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THE SWINE INTESTINAL WALL THICKENING DYNAMIC IN RESULT OF DIFFERENT PRESSURE APPLYING INSIDE THE WELDING ANASTOMOTIC INSTRUMENT MODEL

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Abstract

Introduction. The life-time studies of intestine operate at a pressure of 0.003-0.006 (N/m^2). To create magnetic ring anastomosis 0.1-0.4 N/m^2 pressure is used. The right initial compression of intestine walls before radio frequency electric influence isn't established properly, but obviously has to homogenize the tissues dense. Several publications according 1.125 N/mm^2 pressure was found.

Aim to investigate the thinning dynamics of intestinal walls having human-sized dimensions during the high pressure action, in attempt to determine the optimal moment of anastomotic welding beginning.

Material and methods. The swine organ complex was delivered to laboratory during 6 hours at 4 ºC, and then was heated to 28-32 ºC into 0.9% NaCl. Two intestine walls having human sizes were positioned on electrodes inside the anastomotic device prototype. After fixation, tissues were pressed for 60 or 120 seconds. The 30 experiments were provided using pressure values 2.1, 3.0, 3.9 and 5.0 N/mm^2 for tissues thinning dynamic investigation by connected to electrodes micrometer device.

Results and discussion. The thinning of two intestinal walls, occurs as result of applied by electrodes external pressure, valued in range from 2.1 or 3.9 N/mm^2, significantly reduces it's tempo from 35th to 60th action sec. We allow that this resistance derives from the mucous and submucosal layers. Under a pressure of 1.1 N/mm^2, the similar thickness degree and tempo is achieved by pressure prolongation to 120 sec, but under 5.0 N/mm^2 it needs 20 sec. The pressure by 3.0-3.9 N/mm^2 over 35 sec, or 5.0 N/mm^2 over 20 sec are resulted in much lower tissue stabilizing level. Obviously, its structural ground is a resistance combination of all intestinal layers at the crash edge.

Conclusions. By choosing the appropriate pressure value from 1.1 to 5.0 N/mm^2 and its exposure time from 20 to 120 seconds, it is possible to adjust the degree of tissue dense before the subsequent connection.

Key words: intestine, tissue, pressure, resistance, instrument, pig, human, experiment.

During the process of intestinal walls connection in anastomosis, in the absence of pre-compression, the resulting changes in tissues thickness and anastomosis structure is less uniform accord its circle. Available studies in intestine wall thickness changes have simulated the limits of physiological and clinical conditions, avoiding the reach of structural strength limits. Life-time biomechanical and planimetric studies, as well as created on their base models, operates at a pressure of 0.003-0.006 Newtones /m^2 (N/m^2) [1-5]. To create anastomosis due to prolonged compression by a magnet and subsequent tissue necrosis, the pressure inside the anesthetic rings is 0.1-0.4 N/m^2 [3]. Creation of intestinal anastomosis due to radio frequency electric influence obviously requires the initial compression of intestine walls, rather not by viable pressure value but such that will provide homogenization of tissues mechanical and electrical properties.

Holmer C. with the co-authors noted the best strength of such anastomotic compound was achieved after the initial compression of swine intestinal wall between electrodes by 1.125 N/mm^2 (11 250 N/m^2) [6]. In our initial experiments, the best quality of radiofrequency welding of intestinal, colon and stomach walls was achieved after their initial compression using pressure value in the range of 2 N/mm^2 and more [7]. Any data according the influence of those pressure values to the intestinal structural and related mechanical tissues properties was found in literature.

Aim: to investigate the thinning dynamics of intestinal walls having human-sized dimensions during the high pressure action, in attempt to determine the optimal moment of anastomotic welding beginning.

Material and methods. The research was carried out at the laboratory of Welding and Related Technologies for Medicine and Environment Department of Electric Welding Institute.

The tissues material used for study was the swine intestinal complex. It was taken at agricultural animal, 5 months old pig of "Ukrainian Big White"brade**,** which intestine has human-sized diameter and thickness of the intestine wall, so could be an appropriate bioimitator for human organ.

The intestinal complex was taken at farm immediately after pig death, which was planned with non-experimental reasons, and was carried out in compliance with the Ukrainian Law requirements according animals protection from cruel action, have harmonized with the relevant requirements of EU legislation.

