

Motor Criteria Evaluation of Iso-anisoperistaltic Graft in Oesophageal Reconstruction - An Experimental Study of Isolated Colic Graft Motility Pattern in Dogs

D. Predescu¹, I. Predescu², M. Boeriu¹, S. Constantinoiu¹

¹"Carol Davila" University of Medicine and Pharmacy", Department for General and Esophageal Surgery, "St. Mary" Clinical Hospital, Bucharest, Romania

²ENT Department, "St. Mary" Clinical Hospital, Bucharest, Romania

Rezumat

Evaluarea criteriului motor al grefonului izo-anizoperistaltic din reconstrucția esofagiană - studiu experimental al patternului de motilitate al grefonului colic izolat la câine

În întreaga literatură de profil există un curent favorabil unui dispozitiv izoperistaltic al ansei transplantate, pe considerentul unei activități propulsive superioare și deci cu o funcționalitate mult mai bună, cu fenomene ameliorate ale regurgitației, refluxului sau aspirației. Din punct de vedere tehnic însă, din considerente anatomice, orientarea anizoperistaltică a grefonului este mult mai convenabilă. Este aceasta în detrimentul funcționalității? Care este modelul peristaltic optim? La o privire inițială, pare a se face un compromis între un factor anatomic și consecința sa tehnică față de o funcționalitate superioară. Pentru aceasta, plecând de la pattern-ul tipic de motilitate al colonului, în speță al colonului transvers și stâng, trebuie să identificăm noul comportament motor al segmentului colic izolat. Cum activitatea motorie este generată de undele electrice descărcate din centrul de control zonal, înregistrarea acestora electromiografic ar permite aflarea tiparului contractil al ansei transplantate.

Cuvinte cheie: reconstrucție esofagiană, montaj izo/anozoperistaltic grefon, evaluare motorie grefon

Abstract

In the medical literature there are more than one opinion in favour of the isoperistaltic interposed loop, considering it to render a higher propulsive activity and thus with much better functionality, with less intense symptoms of regurgitation, reflux or aspiration. Technically, however, due to anatomical relationships, anisoperistaltic graft interposition is more convenient. Is this detrimental to functionality? What is the best peristaltic model? At first sight, it seems that due to the local anatomy and surgical technique involved, we compromise at the expense of better functionality. To find the answer to these questions, starting from the typical pattern of colonic motility in the transverse and left colon, we need to identify new motor behaviour of the isolated colic segment. Because motor activity is generated by electric waves discharged from the area control centre, their electromyographic registration would allow finding the contractile pattern of a transplanted loop.

Key words: oesophageal reconstruction, iso-anisoperistaltic graft interposition, motor evaluation criteria

Introduction

The motor pattern of the digestive viscera

The motor behaviour of the digestive viscera has a pattern with strong similarities regardless of the level or the segment involved. The main elements of the digestive motor unit are the three specific cell types: enteric neurons, interstitial

Corresponding author:

Predescu Dragoș, PhD, MD
Clinic of General and Esophageal Surgery
"Saint Mary" Clinical Hospital
Ion Mihalache 37-39, Bucharest, Romania
E-mail: drpredescu@yahoo.com

cells of Cajal (ICC) and smooth muscle cells. The first level of motor coordination is ensured by intrinsic activity that can generate slow motor waves that can propagate over several centimetres and can generate contractile activity. These slow waves originate in specialized areas, populated with Cajal cells (ICC), which are called "pacemaker regions". ICC is the active element, having a unique intracellular timing mechanism having ionic conductance potential that will generate the "pacemaker" power that has the character of slow electrical wave. In the colon we identified two regions with pacemaker role: one is located between the muscle layers and the second at the submucosal surface of the circular layer. ICC are electrically coupled with each other and with neighbouring muscle cells. Slow waves generated by the ICC are propagated along the ICC network and are passively driven by smooth muscle cells. Oscillations of the muscle cell membrane potential determined by slow waves will increase or decrease calcium channel activity. As a result, this will determine a natural contractile behaviour of the smooth muscle cells in areas with slow electric waves, the so-called peristaltic motility pattern. This explains the presence of contractile activity even in the absence of other regulatory factors, ICC and smooth muscle having electrical activity and excitation contraction coupling. Slow wave amplitude and contractile force are modulated by the myenteric nervous system, as well as other factors like hormones, paracrine substances, inflammatory mediators, etc (1,2).

