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CHANGES IN THE GASTRIC ELECTRICAL ACTIVITY AFTER A WHIPPLE PROCEDURE

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SUMMARY

Several recent reports reveal that patients develop symptoms of gastorintestinal motility disorders after the standard Whipple procedure. In the Department of Propedeutics of Surgery at Bulgarian Medical Academy in Sofia we observed the same phenomenon in our Whipple-operated group of patients. But the pathogenetic mechanism was so far unclear that prompted us to conduct an experimental study in this area. Eight mongrel dogs weighing an average weight of 15-20 Kg were operated after a Whipple procedure; five dogs survived postoperatively. Microelectrodes were implanted subserously on the muscular wall of the gastric remnant, afferent and efferent loop of the jejunum, as well as in the duodenum which were kept intact to serve the purpose. Bioelectric tracings were conducted twice or thrice weekly for a period of 2-3 hours up to the end of the first postoperative year. Serious rhythmic as well as characteristic disturbances which are believed to be related to the motility disorders after this operative

procedure were found in the bioelectric activity of the gastric remnant.

INTRODUCTION

Although the first successful pancreatico-duodenectomy has been performed by *Whipple* and coworkers in 1935 (1) , the digestive consequences after this operation are still a moot aspect which attracts scientific attention of many researchers throughout the world. In recent years, Linehan *et al* (1988) have reported that the incidences of the dumping syndrome may reach up to 10% in patients after a standard *Whipple* operation on the pancreas (2). McAfee and coauthors have also disclosed the fact that a slow gastric emptying occurs in patients after the *Whipple* operation (3). We have also observed clinical symptoms of slow gastric emptying in our patients after classical pancreatico-duodenectomy that prompted us to conduct an experimental study in this field. As it has been established, the electrical activity is an equivalent to the gastro-intestinal smooth muscle contractile activity (4-6). We have chosen to study the gastric electrical activity after witnessing this postoperative intervention.

MATERIALS AND METHODS

The experiments were carried out on eight healthy female mongrel dogs with an average weight of 15-20 Kg. It is to be noted that our animal experimentation conforms to the Declarations of Helsinki and Tokyo.

While performing the first pancreatico-duodenectomy on humans *Whipple* and coworkers in 1935 performed a transection on the initial part of the duodenum as the stomach remained intact (1). In 1945, *Whipple* performed a modification of the original operation which bears his name as a standard procedure (7). The latter operation comprises an additional 50% subtotal resection of the stomach. Many of the current surgical texts illustrate an advice on performing the subtotal gastric resection with a view to prevent any possible appearance of ulcer. But *Whipple* himself has acknowledged that he had mistakenly performed the hemigastrectomy, thinking that the tumor originates from the posterior wall of the antrum. Only after gastric resection, he understood that the tumor had pancreatic origin.

As an experimental model of the standard resection of the pancreas after *Whipple* (7), we performed a modified (to serve the experimental purpose) operation on eight female dogs with an aim to study the changes in electrical activity of the gastric remnant after *Whipple* procedure (Fig. 1). In this operation, intitially, we resected the head and body of the pancrease up to the level of 2-3 cm above angulus pancreaticus. The duodenum was separated at the subpyloric level and an $\frac{1}{2}$-$\frac{2}{3}$ subtotal resection of the stomach was carried out. The duodenum was kept intact in order to preserve the ductus choledochus which normally in dogs, enters the duodenum at a site opposite to that of the pancreatic duct; the duodenal vascular bed was prevented from injury. In this way, a choledocho-jejuno anastomosis was avoided, and at the same time we had the opportunity to record the bioelectric activity from a duodenal site. At a distance of 15-20 cm from the ligmentum Treitz, a pancreatico-jejuno anastomosis was done. The gastro-jejuno anastomosis was done terminolaterally at a distance of approximately 25-30 cm from the site pancreatico-jejunostomic site. A Braun anastomosis (laterolateral) was performed between the afferent and efferent loops of the jejunum at a distance of approximate 10 cm below the gastro-jejeuno anastomotic site.

In order to record the bioelectrical activity of the muscular wall of the stomach, a modified method of Papasova and Milenov (1965) was used (8). The bioelectric method has been innovated in 1912 by Stubel who used it in experiments with muscle strips *in vitro* (9). In chronic experiments, the method has been applied by Bass in 1965 (10). The modified method of Papasova and Milenov (1965) finds its application in acute as well as in chronic experiments. In this ponent of the slow waves (16). Szurszewski in 1969 found that the Spike potentials (or spike activity) appears in the rhythm of the slow potentials which define a migrating myoelectrci complex (mmc) (17). The mmc start from the stomach has been revealed by Code and Marlett in 1975 (18) and is said to consist of four phases (19). In our experiments on normal dogs, we recorded a normal spike activity from the stomach as well as from the duodenum (Fig. 2B).

