

RESISTANCE OF THE HUMAN DUODENUM WALL (EXPERIMENTAL STUDY)

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The physical and mechanical parameters of the biological materials have been studied more intensively since the 60s – 70s of the last century. Nowadays, are being made attempts to determine the areas of the weakness of the hollow organs walls. The demand for this kind of research is associated with the increasing frequency of polytrauma, including the involvement of the abdominal cavity organs. The purpose of our research was to determine the location of the lesions of the duodenum wall after the experimentally induced baroresistance test. The studied material was tested with a system for establishing the baroresistance of the hollow organs. The study was conducted on 25 people aged of 21-87 years, 19 male and 6 females. The areas of the duodenal wall with a low level of baroresistance were identified, taking into account their number and length of the wall ruptures. In 8 cases there were registered macroscopically visible ruptures of the wall of the lower horizontal duodenum (DIII) with a mean value of $32,0 \pm 8,52\%$. In 6 cases, ruptures of the duodenal wall in parts DII – DIII with a mean value of $24,0 \pm 7,79\%$ were detected. Similar lesions of the DIII and DIV occurred in 5 cases, with a mean value of $20,0 \pm 7,30\%$. Isolated lesions of the wall of the descending duodenum were found in 3 cases, which mean was $12,0 \pm 5,93\%$. In 2 cases ($8,0 \pm 4,95\%$), under the action of high pressure in the lumen DI, the continuous passage of solution occurred. An isolated duodenal rupture at the level of the duodenojejunal flexure was registered in one case ($4,0 \pm 3,58\%$). The resistance of the human duodenum wall, to a certain extent, tends to reduce in the distal direction from DI to DIV. It also, depended on the direction on which the mechanical stress was applied to the examined samples – longitudinal or transverse. As a result of the experiment an increased resistance limit to tensions in longitudinal direction was established.

Key words: *baroresistance; duodenal wall.*

РЕЗИСТЕНТНОСТЬ СТЕНКИ ДВЕНАДЦАТИПЕРСТНОЙ КИШКИ ЧЕЛОВЕКА (ЭКСПЕРИМЕНТАЛЬНОЕ ИССЛЕДОВАНИЕ)

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Физико-механические параметры биологических материалов стали более интенсивно изучаться с 60-х – 70-х годов прошлого столетия. В настоящее время предпринимаются попытки определить участки непрочности стенок полых органов. Востребованность такого рода исследований связана с нарастающей частотой политравмы, в том числе с вовлечением органов брюшной полости. Целью нашего исследования было определение локализации очагов поражения стенки двенадцатиперстной кишки после проведения экспериментально индуцированного тестирования барорезистентности. Исследуемый материал испытывали с помощью системы определения барорезистентности полых органов. Экспериментальное исследование проведено на 25 человек в возрасте от 21 до 87 лет, 19 мужчин и 6 женщин. Были определены участки стенки двенадцатиперстной кишки с низким уровнем барорезистентности, с учетом их количества и протяженности разрывов стенки. В 8 случаях были зарегистрированы макроскопически видимые разрывы стенки нижней горизонтальной двенадцатиперстной кишки (DIII) со средним значением $32,0 \pm 8,52\%$. В 6 случаях были установлены разрывы стенки двенадцатиперстной кишки в отделах DII – DIII со средним значением $24,0 \pm 7,79\%$. Аналогичные поражения DIII и DIV встречались в 5 случаях со средним значением $20,0 \pm 7,30\%$. Изолированное поражение стенки нисходящей двенадцатиперстной кишки выявлено в 3 случаях, что в среднем составило $12,0 \pm 5,93\%$. В 2 случаях при среднем значении $8,0 \pm 4,95\%$ под действием повышенного давления в просвете DI происходило непрерывное прохождение раствора. Изолированный разрыв двенадцатиперстной кишки на уровне двенадцатиперстно-тощекишечного изгиба зарегистрирован в одном случае, его среднее значение составило $4,0 \pm 3,58\%$. Сопротивление стенки двенадцатиперстной кишки человека в определенной степени имеет тенденцию к снижению в дистальном направлении от DI к DIV. Это также зависит от того, в каком направлении приложено механическое напряжение к исследуемым образцам – продольном или поперечном. В результате эксперимента установлен повышенный предел прочности на растяжение в продольном направлении.

Ключевые слова: барорезистентность; стенка двенадцатиперстной кишки.

Introduction. The interest to physical and mechanical parameters of the biological materials have been increased since the 60s – 70s of the last century. Different ways to set the values of the basic indexes of the biomechanical features of materials, especially of the soft tissues were worked out and verified. Presently practiced tensometric methods became classical in this area with a basis of specific methods and well-defined formulas. The main features of BPD complex – walls of the duodenal segments (DI – DIV) and the ones of the choledocus have been studied. At this point are taken efforts to set the areas with lower strength of the hollow

organs. These types of researches are necessary because of the increased rate of polytrauma, including the involvement of organs of the abdominal cavity.