Serious disturbance of extrinsic control in grafting surgery of oesophageal reconstruction seriously minimizes this component, the regulatory mechanisms of contractile activity of the transplanted segment being controlled almost exclusively by local factors. As a result, the generation and modulation of the various types of colonic contractions are carried out essentially by the enteric nervous system called "the little brain" (3,4).

This being the case, it seemed interesting to investigate the behavioural changes of the "little brain" by electromyography with direct effect on peristaltic activity of transplanted colon segments maintained in transit, containing primary undigested food, on a neo-oesophagus with anastomosis performed in anisoperistaltic fashion.

Method

The procedure involved the study of animal material and followed a standard protocol for all studied cases. The work was conducted in the Research Center of the Department of Anatomy of the University of Medicine and Pharmacy "Carol Davila" Bucharest, in collaboration with the Department of Cellular Biology. The surgical technique was performed on three dogs with weights between 9-14 kg. Bowel preparation was performed with Fortrans Solution (Macrogol 2000), two envelopes, one envelope at a given interval of 8 hours. All received specific premedication - 15 mg / kg Ketamine hydrochloride and 0.5 ml Atropine, Amoxiplus 0.6 g I vial, followed by general anaesthesia. We performed a median abdominal incision. We prepared the segment of transverse

colon between 1/3 right and left, sectioned the mesocolon and performed reanastomosis in anisoperistaltic fashion of the enteric segment at both colonic ends. From one end of the isolated colic segment we have taken a tissue sample for comparative isometric study, in two situations: standard, blank control, isoperistaltic and anisoperistaltic, respectively. Due to the specific large mesenteric pedicle, we have not encountered any signs of ischemia.

The average length of prepared and inverted loop was about 20 cm. The two anastomoses were performed in a single layer, with nylon 10. There was no postoperative drainage. The evolution was good, with complete recovery relatively quick, in about 3 days, with gradual resumption of feeding and early resumption of GI motility from the second postoperative day in all three dogs. There was an observation period of 3 months, during which the feeding behaviour remained unchanged, being identical to the preoperative one. All three dogs had two or three stools/day. Three months after surgery another surgery with the same preoperative preparation was performed, and we have performed the resection of the inverted segment and restoration of digestive continuity with colo-colic anastomosis TT. In two cases we had to mobilize the two colonic angles. All three dogs survived the surgery with complete recovery.

The fragments collected were washed with saline and immediately immersed in Krebs solution at a temperature of 36 ± 1 °C. Krebs solution is a physiological saline solution containing NaCl, KCl, CaCl₂, MgSO₄, potassium dihydrogen phosphate, sodium bicarbonate and glucose (mmol L⁻¹ - NaCl 120, KCl 5.0, CaCl₂ 2.5, MgCl₂, 1.0, NaH₂PO₄ , 1.0, NaHCO₃, 25.0, glucose, 11.0; carbogen continuous bubbling 95% O₂, 5% CO₂).

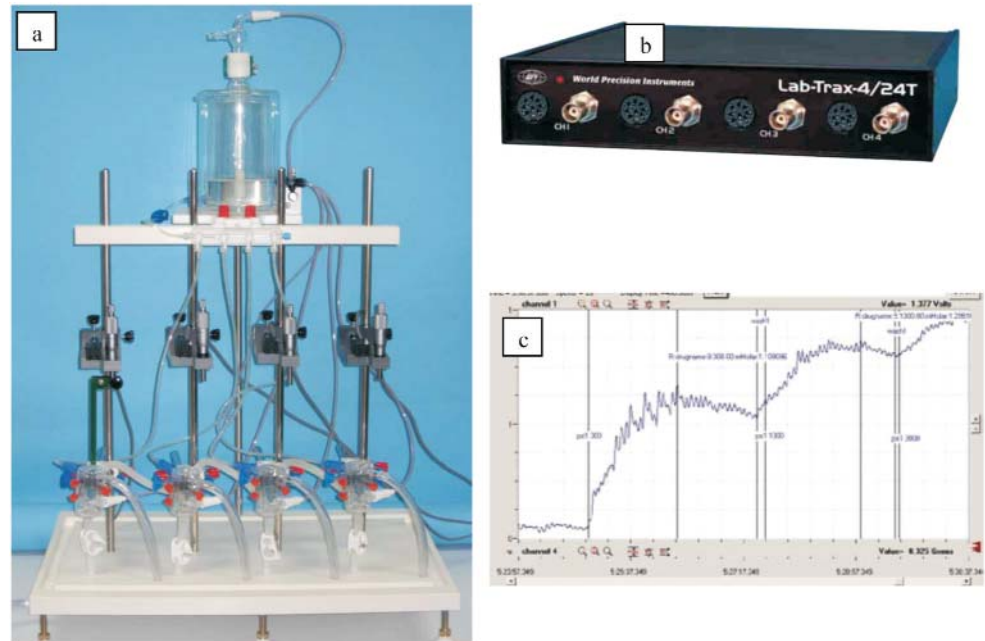
The equipment used (Fig. 1) for the study of colonic contractile activity was provided by World Precision Instruments Inc. - Myobath II - Multi-Channel Tissue & Organ Bath, using a high definition transducer type FORT10-100 with a sensitivity which allows recording differential forces from 0.005 to 10 g, in a measurement range of between 0 and 100 grams. Transducers were coupled to a four-channel amplifier type Transbridge™, each channel allowing a decimal control.

