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Electromyographic study of the mechanism of postoperative cholangitis in congenital biliary atresia

Intestinal motility after Roux-en-Y biliary reconstruction

M. Yagi[1], M. Iwafuchi[1], M. Uchiyama[1], and K. Takano[2]

[1] Department of Pediatric Surgery, Niigata University Hospital, 1-754, Asahimachi-dori, Niigata-City, Niigata 951, Japan
[2] Second Department of Surgery, Yamanashi University Medical School, Tamahochyo, Nakakomagun, Yamanashi 409–38, Japan

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Abstract. Cholangitis after biliary reconstruction for congenital biliary atresia is a troublesome postoperative complication. In order to clarify its mechanism and the changes in intestinal movement after biliary reconstruction by Roux-en-Y anastomosis, we performed electromyographic (EMG) studies of the motility of the reconstructed intestine in dogs. Monitoring the basic electrical rhythm (BER) and migrating myoelectric complexes (MMC), EMG analysis was carried out. As most of the Y-loop MMCs were propagated smoothly to the anal side, according to the continuity of the intestine, the intestinal contents were transported without stagnation. These intestinal movements appear to be useful as a biliary drainage route and to prevent ascending cholangitis. A comparison of short- and long-term intestinal motility after biliary reconstruction showed adaptation of the intestinal movement following the procedure. The outflow of bile appeared to accelerate intestinal motility because of prolongation of the MMC interval in the duodenum and oral jejunum without bile flow.

Key words: Congenital biliary atresia – Roux-en-Y biliary reconstruction – Ascending cholangitis – Intestinal motility – Electromyographic analysis

Introduction

Congenital biliary atresia (CBA) is a common and important disease in the pediatric surgical field, but therapeutic results have not been satisfactory. Kasai's hepatic porto-jejunostomy [7] has been recognized and generally used as the most favorable procedure for this disease, however ascending cholangitis, which critically affects the prognosis, remains a postoperative problem. In order to improve the outcome of this disorder, various types of biliary reconstruction have been aimed principally at preventing reflux [8, 11], but no satisfactory method has as yet been obtained due to the fact that a physiological approach including evaluation of the reconstruction itself has not yet been attempted. We have studied the mechanism of cholangitis after biliary reconstruction in infant dogs by electromyographic (EMG) analysis [14]. The physiology of the intestinal motility suggests that biliary reconstruction by Roux-en-Y anastomosis is more likely to prevent cholangitis than is interposition. The purpose of this study was to clarify the mechanism of cholangitis and the changes in intestinal motility after biliary reconstruction by Roux-en-Y anastomosis in detail.

Offprint requests to: M. Yagi

Materials and methods

Preparation of an animal model

Control group (C group). To assess normal intestinal motility, 4 infant mongrel dogs (6–8 kg) were subjected to median laparotomy after IV anesthesia using pentobarbital 25 mg/kg, and a total of six bipolar electrodes with silver wires were sewn onto the side opposite the mesentery in the sites shown in Fig. 1. The wires were taken out of the abdominal cavity and covered for protection after the operation.

Roux-en-Y biliary reconstruction groups (R1 and R2). To observe intestinal motility in cases where a short or long period had elapsed after biliary reconstruction, 3 infant mongrel dogs were used in the former case (R1 group) and 5 in the latter case (R2 group). Following anesthesia as in the C group, ligation and transection of the common bile duct was carried out and the anal jejunum 40 cm from Treitz' ligament was transected and suspended in a Roux-en-Y procedure for cholecystojejunostomy. In order to avoid side effects immediately after the biliary reconstruction, the electrodes were not implanted at this time. Re-laparotomy was carried out 1–2 months after operation in the R1 group and 10 months to 1 year after operation in the R2 group, and implantation of bipolar electrodes was carried out as in the C group (Fig. 1).