The bioimitator was cooled to 4 ^{o}C, then delivered to the laboratory for 6 hours. Then in the laboratory it was prepared for experiment by immersing in a warm (28-32^{o}C) solution of 0.9% NaCl for 10-20 minutes, until the tissues temperature reached the one in solution. The temperature of the intestine surface and solution was controlled by the infrared contactless device GM 300 (Benetech).

The prepared bioimitator was placed between the circular electrodes, which were the element of electric weld anastomosis device model. It was produced at the Electric Welding

Institute as clinical prototype as well as the element of the experimental electric welding bench.

The intestine walls were oriented on each of the two electrodes by its mucosal surface inward, copying typical location in the surgical stapler, and then fixed to center axis of the instrument.

The 30 experiments were provided. We put previously calibrated mechanical load to the electrodes during 60 or 120 seconds. The compression time period we established by the lack of significant tissues thinning dynamics for 20 seconds.

The load value has been calibrated in accordance with certain pressure value between the electrodes: 1.1, 2.1, 3.0, 3.9, or 5.0 N/mm2 (1.1-5.0 × 10^4 N/m2).

The thinning dynamic was measured using micrometer "The multi-turn clock-type indicator 1 MIGP", accuracy class 1.0 (Zapadpribor LLC). It was attached to the upper, mobile electrode, and determined its horizon position changing during the intestinal wall tissues compression time. The measurings were captured on video. Using the fixed data, we determined the primary and final intestinal thickness between the electrodes, the compression dynamic and amplitude.

The obtained data did not require statistical processing, beside the mean values, due to the small number of tests, But we considered obtained data as sufficient for qualitative analysis because of observed trends.

Results. During the first 1-2 seconds of pressure exposure, we observed the multy-fold thinning of the tissues between the surfaces of the electrodes, from initial 4.2 mm thickness. The further thinning curve became smooth, so we presented two chart types: from the beginning of compression, and after the initial compression phase.

Under the influence of pressure 1.1 N/mm^2 or 2.1 N/mm^2, the intestinal walls thinning took place as a similar two-stage process. But under the pressure of 1.1 N/mm^2, thinning continued after 60 seconds up to 120 seconds at a significant height - 0.09-0.13 mm - (Figures 1a, 1b).

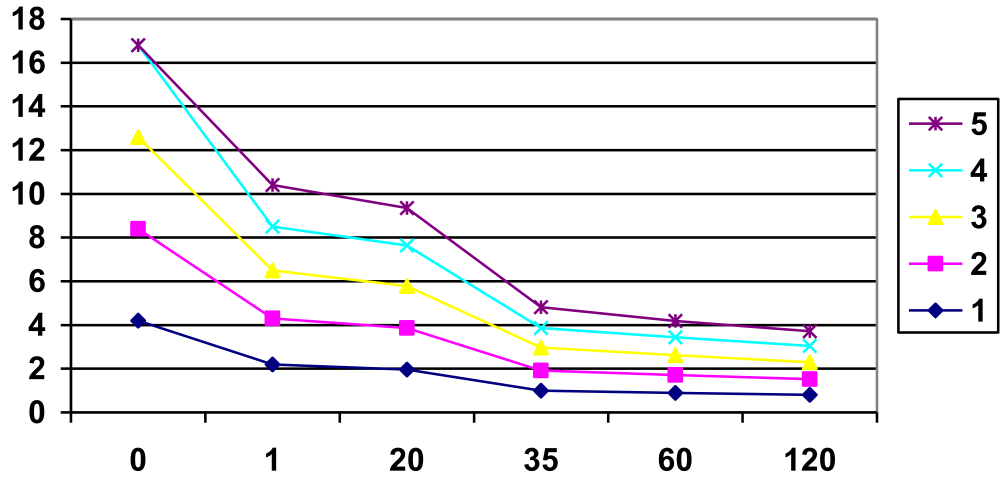

Figure 1a. The common intestinal two-wall thickness dynamic under the pressure of 1.1 N/mm^2 action (started from initial pressure point).

Instead, under the pressure of 2.1 N/mm^2, thinning curve had a deep failure at its the second stage, after about 35 seconds of pressure (Figures 2a, 2b). As a result of this case, the intestinal walls thickness became stabilized by the 60th second (Figure 2). After that to 120th second the tissues thinning was 0.04-0.07 mm. The end tissues stabilization point has quite the same level: 0.74 mm after applying pressure of 1.1 N/mm^2, and 0.63 mm after 2.1 N/mm^2.