The software used for recording was a standard type digital map, from Data-Trax, which allows analysis and various conversions (eg, converting volt units in grams or mmHg). The type of graphical interface was Python 2.2 from Scientific Python (SciPy), using Tkinter graphic library for the date model with non-linear regression, from Numeric libraries Raymond Hettingers Public Domain Matfunc module.

Results

Graphical representation of the contractile muscle activity on normal colon showed almost normal values in terms of amplitude and frequency of the waves of contraction in all control measurements on the three dogs. Although electromotor activity in vitro of the two layers is somewhat different, recent data (5,6) shows that in vivo they are coupled, with mutual influences. Therefore, the study aimed the muscle layer

Figure 1. Equipment used for electromyographic study **A)** the organ bath, **B)** amplifier channels activity, **C)** digital map Data-Trax



activity as a whole and not separately in components. At the end of the initial phase, on the control samples, we can say that all dogs initially had a normal colic peristaltic activity - (Fig. 2 A, B, C).

After the long term measurements (after 3 months), we find important changes of contractile activity pattern. Thus, in case no.I (Fig. 3) we notice the presence of peristaltic activity in physiological direction but with an attenuation of amplitude of over 50%; also we notice that its value has a variable character, due to completely different amplitude and frequency ratios obtained after sampling of tissue material from several locations on the piece of resection. A second remark is based on the presence of a quasi-normal contractile colic frequency.

For the other two cases though (no II & III), the obtained values showed different results, obviously different from the first one. Specific determinations found variable attenuation indices obtained with active, important anti-peristaltic contractions (Fig. 4, 5). In conclusion, the data obtained are highly contradictory.

Extremely interesting is case I where there is a reversal of contractile direction, suggesting an adaptation of the intestinal pacemaker to the new situation. It is true, however, that despite a normal discharge frequency, amplitude is low and so the visceral contractility is weak. Do not forget that it operates autonomously and is disconnected from the upper control stations and neuro-hormonal regional influences and it is possible to suffer a process of "reverse function", especially after some time. This phenomenon is also suggested or even confirmed in the medical literature (7,8), data obtained on histological, manometry, electromyographic and scintigraphic criteria (9-12) leading in this direction.

In the other two cases (II & III), physiological motility alteration was significant. Muscle contractions were always recorded when there was a maximal action potential (spike), but never under conditions of slow waves. The main motor feature was, as expected, the presence of peristaltic waves, but significant attenuation of the two defining elements: frequency and amplitude. The different degree of electro-motor attenuation has two possible explanations: (i) either the motor command is in an adaptive phase, the time required for rebalancing the motor pattern being longer, ranging chronologically from one case to another or (ii) the download center has an erratic behaviour, more or less dependent of the regulatory of ontogenetic influences from the colonic layers or extra-visceral. A regulatory element that could be very important and would explain the capricious nature of electrical activity could be the neural control from a higher level. The distribution of neural threads to colonic muscle follows the same path as vascular elements. Since there is a multitude of vascular patterns and during surgery some vascular pedicles are sacrificed, based on the anatomical situation, it is obvious that this type of control is customized for each case. Basically, there will be but a loosely defined area on the graft that will receive the neural influences due to the neural threads that are reaching the colon together with nourishing vessels. Here we might find the explanation of the dual electro-stimulatory behaviour of the colon samples with various locations on the graft, sampled for the electromyographic study (see case no I - Fig. 3). Another possible cause could be the different motor behaviour of the colonic segments, whose discharge rate and amplitude vary significantly depending on the sample location (13-15).