Electromyography

Recording the EMG. When 2 weeks to 1 month or more had passed after the operation and oral alimentation became possible, recording of the EMG was started. The operated dog was kept in a cage made of stainless

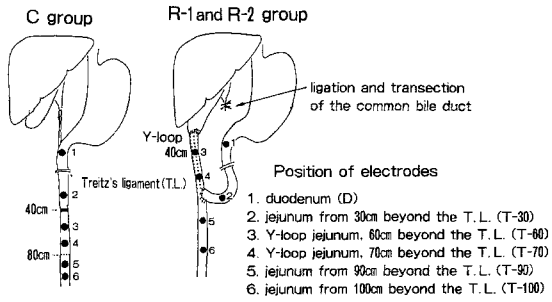

Fig. 1. Schematic presentation of experimental method and electrodes sites in Roux-en-Y dogs. Six bipolar electrodes with silver wires sewn opposite the mesentery on each side of jejunum and duodenum

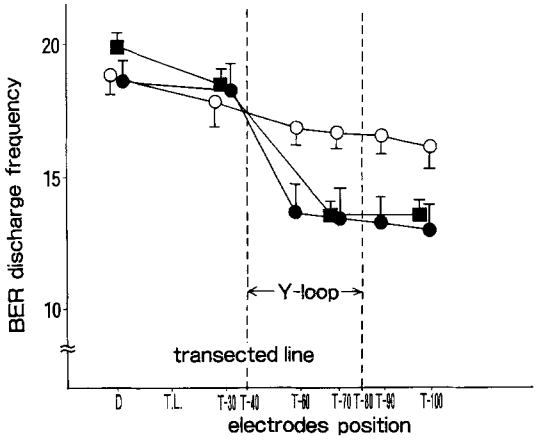

Fig. 2. BER discharge frequency decreases at all sites below the Y-loop after Roux-en-Y reconstruction. ○, C groups; ■, R-1 group (short-term); ●, R-2 group (long term) (M±SD) T. L. = Treitz' ligament, T- = distance from T. L.

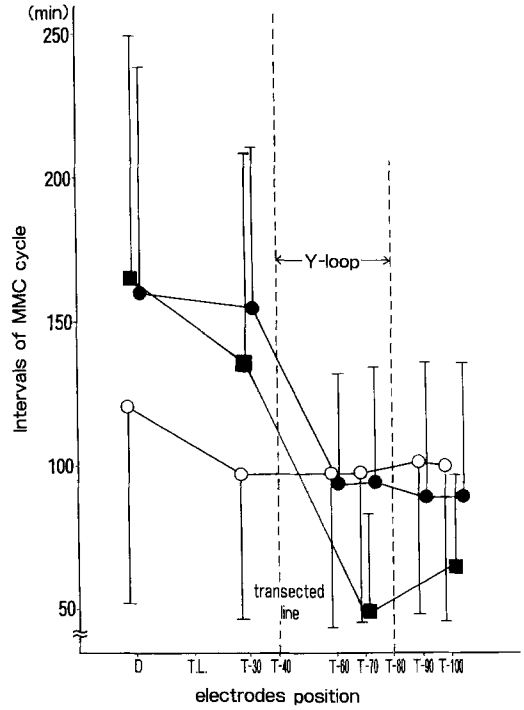

Fig. 3. Intervals of MMC cycle are prolonged in the duodenum and oral jejunum in R-1 and R-2 groups after Roux-en-Y reconstruction. ○, C group; ■, R-1 group (short term); ●, R-2 group (long term) (M±SD)