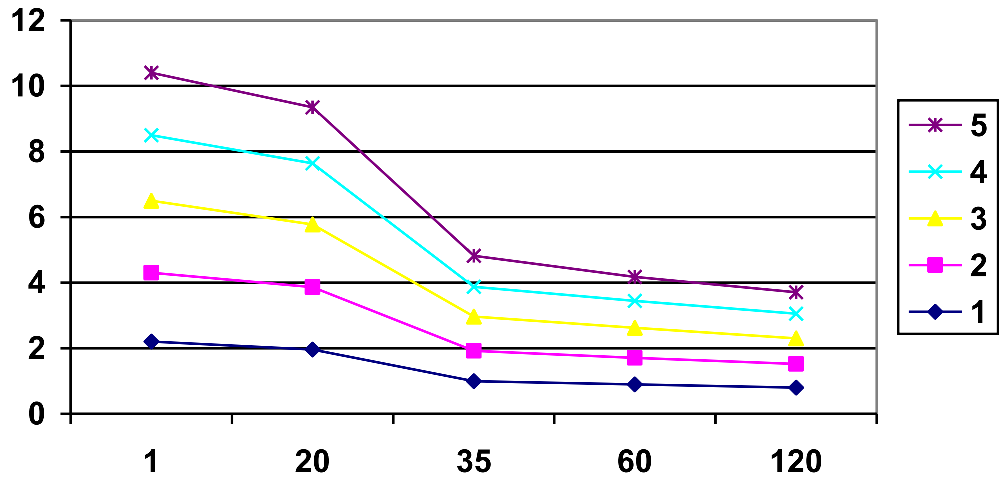

Figure 1b. The common intestinal two-wall thickness dynamic under the pressure of 1.1 N/mm^2 action (started from the point after 1st second pressure).

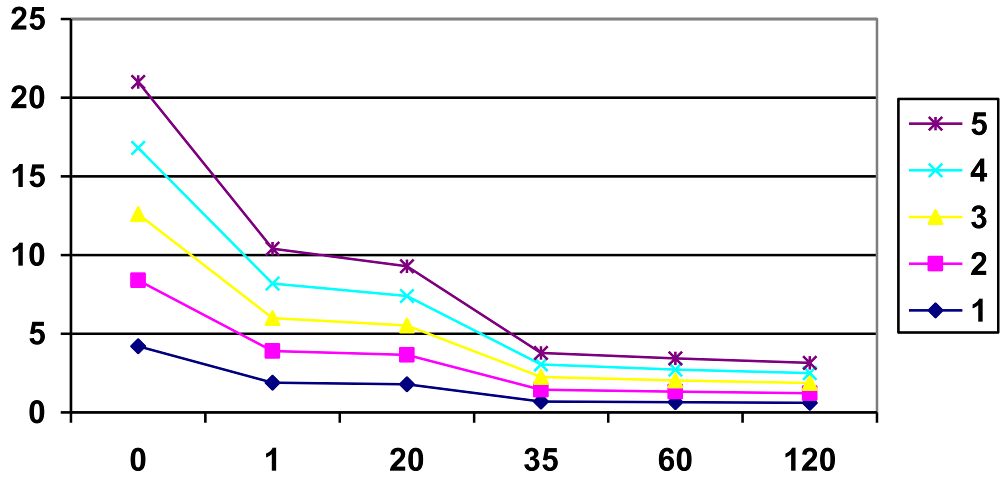

Figure 2a. The common intestinal two-wall thickness dynamic under the pressure of 2.1 N/mm^2 action (started from initial pressure point).