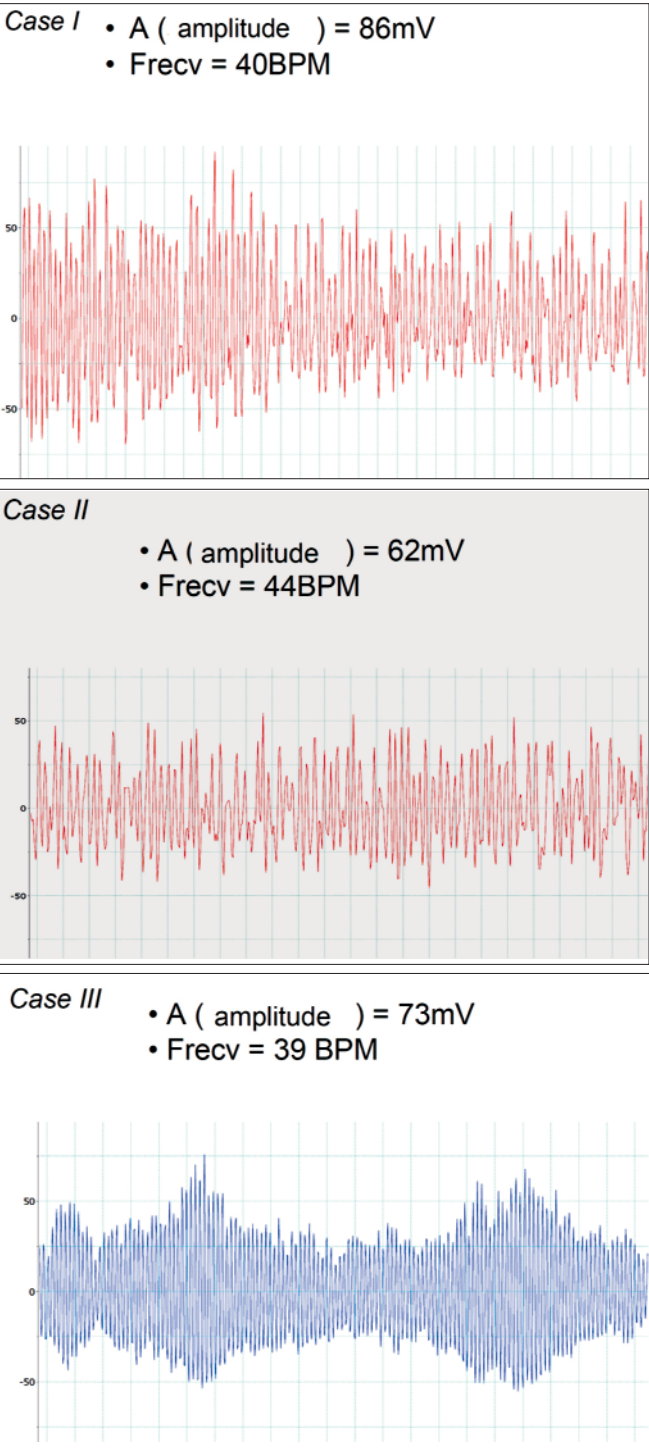


Figure 2. (Case I, II,III). Peristaltic waves with normal amplitude and frequency (control group)

Conclusions

Most of the studies (7,16-22) made regarding iso-anisoperistaltic colic graft function and motor behaviour, regardless of the valuation methods used (radionuclides, manometry, pH meters), report a poor propulsive activity compared with the oesophagus. The longer the graft is, the

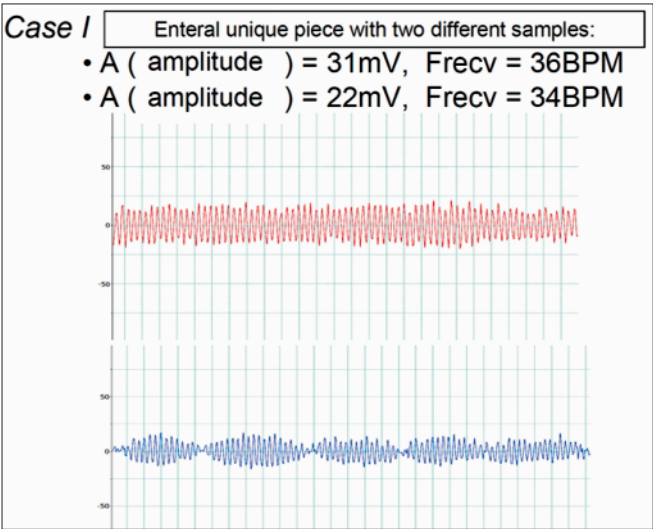


Figure 3. Case no.I - The presence of a peristaltic activity, normal frequency but with low amplitude. Different amplitude and frequency for tissue samples from several locations