The specialty literature also provides tensometric studies of other anatomical structures. Thus, Catereniuc I. (2010) [1] determined the values of the tensometric indicators of the ligamentary apparatus of the liver; Belic O. (2005) [2] conducted a similar study related to the ligamentary apparatus of uterus. An experimental study, which also includes tensometric examinations of injuries' sutural materials – *arahnopiafilum* and catgut standard – was carried out by Turchin R. (2010) [3]. Due to the researchers conducted by Kuznetsov N. N. (1958) [4], the practical medicine enriched with a lot of new plastic materials at that time, made of bovine visceral peritoneum. The author also studied the physical and mechanical properties of the peritoneum, strips of which (with an area of 1 mm² in transverse section) supported a force equal to 6 – 7 kg/f. The cranium's biomechanical properties, as well as the Achilles tendons were investigated [5].

Taking into consideration that the physical and mechanical properties of the gastrointestinal tract, biliary and pancreatic ducts, as well as those of the other components of the biliopancreaticoduodenal complex are not so well elucidated in the specialty literature, we decided to set up our experiment and to study those properties.

Aim of study. To study the baroresistance of the human duodenum walls at artificially increased intraduodenal pressure.

Materials and methods. The studied material was tested with a system for establishing baroresistance of tubular organs developed by Suman S. From this viewpoint, an experimental study was conducted on 25 corpses aged between 21 and 87, 19 men and 6 women. In the necropsy room, the material was collected from the cadavers (as soon as possible after death) and it was placed into physiological solution (NaCl 0,9%). Then the material underwent experimentation within a limited time (few hours).

Results. Thus, it followed to establish the areas of the duodenal walls with lower strength, taking into account the duodenum portions, direction, number and length of the duodenal wall's ruptures.

The strength of the duodenum walls showed to be lower compared to that of the common bile duct. The duodenal walls strength was calculated in mm Hg, and it did not exceed 300 mm Hg.

Therefore, macroscopically accessible ruptures of the duodenal walls were mainly recorded (32,0±8,52% – 8 observations) at the level of the lower horizontal part of the duodenum (DIII). Ruptures within the limits DII – DIII occurred in 6 (24,0±7,79%) cases. Similar injuries at the level DIII and DIV happened in 5 (20,0±7,30%) subjects. Single injuries of the walls of the descending duodenum were discovered in 3 (12,0±5,93%) cases. Under the action of the increased pressure in the DI lumen, continuous passage of the solution occurred in two (8,0±4,95%) cases. Single ruptures at the level of the duodenojejunal flexure happened in one case (4,0±3,58%).

As to establishing the areas with lower strength of the human duodenal walls, the analysis of the own data, demonstrated that DIII has a lower resistance of the duodenal lumen under experimentally increased pressure. In this segment, the quota of ruptures of the duodenal wall was of $32,0\pm 8,52\%$ ($n=25$). Related mechanic injuries, with involvement of DII – DIII and DIII – DIV, were noted in $20,0\pm 7,30\%$ of cases in the mentioned segments apart. Ruptures of the DII wall were established in $12,0\pm 5,93\%$ – 3 observations and those of the DI were noticed in 2 ($8\pm 4,95\%$) corpses. The ruptures of the duodenal wall in both cases were on the lower part of DI.

The case when injury of the duodenal wall was at the level of the duodenojejunal flexure displayed by the presence of two parallel ruptures of 0,6, and respectively 0,7 cm, they partially affected the concave surface of the duodenal segments DII and DIII. Therefore, those injuries of the duodenal wall may be analysed with the other 6 cases, in which the walls of the segments DII and DIII were injured concomitantly. Even without this case, the highest rate of ruptures ($32,0\%$) of the duodenal wall was on the segment DIII.

Thus, we may conclude that, under the action of the increased intraduodenal pressure, the most injuries $64,0\pm 8,76\%$ of cases, occurred within the limits of the segments DII and DIII, and they were located mainly on the concave surface of the duodenum, or near the anterosuperior and posterosuperior margins of the DIII.

As regards the values of the intraduodenal pressure, which may cause mechanical injuries (ruptures) of the duodenal wall, they vary between 190- and 296-mm Hg. In order to be clearer as to the pressure's values, the cases were divided into two subgroups: up to 250 mm Hg and beyond 250 mm Hg. The first subgroup got $32,0\pm 8,52\%$ of the total sub-lot ($n=25$), whereas the second subgroup – $68\pm 8,52\%$ of cases – 17 observations (251 – 296 mm Hg). Most data referring to the strength of the duodenal wall to mechanic factors in man were obtained by traditionally-type tensometric researches.

Regarding the length of continuous solutions passage, it worth to be mentioned that they varied a lot from one case to the other– from 0,3 – 0,4 cm up to 2,4 cm. Double, parallel, same level ruptures were found in 8 ($32,0\pm 8,52\%$) of cases.

Conclusions. The tensometric studies were supplemented by experimental examinations on non-fixed cadaveric material. By the devices developed by one of the co-authors, there were established the areas of the duodenal wall with low strength to artificially created intra-lumen bar-pressure. Referring to the walls of the duodenum it was noticed that DIII has lower resistance to the bar-pressure. Mechanical, macroscopically accessible injuries of DIII walls were observed in $32,0\%$ of cases ($n=25$). Injuries of DI wall was noticed only in $8,0\%$ of cases. The most susceptible area to mechanical injuries at increased bar pressure is the concave surface of the duodenal segments DI – DIII.

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