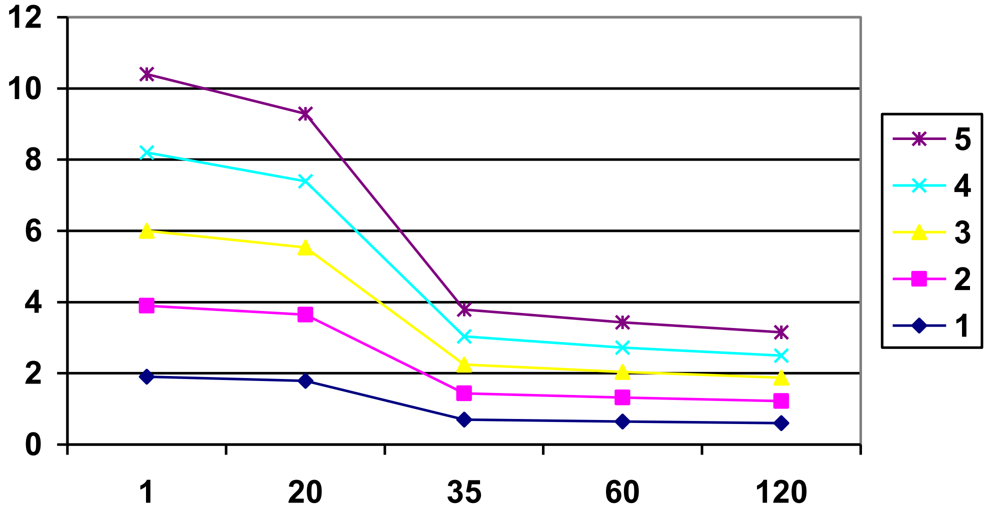

Figure 2b. The common intestinal two-wall thickness dynamic under the pressure of 2.1 N/mm^2 action (started from the point after 1st second pressure).

Under the pressure of 3.0 or 3.9 N/mm^2 action, the step-like thinning dynamic (Figures 1, 2) varied to exponential (Figures 3, 4).

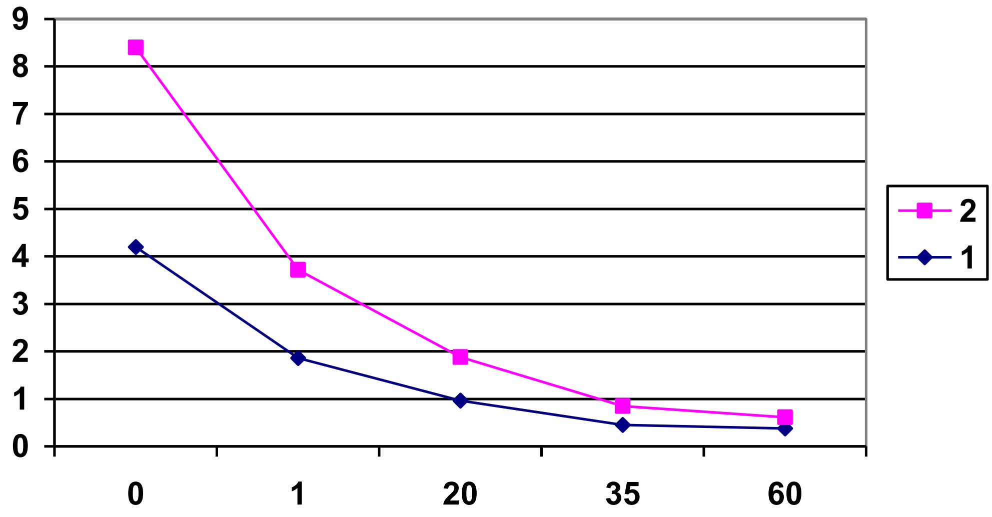

Figure 3a. The common intestinal two-wall thickness dynamic under the pressure of 3.0 N/mm^2 action (started from initial pressure point).

