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Discussion

Dr. Clarence Dennis (Brooklyn): My associate, Dr. Adrian Kantrowitz, has been working in this same field and is equally gratified with the experimental and clinical results which have been obtained. He has, however, embarked on some basic studies, to begin with, on the type of stimulus which is to be employed, whether it is a direct current stimulus or an alternating current stimulus; whether, if it is an alternating current stimulus, the frequency of cycles should be rapid or slow, or whether the shape of the wave of stimulus should be square wave, sine wave, or of what shape; and finally, the studies on the importance of the frequency of bursts of stimulation which take place.

Inasmuch as Dr. Bilgutay did not mention such basic studies in his presentation, I am very curious what his basic studies show in this regard.

Dr. C. Walton Lillehei (closing): There are relatively few cherished institutions left at Minnesota, but one that did seem almost invulnerable was use of the nasogastric tube with siphon drainage.

Nonetheless, I can emphasize, from our clinical experience to date, that this method of gastro-intestinal pacing is very effective. Exactly how far the method can go in eliminating the need for nasogastric intubation is not completely definable at this time. However, of the 45 patients treated to date referred to by Dr. Bilgutay in his presentation, a number required no gastric suction whatsoever during their postoperative interval. Others had suction with stimulation beginning immediately postoperatively for a period of time until they passed their first stool. In these postsurgical patients, this interval ranged from six to 24 hours with an average of 16 hours. At the time that they passed their first stool, pacing and intravenous fluids were discontinued and oral intake instituted.

The current that has been used for pacing in the clinical cases is provided by this small ($9 \times 6.25 \times 2.5$ cm.), self-contained battery powered unit called the Peri-Start which I am holding up. The large unit which you saw in the motion picture was our experimental stimulating unit which permitted us to vary the strength, type, and duration of the stimulating current. Extensive investigation has been done in our animal laboratory, and in humans under fluoroscopy and at operation with the abdomen open upon the types of current optimal for bowel stimulation. The results of those studies have allowed us to simplify this clinical unit (Peri-Start) because it does not need to be variable. The Peri-Start provides a current of 10 milliamperes at 50 cycles per second. The duration of the stimulus is 5 to 10 seconds, and it seems best if the stimulus occurs once a minute. A disposable nasogastric catheter electrode of polyvinyl plastic is provided for clinical usage.

In the motion picture just presented you were able to see the very prompt response of the gastro-intestinal tract to pacemaker stimulation in the dog with bile peritonitis. In fact, the induced contractions were identical to those occurring in the normal animal. It is interesting that in a paper in 1909 upon gastro-intestinal function, Hotz mentioned the fact that in his animal studies the bowel even though covered with pus from peritonitis was responsive to mechanical stimuli in virtually a normal manner, and that there was no real impairment in contractility unless distention took place. Distention is, of course, the most potent inhibitor of bowel motility. Therefore, often in ileus we do have a vicious circle of bowel distention due to swallowed and bacterial gas together with accumulation of the intestinal secretions further distending the bowel, this distention in turn increases the severity of the paresis and the entire cycle of bowel paralysis is kept in motion. Gastro-intestinal pacing, combined with a period of suction when

the bowel is already distended before treatment is begun, can, I believe, interrupt and reverse entirely this undesirable cycle.

Some patients have been stimulated solely through the rectal electrode. We have referred to that as an *electronic enema*. As near as we have been able to ascertain so far, the rectal route for stimulation is very effective and comparable to that achieved with the stimulating electrode in the upper gastro-intestinal tract.

Also investigated and found effective were electrodes applied directly to the serosal surface of the stomach or bowel.

I should like to emphasize one point that Dr. Bilgutay did not have time to do in the presentation; namely, that electric current, at effective levels of stimulation either by nasogastric, direct serosal, or by rectal routes, is entirely imperceptible to the patient.

Our neurosurgeons and urologists have been working with urinary bladder pacemakers and in considering other areas of the body where pacemaker stimulation might be helpful Dr. Bilgutay and I have suggested investigation of the effects of uterine stimulation. It seemed to us that in situations of uterine inertia during or after delivery electrical stimulation might offer a safer and perhaps more effective method than use of drugs.