8]. We regard that the results obtained by us and the adduced bibliographical data are an indication of an expansion of the gastric wall in late fetuses by a growing volume of swallowed amniotic fluid.

With the results we have obtained we have found that the thickness of the submucous layer of the pyloric portion of the stomach depends on its topical position which has a good reason to refute the bibliographical findings [9] to the effect that its thickness is identical on all walls. Thus, 10-15% of the entire thicknesses of the digestive wall belong to the tela submucosa within the limits of the contiguity of the pancreas to the GDJ, whereas the abutment on the rest of its perimeter makes up 20-35%. The share of the thickness of the mucous

coat of the pylorus makes up 45-65%. Our data agreement with the statement of D. Bourdelat et al [10], dealing with a two-layer structure of the pyloric mucous membrane in fetuses. Ratios of the thickness between the longitudinal and circular layers make up 1:8 in fetuses and 1:9 in newborns. This particular fact is a confirmation of the bibliographical findings [11] to the effect that an increase of the thickness of the muscular layer of the GDJ occurs at the expense of the circular muscular layer.

On the basis of the obtained findings we have elaborated a histotopographic scheme of the GDJ structural organization of fetuses and newborns. This is characterized by a lesser thickness of the tela submucosa, by a chaotic localization of leiomyocytes of the circular layer, by a denser interlocation of the cells of the longitudinal layer, a small number of vessels of the small caliber and a marked character of the connective tissue layers between the tela submucosa and the serous tunic. The transitional sector, bordering on the syntopic field of the pancreas differs by a relatively parallel arrangement of the leiomyocytes of the circular layer, higher density and a small gauge of the blood vessels of the muscular tunic. The pancreatic sector is characterized by the greatest thickness of the tela submucosa, a loose and parallel interarrangement of the leiomyocytes of the circular layer, a great number of blood vessels with a large diameter in the muscular tunic, a lesser thickness of connective tissue layers between the tela submucosa and the serous tunic.

It has been ascertained for the first time that during the perinatal period a loop of the transverse colon often abuts on the anterior surface of the GDJ which shifts more caudally from the level of the pylorus. The frequency of such an interabutment of the tubular segments with a prolongation of the term of the prenatal development increases from 70.3% in the 2nd trimester to 75.9% in the 3rd trimester. The number of similar anatomical variations decreases (63.6% during the neonatal period). The GDJ abuts on the gallbladder less seldom than on the large intestine. The frequency of their interabutment in the 2nd trimester makes up 63.0%. With a prolonged gestational period, the frequency of such a variant diminishes and constitutes 45.5% in neonates.

Skeletopically, the GDJ shifts from the level of the superior margin of the XIIth vertebra (in the 4th month) to the level of the intercostal space between the XIIth thoracic and the 1st lumbar vertebrae (in the 6th – 7th months) and the superior one-third of the 1st lumbar vertebra (in the 9th month and in newborns) during the fetal period.

It has been detected by means of an ultrasound-examination that the length of the pyloric canal is probably larger in boys than in girls. The luminal value of the length of the pyloric canal is up to 15 mm in newborns adduced in the publication [12], which confirms the findings obtained by us. Probable sex-related distinctions based on the diameter of the pyloric canal are observed in newborns, in contrast to infancy it is longer in newborn boys (8.14 ± 0.97 mm) than in newborn girls (5.58 ± 0.47 mm). The diameter of the pyloric ostium measured by us (in newborns of both sexes – $2.73 \pm$

0.25 , in nurslings of both sexes – 3.01 ± 0.29) coincides with the bibliographical data [13]. The thickness of the pyloric wall makes up 4.11 ± 0.37 mm in newborns and 4.61 ± 0.42 mm in infants. The sex-related difference is characteristic only of newborns; the pyloric wall is thicker in boys. It is precisely this fact that explains why congenital pylorostenosis occurs 3.5-5 times more often in boys than in girls [14].

Conclusions

In the 3rd trimester of gestation and at an early stage of the neonatal period, the wall of the gastroduodenal junction differs by a larger thickness of the tela submucosa, by a parallel interarrangement of leiomyocytes and by a lesser diameter of the blood vessels of the muscular tunic.

In fetuses aged 8-9 months and newborns, the muscular layer of the gastroduodenal junction is permeated with connective tissue bands from the serous tunic to the tela submucosa whose thickness is the largest within the range of the syntopic field of the pancreas.

The diameters of the pyloric canal and the pyloric ostium as well as the thickness of the wall of the gastric pylorus are greater in infants than in newborns according to the findings of an ultrasonographic examination; these particular parameters are greater in boys than in girls.

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