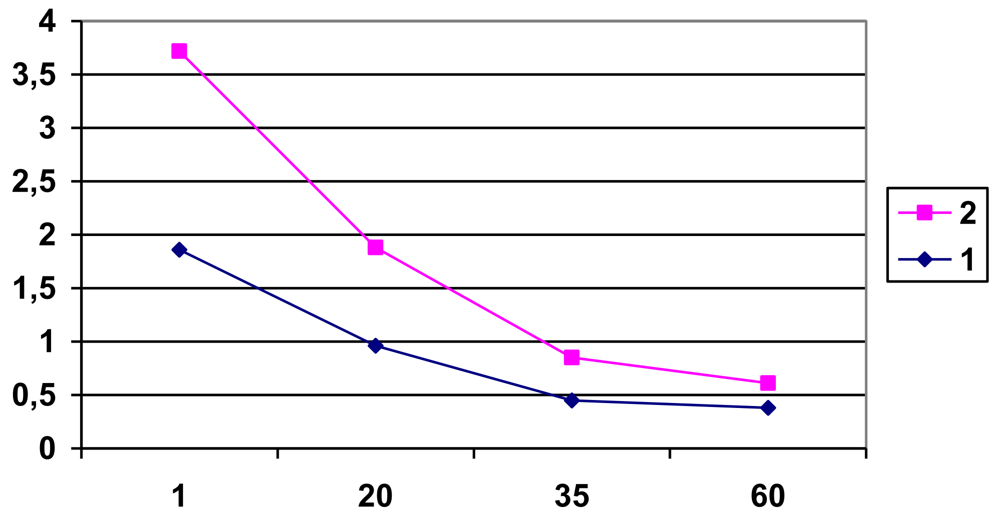

Figure 3b. The common intestinal two-wall thickness dynamic under the pressure of 3.0 N/mm^2 action (started from the point after 1st second pressure).

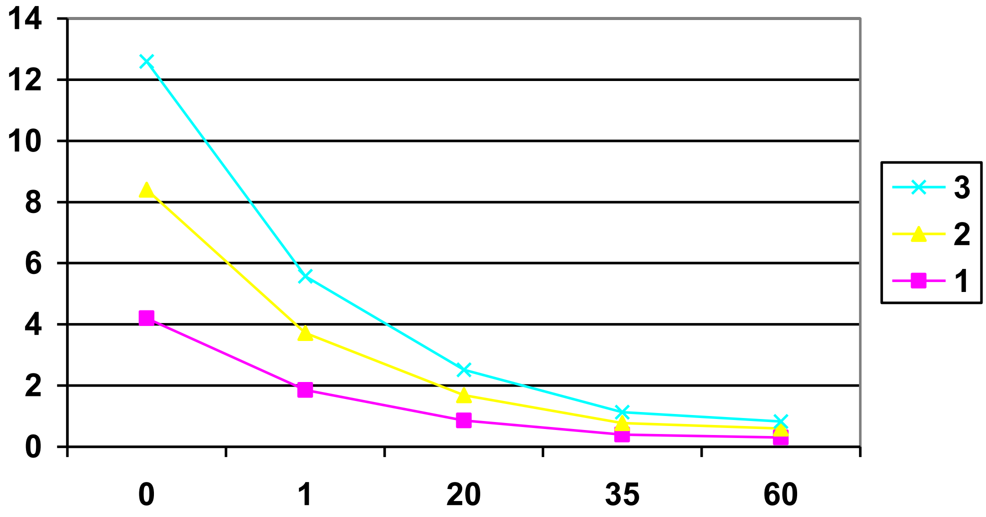

Figure 4a. The common intestinal two-wall thickness dynamic under the pressure of 3.9 N/mm^2 action (started from initial pressure point).

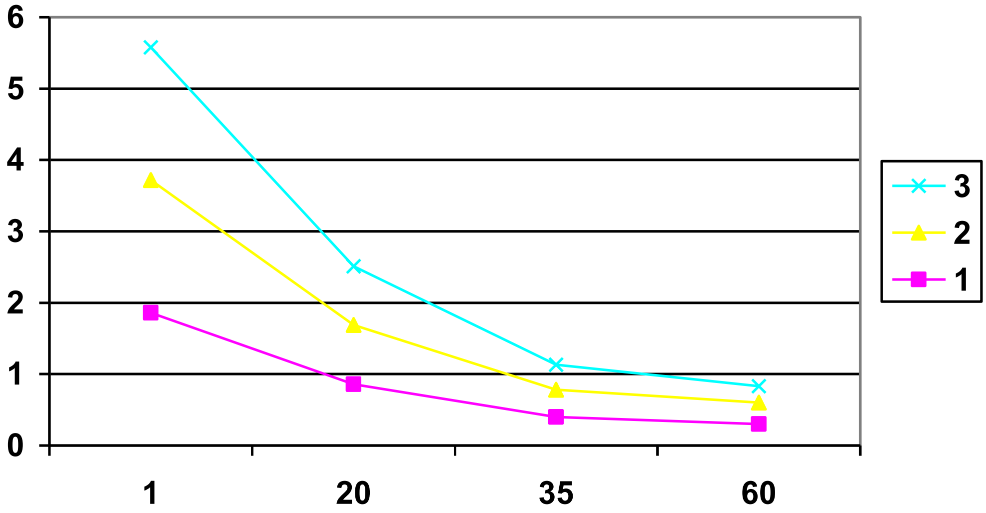

Figure 4b. The common intestinal two-wall thickness dynamic under the pressure of 3.9 N/mm^2 action (started from the point after 1st second pressure).