Our electrophysiological study on dogs after the *Whipple* operation has revealed an intestinalisation of the electrical activity of the gastric remnant. As early as at the end of the first week after the operation in separate periods of time, in recordings from the stomach adjacent to the anastomosis (electrode 1, Fig. 3, Fig. 1) an appearance of slow potentials with comparatively low amplitude, but with rhythm identical to that recorded from the jejunum was observed. At this stage, it is very difficult to predict the origin of this stage, and predict the origin of this electrical rhythm, whether it propagated from the efferent or afferent loop of the jejunum. The appearance of Spike potentials provides the possibility for further evaluation of this question. In Figuer 4, the Spike potentials appears at the efferent loop (electrode 3) and instantly after this the spike potentials has also been observed in recordings of the electrode implanted at gastric region (electrode 1). At the same time, the afferent loop of the jejunum demonstrates only slow potentials.

In reality, the intestinalisation of the gastric electrical activity starts from the efferent loop of the jejunum, which is clearly shown in Figure 5. In this case, the Spike activity is recorded from the afferent loop while the efferent loop and stomach demonstrate only slow waves.

In latter periods, after the operation (in this instance, the recording has been done a month after the operation). The intestinalisation of the gastric electric activity has also been observed in the recordings from the electrode placed proximally on the gastric wall (electrode 1, Fig. 6). It is to be noted that amplitude of the slow waves, particularly of those recorded from the electrode placed distally was comparatively higher.

In Figure 7, a recording is shown after the ingestion of meal. It is clear from the figure that the amplitude of the slow waves recorded from the gastric remnant increases postprandially. The Spike potentials has been observed in recordings from the afferent and efferent loop of the jejunum, while a low amplitude Spike potentials has been found to be present also in recordings obtained from the gastric remnant.

This study in experimental animals operated after a *Whipple* procedure shows a clear intestinalisation of the rhythm of the generation of the slow waves from the gastric remnant. It is to be noted that the *Whipple* operation has not been tolerated by the experimental animals, as only five of eight operated animals survived postoperatively.

It is interesting to be added that we have not observed the appearance of slow potentials characteristic of the gastric muscular wall during 2-3 hours bioelectric recordings from the gastric remnant at a follow-up study up to the end of first postoperative year after the *Whipple* rocedure. It can be noted that apart from the gastric resection itself an additional factor in this pathology plays a role, most probably as the disturbed function of the pancreas after this operation. That is why during intravenous infusion of insulin in glucose solution in *Whipple*-operated animals, in some instances, we have observed the appearance of isolated high amplitude slow waves from the gastric remnant identical to the characteristic gastric slow potentials. Probably, here the proportion of the dose of insulin plays an important role. Our study up to this level does not provide the possibility to clarify the latter question; further investigation is needed to explore more in this direction.

DISCUSSION

Our electrophysiological study on animals after a *Whipple* procedure reveals an intestinalisation of the bioelectric activity of the gastric remnant. This intestinal type of electrical rhythm of the gastric remnant explains reports of several authors in the literature (3, 20), that the gastric emptying is slowed in patients after the *Whipple* type resection of the pancreas.

A definite dynamic course has been found in the development of the intestinal type of bioelectric rhythm recorded from the gastric remnant depending on the duration of the postoperative period. In the first postoperative week the intestinal type of slow waves has been found episodically at distal part of the gastric remnant adjacent to the gastro-jejuno anastomotic site. One month later, it has been found that the proximal part of the gastric remnant starts generating the intestinal type of the electrical activity. Onwardly this change of the electrical activity of the gastric remnant has been noticed almost uninterruptedly (bioelectric activity of the gastric remnant has been recorded for 2-3 hours). This intestinalisation of the electrical activity has been observed from the first postoperative month onwards up to the follow-up period of one year after operation. Feeding the animals has led to an increase in the amplitude of slow waves of the gastric remnant and also in the appearance of Spike potentials in the efferent and afferent loop of the jejunum as well as in the stomach wall. Simultaneous Spike activity at the efferent loop of the jejunum and the gastric remnant without the presence of that at the afferent loop indicates that the intestinal rhythm of slow waves of the gastric remnant most probably originates from the efferent loop.

Our results after *Whipple* operation partially coincide with the study of Schaap and coworkers (1988) in patients and dogs after *Billroth* II gastric resection (21). The latter group of researchers has reported that a retrograde conduciton of the jejunal electric activity to the distal part of the gastric remnant has been observed in patients as well as in the experimental animals after Billroth II gastric resection. According to them, the electrical activity as well as the phasic contraction of the stomach is preserved after *Billroth* II resection. They have found that the additional jejunal activity in the stomach at the interdigestive or postprandial period is correlated to the symptoms of heaviness, nausea and vomiting in patients and dogs after *Billroth* II resection. In spite of their data, we have found the intestinal rhythm not only at the distal but also at the proximal part of the gastric remnant. It is more interesting that in our cases after *Whipple* operation, we have not observed slow potentials characteristic of the gastric smooth muscle even after the first postoperative year. Most probably, the intervention on the pancreas additionally aggravates the electrical feature of the gastric remnant.