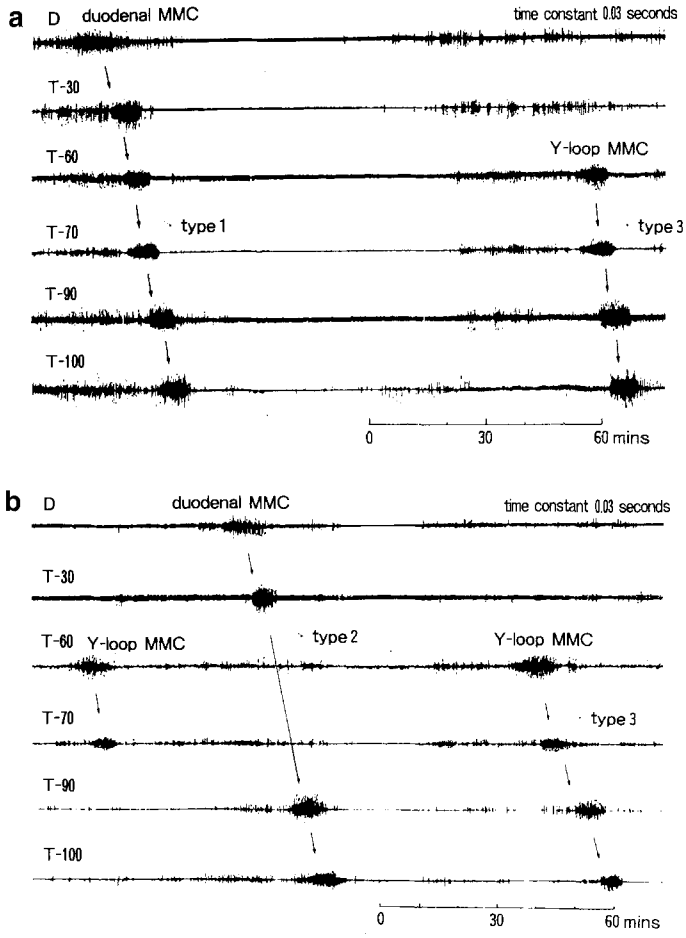

Fig. 4. Three types of MMC propagation mode are recognizable: (1) MMC from duodenum propagated to anal jejunum according to inherent intestinal continuity; (2) MMC from duodenum propagated to anal jejunum beyond Y-loop; (3) MMC from Y-loop propagated to anal jejunum

steel in a room sufficiently shielded with steel plates. In leading and recording the EMG, we made an effort not to interfere with the sleeping, feeding, excretion, etc of the dogs.

Leading and recording of the EMG were carried out using a heat-sensitive recorder with a cut-off frequency of 20 Hz and a time constant of 0.03 s. The EM-2 from Fukuda Denshi Co. was used as an amplifier. The velocity of the recording paper was 2.5 mm/min. The wires from the electrodes were connected to the amplifier after the animal had fasted for 24 h, and continuous recording was carried out for 12–24 h to obtain an EMG in the interdigestive state.

EMG analysis. An EMG lead, as in Szurszewski's analysis [12], consisted of basic electric rhythm (BER) and spike potentials (SP) and was classified into phases I–IV corresponding to the distribution over time. In phase III particularly, all BERs were overlapped by SP and groups of contractions were propagated from the duodenum to the lower small intestine that were referred to as migrating myoelectric complexes (MMC). The intestinal motility was evaluated on the basis of these BER and MMC. The frequency of the BER, interval, and mode of propagation of MMC were analyzed according to Takakuwa's method [13].

Results

BER discharge frequency in both the R1 and R2 groups decreased by about 23% below the Y-loop, as shown in Fig. 2, compared to the C group. The MMC intervals

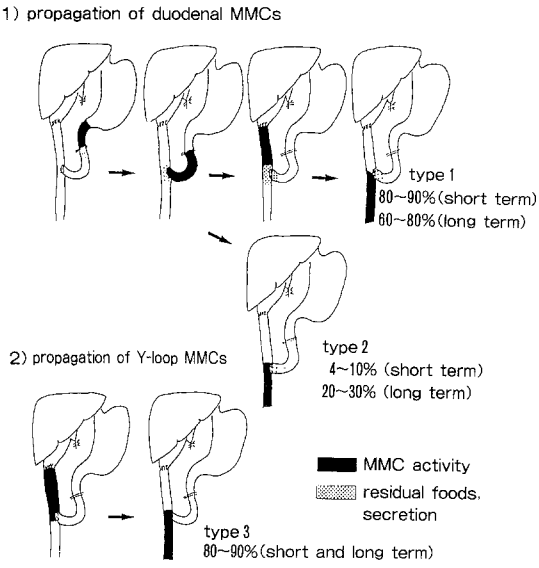

Fig. 5. Type 3 MMC propagation similar in both short- and long-term cases; type 2 increased and type 1 decreased in the long term

tended to be retarded in the duodenum and oral jejunum in the R1 and R2 groups (Fig. 3) compared with the C groups. No significant differences in BER and MMC intervals were identified between the R1 and R2 groups.

Propagation of MMC in the C group occurred from the duodenum to the anal jejunum and showed regular periodicity, but after ligation and transection of the common bile duct and Roux-en-Y biliary reconstruction the incidence and mode of propagation of MMC varied (Fig. 4a, b). In the R1 group, there were cases where MMC occurring in the duodenum were propagated to the oral jejunum, in keeping with the inherent continuity of the intestinal tract (type 1,80%–90% of duodenal MMC), and where individual MMC from the jejunal Y-loop (Y-loop MMC) were propagated to the anal jejunum (type 3,80%–90% of Y-loop MMC). In the duodenum, such MMC were propagated to the oral jejunum and thereafter directly to the anal jejunum beyond the Y-loop anastomosis (type 2, 4%–10% of duodenal MMC). On the other hand, in the R2 group the propagation frequency of type 2 MMC was increased to 20%–30% and that of type 1 decreased to 60%–80% (Fig. 5).