The tissue thickness stabilized after 60 seconds of compression at both cases. The thinning between the 35th and the 60th action seconds was the similar to that under the pressure of 2.1 N/ mm^2 action (Figure 2), 0.07-0.12 mm vs. 0.04-0.09 mm, comparatively. But at the same time, the horizontal point of stabilization after the pressure 3.0-3.9 N/mm^2 action located twice lower comparatively to 2.1 N/mm^2 action: 0.28 mm against 0.63 mm.

The average tissues thinning in the time interval between the 35th and 60th seconds after the 2.1 N/mm^2 pressure action was 9.5%, in comparing to 27.3% after 3.0-3.9 N/mm^2 action.

Under the pressure of 5.0 N/mm^2 influence, the exponential type of thinning curve have observed in previous (Figure 3, 4) modified to the angular (Figure 5) due to the obvious excess of the intestinal muscle layers natural resistance.

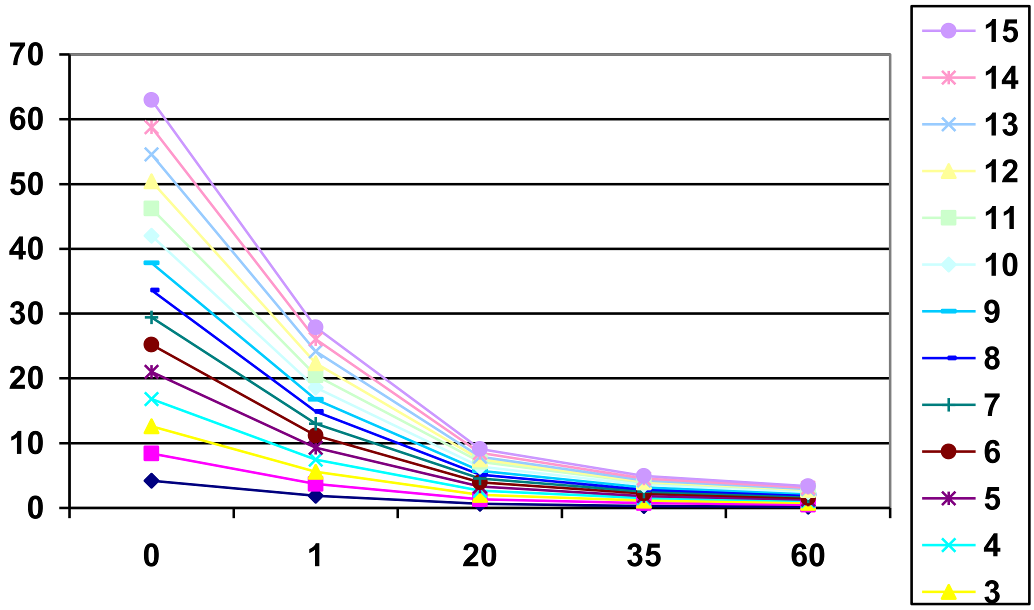

Figure 5a. The common intestinal two-wall thickness dynamic under the pressure of 5.0 N/mm^2 action (started from initial pressure point).

