

# The rat choledochojunostomy model for microsurgical training

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**Purpose:** The feasibility of a rat choledochojunostomy (CJ) training model was investigated, as an introductory model to microsurgery for general surgeons.

**Methods:** Roux-en-Y CJ was performed on 20 rats. Interrupted 10-0 prolene sutures were used to perform CJ. The animals were observed for 7 days and sacrificed and examined.

**Results:** The rats were divided into 2 groups of 10 based on surgical order. The CJ time showed a significant decrease from  $36.2 \pm 5.6$  minutes in group 1 to  $29.4 \pm 5.7$  minutes in group 2 ( $P = 0.015$ ). The bile leakage rate was 40% in group 1 and 10% in group 2. The survival time was  $5.4 \pm 2.2$  days in group 1 and 7 days in group 2 ( $P = 0.049$ ).

**Conclusion:** The rat CJ training model is a feasible introductory model for general surgeons with no previous experience in microsurgery.

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**Key Words:** Choledochostomy, Microsurgery, General surgery, Rats

## INTRODUCTION

To perform a safe and uncomplicated operation, a surgeon needs to have knowledge and experience. Thus, an adequate hands-on training model is necessary before an inexperienced surgeon can start performing surgery on actual patients. Various types of training models that can facilitate the learning of surgical skills have been developed in many fields of surgery.

Microsurgery is one of the fields in which training models are being actively developed. Since microsurgical techniques are most often used in plastic surgery, most training models are developed for use in plastic and reconstructive medicine [1-3]. However, microsurgical skills can be very useful for general surgeons. A surgeon proficient in microsurgery can perform procedures such as vascular anastomosis. Also, a much wider

range of animal studies can be performed, including experimental rat surgery. However, in many centers, it is difficult for general surgery residents to receive training in microsurgery. This is because microsurgery is often learned from special courses or laboratory projects.

Animal research using experimental microsurgical techniques is being actively performed in the field of hepatobiliary surgery. Many authors have reported articles utilizing rat liver transplantation [4,5]. But procedures such as rat liver transplantation require specialized equipment, and advanced technique. In contrast, choledochojunostomy (CJ) is a procedure that can be performed relatively easily, with basic microsurgical equipment. CJ has been used in experimental rat models to investigate issues such as the effect of different biliary drainage procedures, or the effect of biliary drainage on

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the liver [6,7].

In 2010, Kraemer et al. [8] reported a microsurgical training model that can help gynecologists acquire microsurgical skills. This study showed that a well-designed training model can help train surgeons new to microsurgery. The authors of this study hypothesized that an introductory microsurgical training model using rat CJ can be developed for general surgeons with no previous experience in microsurgery.

## METHODS

### Study design

This study was approved by the institutional animal care and use committee of College of Medicine, The Catholic University of Korea. A total of 20 Sprague-Dawley rats were used. All rats were males with a body weight of approximately 250 to 300 g. Roux-en-Y CJ was performed on all animals. All operations were performed by a general surgery fellow with no experience in microsurgery. The bile duct diameter, surgical time, anastomosis time, and survival at 7 days were recorded. After the operation, the animals were observed for 7 days. At the end of 7 days, the animals were sacrificed and the anastomoses were checked for bile leakage.

### Operative technique

A midline incision was made after general anesthesia and preparation of the abdomen. Self-retaining retractors were placed in the abdomen to retract the liver upward and the small bowel downward. The common bile duct (CBD) was easily identified as a thin, green-colored tubular structure connecting the liver to the duodenum. The CBD was dissected and divided, and then, the distal CBD was suture ligated using 7-0 prolene sutures (Prolene; Ethicon, Somerville, NJ, USA). The jejunum

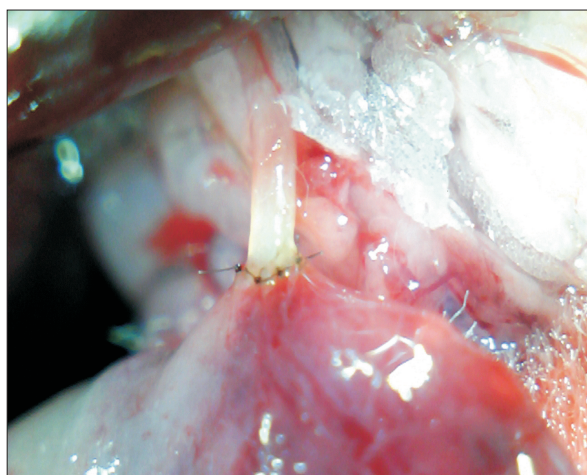
was identified and divided approximately 5 cm from the Treitz ligament. The stump of the distal loop was closed with 7-0 prolene sutures and retracted upward and laterally to form the Roux limb. A 20-gauge needle was used to create a jejunal opening. CJ was performed with interrupted sutures of 10-0 prolene using a dissecting microscope (Boom stand Microscope; AmScope, Irvine, CA, USA). Six sutures were placed in the anastomosis: 1 suture on each of the lateral edges and 2 sutures on both the posterior and anterior aspects. The completed CJ is shown in Fig. 1. The proximal jejunum was anastomosed to the Roux limb in an end-to-side fashion using continuous 7-0 prolene sutures. Hemostasis was performed, and the wound was closed using continuous 2-0 nylon sutures.

