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Original Article

## Clipless Laparoscopic Cholecystectomy with Knot Pusher: Experience from More Than 500 Cases

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### Abstract

**Objective:** This study aims to demonstrate that laparoscopic cholecystectomy utilizing the extracorporeal sliding knot technique with a knot pusher can achieve satisfactory outcomes, such as no dislodgement of the tied cystic duct and minimal complications. The technique was efficient, secure, and cost-effective, with no instances of accidental knot failure observed, and requiring only a single nylon suture for knot tying.

**Materials and Methods:** A retrospective study was conducted on the elective symptomatic gallstone disease treatment outcomes via laparoscopic cholecystectomy (LC) utilizing the extracorporeal sliding knot technique with a knot pusher. The diagnosis was confirmed in all cases using ultrasound, and no instances of acute cholecystitis were included in this study. This study was carried out at the General Surgery Department of Chiangrai Prachanukroh Hospital between September 2008 and August 2019.

**Results:** The results of this study indicated favorable outcomes for LC performed using this method. A total of 512 patients were included, comprising 94 males and 418 females. The mean age of the participants was 49.1 years, with an age range of 21 to 91 years. The average duration of surgery was 35 minutes, ranging from 16 to 72 minutes. Blood loss during surgery averaged 15 ml, ranging from 2 to 120 ml. The average hospital stay was 2.5 days, ranging from 1 to 5 days. No serious complications related to cystic duct ligation were observed using the extracorporeal sliding knot technique. The average time required to tie all knots in each case was 4 minutes, ranging from 2 to 7 minutes.

**Conclusion:** Laparoscopic cholecystectomy using the extracorporeal sliding knot technique with a knot pusher enhances cystic duct closure efficiency by simplifying surgery, lowering complications, and reducing costs. It ensures secure closure, is easy to learn, and adds minimal time to the procedure compared to clipping, making it an effective alternative technique.

**Keywords:** Laparoscopic cholecystectomy, Extracorporeal knotting, Sliding knot, Knot pusher

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## INTRODUCTION

Gallstone disease is a prevalent condition that poses significant clinical challenges. Laparoscopic cholecystectomy (LC) has transformed the management of gallstone disease, providing numerous advantages over traditional open surgery, including reduced postoperative pain, shorter hospital stays, and expedited recovery times.<sup>1-5</sup> Approximately 750,000 laparoscopic cholecystectomies are performed annually in the United States, representing about 90% of all cholecystectomies, with a notable decline in the overall serious complication rate since its inception.<sup>6,7</sup> The cystic duct and its associated vessels are critical components in the surgical management of gallstone disease. Various techniques have been developed for cystic duct closure during laparoscopic cholecystectomy.<sup>8,9</sup> Endo-clips are the most commonly utilized devices for bile duct closure, with multiple types available, indicating no consensus on a single optimal device. Intracorporeal knot tying is an alternative technique; however, it requires a higher level of technical skill to master. Among these, the extracorporeal knotting method offers distinct benefits over the intracorporeal approach, including greater simplicity, reduced procedural time, and a less steep learning curve for surgeons.<sup>10-12</sup> In our practice, we utilize Nylon No. 1 suture as the preferred material for securing the cystic duct and vessels. This technique involves bringing both ends of the nylon suture outside the abdomen to perform a sliding knot extracorporeally. Subsequently, a knot pusher is employed to secure the knot firmly around the cystic duct and its associated vessels.

## MATERIALS AND METHODS

A retrospective analysis of LC utilizing extracorporeal knot (Figure 1) and knot pusher (Figure 2) was performed between September 2008 and August 2019. This present study was conducted using medical records from the General Surgery Department of Chiangrai Prachanukroh Hospital. All procedures in this study were performed by a single surgeon. The inclusion criteria included patients aged 18 years or older of both genders with elective symptomatic gallstone disease, confirmed through ultrasound examination. Cases of acute cholecystitis were excluded from this study. Ethical approval was taken from the institute board members of Chiangrai Prachanukroh Hospital. Patient data were extracted and analyzed, including demographics, surgical time, hospital stay, and postoperative complications.

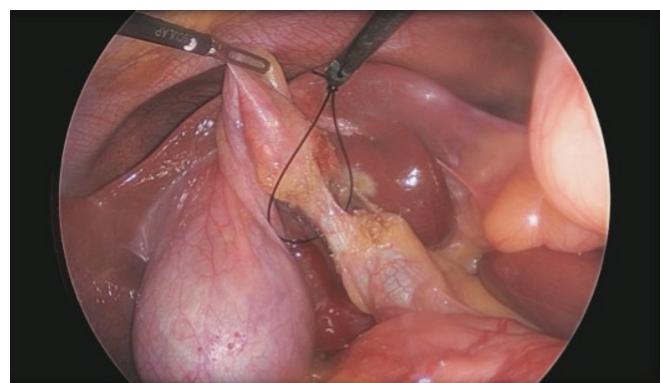


Figure 1 LC, knot pusher



Figure 2 Knot pusher

## Procedure

Most patients without a documented allergic reaction to cephalosporins receive preoperative Cefazolin (1 g). In our practice, laparoscopic cholecystectomy is typically executed using a three-port approach. The port arrangement follows a modified standard protocol for laparoscopic cholecystectomy, incorporating a 10-mm optical port at the infraumbilical fold, along with two additional 5-mm ports positioned in the epigastrium and the right subcostal area along the midclavicular line. This insertion method is referred to as the “10-5-5” configuration. For cases without previous surgical procedures, the first port is introduced into the abdominal cavity using a Veress needle. In contrast, an open technique is utilized for patients with a history of prior surgeries. The subsequent ports are inserted under direct visualization provided by

the camera port. Dissection of the cystic duct and artery follows. The gallbladder is grasped at Hartmann's pouch using an instrument inserted through the right subcostal port, ensuring adequate tension on the cystic duct. The critical view of safety is then established. A nylon No.1 suture, measuring 90 cm in length, is threaded through the epigastric port to hook around the cystic duct. An extracorporeal sliding knot is created. This knot is then pushed inside the abdomen to ligate firmly around the cystic duct, with the initial knot placed at the junction of the cystic duct and Hartmann's pouch. A second knot is subsequently tied at a distance medial to the prior knot, allowing for safe division of the cystic duct. Ligation of the cystic artery at both its proximal and distal ends is conducted before transection. A fourth 5 mm port may be added in rare instances requiring enhanced access or maneuverability. Gallbladder extraction is performed using an extraction bag.