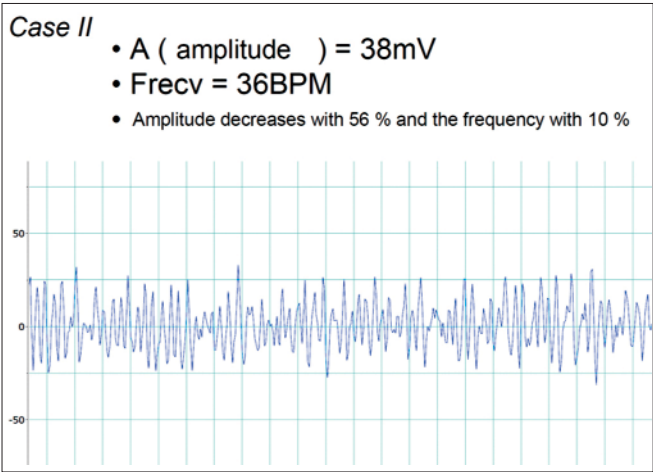


Figure 4. Case II - The presence of peristaltic waves with significant attenuation for amplitude and frequency

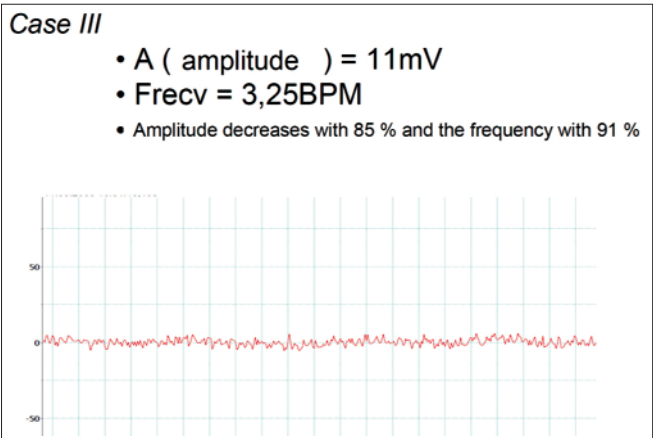


Figure 5. Case III - The presence of antiperistaltic waves with impairment of amplitude and frequency

more intense are the retention phenomena, while a limited segment has a clearance similar to the oesophagus. In the first few months the graft seems to be lacking contractile waves, the food passage through the anisoperistaltic loop being essentially passive, dependent on gravity.

With no intent to have a statistical role and draw definitive conclusions, our study captures four distinct behavioural instances of isolated colonic loops. Firstly, we notice the presence of contractile activity in the graft, regardless of iso-anisoperistaltic anastomosis. Secondly, the key elements of a contraction (amplitude, frequency) undergo unorganized, non-specific, individual changes. Thirdly, electrical activity has a different behaviour for different locations of the same isolated segment. Fourthly, despite an anisoperistaltic anastomosis, a reverse motor activity may occur, most likely long-term after surgery. We cannot predict, however, whether this phenomenon will certainly appear and, if it does, how long it will be before installing.

Long term studies (23,24) often find an astounding motor diversity, but one thing is certain: there is peristaltic activity in the graft. Regarding the anisoperistaltic anastomosis, the grafted loop tends to maintain the pattern of motility, leading to anti-digestive propulsion. In other words, the graft does not have an inert, tube-like behaviour. Contractile waves undergo a change in duration, amplitude and motility index. The consequence is a prolonged oesophageal clearance, with accumulation of food content that will produce colic wall distension, leading to motor activity by direct stimulation. The inefficiency of enteric anti-gravitational contraction seems to initiate the mechanism of adaptation and modification of intestinal pacemaker. The longer the time elapsed from surgery is, the more the peristaltic mechanism seems to adapt to the new digestive situation (25,26). Even under these favourable adaptive circumstances, gravity will play a key role in the food passage between the hypo-pharyngeal and gastric segment (27).

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