## RESULTS

Roux-en-Y CJ was performed on 20 male Sprague-Dawley rats. To evaluate the training effect of this rat model, the rats were divided into 2 groups of 10 based on the surgical order. The perioperative data are shown in Table 1. The diameter of the CBD was  $0.65 \pm 0.11$  mm for group 1 and  $0.63 \pm 0.13$  mm for group 2, which was not significantly different. The CJ time showed a significant decrease from  $36.2 \pm 5.6$  minutes in group 1 to  $29.4 \pm 5.7$  minutes in group 2 ( $P = 0.015$ ). The total operation time was  $51.4 \pm 10.3$  minutes in group 1 and  $45.5 \pm 4.5$  minutes in group 2. The bile leakage rate was 40% in group 1 and 10% in group 2. There were no significant differences in the total operation time or bile leakage rate. The survival time was  $5.4 \pm 2.2$  days in group 1 and 7 days in group 2, which was statistically significant ( $P = 0.049$ ). The 7 day survival rate was 50% in group 1 and 100% in group 2, which was also statistically significant ( $P = 0.033$ ).

## DISCUSSION

The purpose of this study was to evaluate the feasibility of an introductory model for microsurgery. In the current age of patient safety awareness, the importance of an adequate



**Fig. 1.** Completion of rat choledochojejunostomy using interrupted sutures of 10-0 prolene.

**Table 1.** Perioperative data of rat choledochojejunostomy

Variable	Group 1 (n = 10)	Group 2 (n = 10)	P-value
CBD diameter (mm)	$0.65 \pm 0.11$	$0.63 \pm 0.13$	0.707
CJ time (min)	$36.2 \pm 5.6$	$29.4 \pm 5.7$	0.015
Total operation time (min)	$51.4 \pm 10.3$	$45.5 \pm 4.5$	0.120
Survival (day)	$5.4 \pm 2.2$	$7.0 \pm 0$	0.049
7-Day survival rate	5 (50)	10 (10)	0.033
Bile leakage	4 (40)	1 (10)	0.303

Values are presented as mean  $\pm$  standard deviation or number (%). CBD, common bile duct; CJ, choledochojejunostomy.

training model cannot be overemphasized. One of the most important functions of the training model is that it prevents the novice surgeon from practicing on patients in the operating room. Considering the unique technical difficulty of microsurgery, hands-on training in the laboratory setting before progressing to clinical practice is very important [9].

Several different types of training models have been developed with the purpose of microsurgical training. There are training models that use either artificial material or nonliving animal tissue [1,10-12]. In these types, there are no ethical issues to be considered, and the cost of setting up the training model is relatively inexpensive. There is no need for anesthesia, and this can reduce stress for the trainee. Also, a specialized facility for animal care is unnecessary. On the other hand, nonliving tissue cannot fully simulate living tissue. Modified training models have been developed that simulate the pulsatile movements of living tissue. Schoffl et al. [9] reported a training model using a membrane pump that generates a pulsatile flow within a porcine heart. Nam et al. [13] reported a porcine thigh model that uses an infusion pump. Although these modified models can be somewhat superior to static models, the simulation effect may be less than that of living training models. In this study, a living animal training model using the rat was evaluated. Rats are the preferred subjects due to the relatively inexpensive cost, ease of maintenance, and disease resistance [14]. Many living animal training models using the rat have previously been reported for various procedures [2,3,15,16]. In the living animal model, there is the difficulty of anesthesia and animal care. A specialized facility is required, which is often a remote location from where the trainees usually work. But even with these issues, the degree of simulation is excellent in the living animal model. Respiratory movement, pulsatile movement of the blood vessels, and the tactile sense of living tissue are nearly the same as that of human tissue. In addition, when a living animal model is used, a survival analysis can be performed. This can be a very good method for evaluating the feasibility of a surgical technique.

Most of the reported microsurgical training models use vessel

anastomosis. The rat femoral vessels are the standard in such models [17,18]. However, these models may be too difficult for surgeons with no previous experience in microsurgery. This study used Roux-en-Y CJ in the rat. In contrast to the femoral vessels, the CBD is easier to approach because it only requires a midline incision. The CBD can easily be visualized with minimal retraction of the liver and small bowel. Additionally, because end-to-side anastomosis is performed with the jejunum, there are no specialized vascular clamps needed. The only microsurgical instruments used in this study were basic instruments such as one pair of straight microforceps, one pair of curved microforceps, and one microsurgical needle holder. Moreover, because no blood vessels are dissected, there is rarely lethal bleeding.

In this study, Roux-en-Y CJ was performed on 20 rats. All operations were performed by a surgical fellow with no experience in microsurgery. To evaluate the training effect of the rat CJ model, the first and last 10 rats were categorized as groups 1 and 2, respectively. The CJ time of group 2 was significantly decreased compared to that of group 1. By repeatedly using the rat CJ training model, the microsurgical skills of the trainee progressed and eliminated unnecessary movements, which reduced the time needed to complete CJ. Although the bile leakage rate did not show any significant differences, the survival time and the 7-day survival rate improved significantly in group 2. Thus, repeatedly performing CJ under microscopic vision improves the surgeon's technique and patient survival.

In conclusion, the rat Roux-en-Y CJ training model is a feasible introductory model for general surgeons with no previous experience in microsurgery. It can improve hand-eye coordination under microscopic vision and facilitates the process of learning basic microsurgical techniques.

## CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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