Discussion

Many studies on the cause of cholangitis after biliary reconstruction for CBA have been reported. However, these studies involved a bacteriological [2, 9] rather than a physiological approach. Since EMG records intestinal motility as the change in electrical activity of smooth muscles, it is the most suitable method for studying intestinal motility visually and quantitatively. We therefore performed EMG analyses of intestinal motility in infant dogs in order to analyze the mechanisms of cholangitis and intestinal movement after biliary reconstruction by Roux-en-Y anastomosis. Furthermore, to clarify the changes in intestinal motility after reconstruction we studied short-term (R1) and long-term (R2) groups after the operation.

The motility of the small intestine was investigated in short-term cases 1–2 months after Roux-en-Y biliary reconstruction and in long-term cases 10 months to 1 year after the reconstruction. The EMG of the small intestine measures a potential change inherent to smooth muscle and consists of BER (slow wave), which indicates periodic depolarization of smooth-muscle cells [5, 15], and SP, which appears with muscle contraction. The more distal in the small intestine, the smaller the frequency of the BER. Since the BER is overlapped by SP, it is speculated that the BER controls the occurrence of SP, as described by Bass [1]. BER frequency below the level of transection decreased by 23% in this study, as well as in Diamant and Bortoff's report [5], and did not recover in the long term. A low frequency of BER is thus likely to result in stagnation of the intestinal contents, which could be a cause of cholangitis. It has been suggested that biliary reconstruction with multiple intestinal transections is not suitable for bile drainage. On the other hand, MMC form an anally-propagating contraction zone and send interdigestive contents of the small intestine toward the anus, and have been considered to be interdigestive housekeepers who provide for the next meal in the small intestine [12]. We thus considered BER and MMC as important parameters for investigating intestinal motility, including bile drainage, in the interdigestive state.

Regarding the mode of propagation of MMC, Carlson et al. [4] found that MMC occurring in the duodenum were propagated according to the inherent continuity, regardless of transection or interposition of the intestine, and that therefore the extrinsic neural system was responsible for the propagation of MMC, based on their experiments with the Thiry-Vella loop.

Bueno [3], Pearce [10], and Itoh [6] subsequently reported that MMC occurring in the Thiry-Vella loop were initiated there inherently and were not propagated from the oral intestine. This implied that intestinal continuity would be important for MMC propagation and the influence of the extrinsic neural system would be less. The propagation pattern according to inherent continuity predominated in propagation modes of MMC, while Y-loop MMC appeared individually and were propagated according to continuity. It is speculated that most Y-loop MMC are propagated to the anal side, according to intestinal continuity, and that intestinal contents are smoothly transported in cases of transient stagnation from the duodenum to the oral jejunum.

The modes of intestinal movement after Roux-en-Y anastomosis corresponded to three types. First, MMC arising from the duodenum were propagated to the intestine according to inherent intestinal continuity. Second, MMC arising from the duodenum were propagated to the distal jejunum according to the new intestinal continuity smoothly and without stagnation. The third mode was propagation in the Y-loop. The frequency of MMC arising from the duodenum and propagated according to the new intestinal continuity was 4% to 10% in the short term after operation; in the long term MMC frequency increased to 20% to 30% after operation. These changes appeared to represent adaptation to the new intestinal continuity after surgery.

The interval of MMC in the R1 and R2 groups was prolonged in the duodenum and upper jejunum compared with the C group, which was considered particular to the Roux-en-Y anastomosis. It was suggested that this was related to the lack of bile flow in the duodenum and upper small intestine. This fact corresponds to the report that there is a close relationship between secretion of digestive juice and motility of the digestive tract [16]. The outflow of bile accelerates the motility of the reconstructed intestinal tracts, including the Y-loop, which functions as a good bile drainage route and may help to prevent ascending cholangitis. This operation is thus considered suitable for CBA, but in cases where bile outflow is insufficient, ascending cholangitis is more likely to develop due to stagnation of the intestinal contents. This problem should be further investigated in the future.

Conclusion

To clarify the mechanism of ascending cholangitis after operation for CBA, we carried out EMG analyses of intestinal motility. It is proposed that Roux-en-Y anastomosis is a favorable operative procedure that does not promote stagnation of the intestinal contents in patients with sufficient bile flow in the long term.

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