Ehrlein and co-authors in 1989 have found slow evacuation of the gastric remnant (with a simultaneous reduction in the gastric and jejunal motility) for meals with medium and high viscosity in dogs after Billoro th II resection with gastro-jejuno and entero-entero anastomosis (22). The same group of authors in another work has reported that orally propagating intestinal contractions are frequently present in the efferent loop of the jejunum after Billro th II gastric resection. Now it becomes clear that the intestinal electrical rhythm in stomach as found in the study of Schaap and co-workers (21) as well as in our experiments can be explained by the reports of Ehrlein and co-workders (23) about orally propagating jejunal contractions followed by slow waves which in turn are connected with entero-gastric reflux after a Roux-gastrectomy. Those authors have succeded to remove the ectopic pacemaker by electrical pacing which led to remove the ectopic pacemaker by electrical pacing which led to a remedy of the reflex. This gives us a basis to accept that the intestinal type of electrical rhythm of the gastric remnant in our study after *Whipple* operation may have originated from the generation of an ectopic pacemaker in efferent loop of the jejunum.

The studies of Atanassova and Bayguinov (1982, 1984) have revealed that the gastric fundus changes its electric and contractile activity approaching to the same of the corpus (26, 27). According to them, to restore the rhythm of generation of the slow potentials after gastric resection, it is best to preserve the normal pacemarker zone located at the proximal corpus while resecting the stomach. But Hocking et al. (1981) have reported that the volume of the gastric resection (antrectomy versus 2/3 subtotal resection of the stomach) has a minimal effect on gastric evacuation of solids in dogs after subtotal resection of the stomach (28). In our experiments after Wipple operation, probably the regenerative process at the anastomotic site is related to infiltration of smooth muscle cells from small intestine to the gastric remnant which receive the rhythm of generation of slow waves from the efferent loop site included in the anastomosis. From the efferent loop muscle cells, impulses are conducted to the musculature of the gastric remnant which in its turn starts generating slow waves with intestinal rhythm.

The absence of slow potentials characteristic of the stomach in our recordings done up to the end of one year after *Whipple* operation is a difficult question to be explained. Possibly, the disturbed funciton of the pancreatic gland after operative intervention plays a role in this pathology. In a study, we have shown that a partial resection of the pancreas without any operative involvement on the stomach or duodenum causes gastric dysrhythmias (29) which seems to be triggered by the post-operative hyperglucagonemia (30,31). After pancreatic resection pathomorphological changes occur at various levels of the gastrointestinal tract (32), which are believed to be related to the hormonal changes after pancreatic intervention (23). A post-operative rise in plasma Thromboxane B_2 (T_x B_2) level has been observed after simple pancreatic resection

(34), which is believed to have an action on smooth mucle function. That the intravenous infusion of insulin in glucose solution in animals after *Whipple* operation has led to the appearance of some high amplitude slow waves from the gastric remnant resembling the gastric slow potentials suggests some intuition that hormonal disturbaces after *Whipple* operation may be involved in the disappearance of gastric slow potentials after this operative procedure, an area which needs further elucidation.

In conclusion, the presence of intestinal electric rhythm in the gastric remnant after *Whipple* operation explains the pathognomonic slow gastric emptying in patients after the *Whipple* operation. With the advancement of the technique for surface electrogastrogram in future, it would be possible to clarify different gastrointestinal motor disorders in clinical practice in patients after different surgical inverventions (14).

Figure 1. Eperimental model of pancreatic resection after *Whipple* with preservation of the duodenum:

A) gastro-juno anastomosis, B) jejuno-jejuno (Braun) anastomosis, C) pancreatico-jejuno anastomosis, D-ligamentum Treitz. The numbers denote sites of implantation of the electrodes: 1-at 2 cm above A (at the gastric remnant), 1-at 2 cm above electrode 1, 2-at 4 cm below A (on the afferent loop), 3-at 5 cm below A (on the efferent loop) and 4-at 5 cm below the duodenal stump.

Figure 2. Bioelectrical activity recorded from the stomach and duodenum in intact animals:

A)at rest

B) during Spike activity

Figure 3. Intestinalisation of the gastric remnant electrical activity after *Whipple* peration: recording of slow waves followed by Spike potentials simultaneously from the efferent loop and the gastric remnant.

Figure 5. Intestinalisation of the gastric electrical activity: recording of only slow waves from the gastric remnant and efferent loop of the jejunum with the presence of Spike activity at the afferent loop.

Figure 6. Conduction of the intestinal rhyth also to the proximal part of the gastric remnant

A) at rest at the end of the 1st post-operative month

B) during Spike activity, at the end of the 3rd post-operative month

Figure 7. Changes in the amplitude of slow waves of the gastric remnant after ingestion of a meal.

A) control

B) 3 min. after ingestion of a meal (200g of minced meat).

Please, mark the presence of high amplitude Spike potentials in recording from the gastric remnant

A) upper three tracings

B) lower three tracings

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