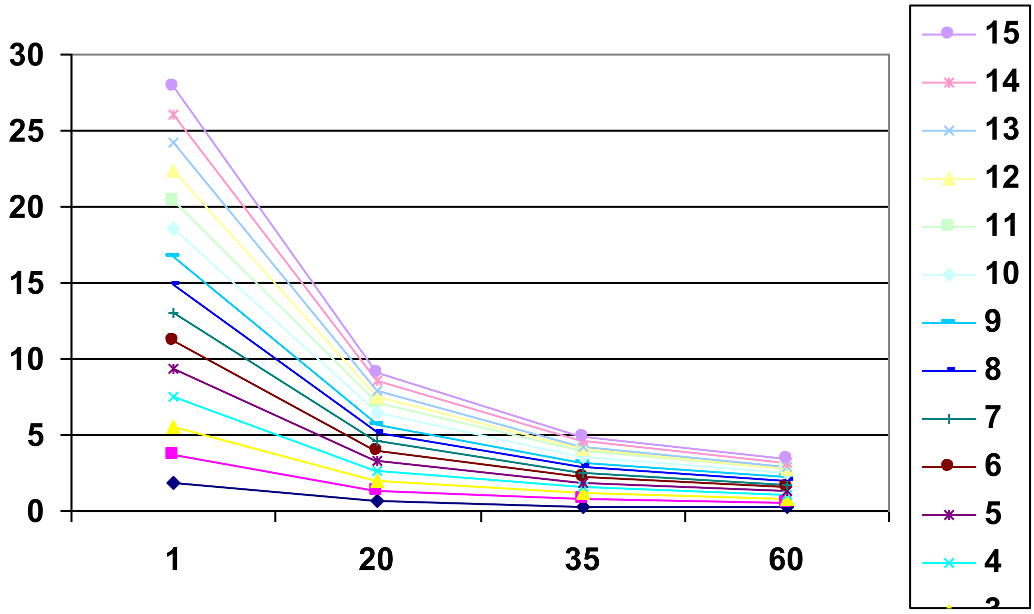

Figure 5b. The common intestinal two-wall thickness dynamic under the pressure of 5.0 N/mm^2 action (started from the point after 1st second pressure).

During the first 20 seconds of those pressure volume action, the amplitude of tissues thinning was sevenfold, then dynamic was visually almost absent, and amounted to an average of 0.1 mm.

The interesting point is remaining the tempo of thinning during the whole pressure action period: 44.3% thinning to 20th second, 47.2% - from 20th to 35th, and 30.3% - from 35th to 60th.

In comparing, the average thickness of the two intestinal walls after 60 seconds of 3.0-3.9 N/mm^2 pressure action was 0.29 mm, vs. 0.23 mm after 5.0 N/mm^2 pressure action.

Discussion. As the surgeons, we afraid the long waiting in the operating conditions is the wrong practice, so the duration to 60 seconds of compression was considered as optimal.

During the experiments, the intestine walls thinning dynamic dependence on the applied outside pressure value was established.

Falling of thinning curve for 35 seconds of 2.1 N/mm^2 pressure influence indicates the achievement of certain structural changes inside intestinal tissue, have unattainable under the pressure 1.1 N/mm^2 influence for 60 seconds. Making a projection to intestinal anatomic structure, we can allow that reflected changes derives from the mucous layer, as well in the submucosal layer, while the mechanical resistance of two layers increases to pressure value.

The next level of structural resistance becomes possible only with the pressure value increasing to 3.0-3.9 N/mm^2. Under such pressure influence the occurred two-stage curve changes into an exponential one, then stabilizing at the much lower thickness point. We have reason to establish this point as next structural resistance level, grounded on the pressure effect of higher value - 5.0 N/mm^2. After this high pressure value any could observe the return of tissues thinning up to 60th second, and resulting in the lowest point of stabilization.

Obviously, the structural ground of this level is a resistance nature combination of mucosal, submucosal and the muscular layers.

According to thinning tempo remaining during the whole 5.0 N/mm^2 pressure period, the visual curve stabilization after the 60th influence second may not be the final, but only a pause before further tissues crash. Especially we have to note the intestinal walls thinning is over 94.5% in such conditions.

Conclusions

1. The thinning of two intestinal walls, occurs as result of applied by electrodes external pressure, valued in range from 2.1 or 3.9 N/mm^2, significantly reduces it’s tempo from 35th to 60th action second.

2. Under a pressure of 1.1 N/mm^2, the similar thickness degree and tempo is achieved

by pressure prolongation to 120 seconds, but under 5.0 N/mm^2 it needs 20 seconds.

3. By choosing the appropriate pressure value from 1.1 to 5.0 N/mm^2 and its exposure time from 20 to 120 seconds, it is possible to adjust the degree of tissue dense before the subsequent connection.

Prospectives. By establishing the stages of tissue structural dense under the certain pressure values effect, we makes benchmarks for further combined studies according physical factors influence during high-frequency electric welding to create the highest quality intestinal connection.

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