## RESULTS

This retrospective analysis examined the outcomes of symptomatic gallstone treatment via laparoscopic cholecystectomy (LC) utilizing the extracorporeal sliding knot technique with a knot pusher at the General Surgery Department of Chiangrai Prachanukroh Hospital from September 2008 to August 2019. The findings indicated favorable results for LC performed with this method. Among the 512 patients, 94 (18.4%) were male and 418 (81.6%) were female. The mean age of participants was 49.1 years, spanning from 21 to 91 years. Coexisting medical conditions were present in 32% of the study population, including hypertension, diabetes, and chronic obstructive pulmonary disease (COPD), as detailed in **Table 1**. The average duration of surgery, measured from incision to skin suture, was 35 minutes, with a range of 16 to 72 minutes. Blood loss averaged 15 ml, with a variation from 2 to 120 ml. Patients had an average hospital stay of 2.5 days, ranging from 1 to 5 days, as shown in **Table 2**. Notably, there were no instances of bile leakage or other complications associated with cystic duct ligation. The time required for tying all the knots in each case varied between 2 and 7 minutes, averaging around 4 minutes (this item was collected from the last 2 years of studying).

**Table 1** Demographics Data

Demographics	Case (%)
<b>Gender</b>	
Male	94 (18.4)
Female	418 (81.6)
<b>Age</b>	
Mean: Year	49.1
Range: Year	21-91
<b>Co-morbidity</b>	164 (32)
Hypertension	112 (21.9)
Diabetes	37 (7.2)
COPD	21 (4.1)

**Table 2** Clinical Data

Clinical data	
<b>Operation time</b>	
Mean: minute	35
Range: minute	16-72
<b>Blood loss</b>	
Mean: ml.	15
Range: ml.	2-120
<b>Hospital stays</b>	
Mean: Day	2.5
Range: Day	1-5
<b>Tying time*</b>	
Mean: minute	4
Range: minute	2-7

\*This data was collected from the last 2 years of studying

## DISCUSSION

This retrospective study included consecutive elective laparoscopic cholecystectomy (LC) cases performed for symptomatic gallstone disease. The demographic characteristics and comorbidities of the study population were suitable for undergoing general anesthesia.

Within the domain of surgical knot-tying techniques, I advocate using a simple sliding knot, as shown in **Figure 3**. This method demonstrates remarkable effectiveness in securely ligating the cystic duct and its associated vessels across various clinical scenarios. The significant advantages of employing extracorporeal knot ligation become particularly evident in cases where the cystic duct exhibits a substantial diameter, making alternative duct ligation techniques challenging to implement with the requisite confidence.<sup>13</sup>

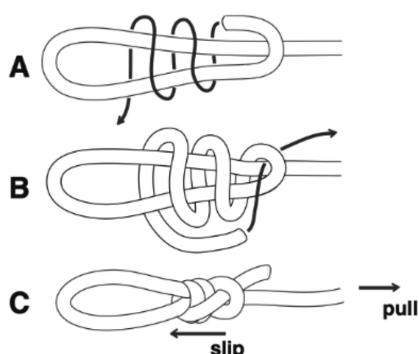


Figure 3 Sliding knot

The extracorporeal knot-tying technique involves forming a knot outside the body and subsequently deploying it into position using a specialized knot pusher device. This approach circumvents the complexities often associated with intracorporeal knot-tying methods. Our data indicate that the average surgical duration for this procedure is approximately 35 minutes, which aligns with established benchmarks for laparoscopic cholecystectomy (LC), thereby reflecting efficient operational standards at our medical center.<sup>14</sup> Furthermore, an average hospital stay of 2.5 days underscores the efficacy of our postoperative care protocols and patient recovery processes.<sup>15-18</sup>

Notably, the absence of complications such as bile duct leakage, biloma, intra-abdominal collections, or postoperative bleeding in all cases attests to the surgical team's proficiency and strict adherence to established protocols. The reduced length of hospital stays not only enhances patient recovery but also contributes to cost-effectiveness within our healthcare system, while the average time for knot tying is recorded at 4 minutes, potentially longer than that required for duct endo-clip applications. Surgeons typically experience a significant decrease in closure time as they gain familiarity with this technique. Over time, consistent application of this method can lead to improved operational efficiency and further reductions in operative durations.

Gallstone disease is a prevalent condition in contemporary clinical practice. Laparoscopic cholecystectomy (LC) has become the gold standard treatment, replacing traditional open cholecystectomy due to its minimally invasive nature and improved patient outcomes. With the increasing frequency of LC procedures, it is essential to consider both the safety and cost-effectiveness of the surgery.

My journey with laparoscopic cholecystectomy began in 1997 when I invited a distinguished professor of surgery from Siriraj Hospital, Mahidol University, to demonstrate the procedure. Since then, I have successfully performed over 1,000 laparoscopic cholecystectomies. However, I am reporting on 500 cases due to incomplete medical records prior to 2008. Since 1999, I have employed the extracorporeal knotting technique using a knot pusher for cystic duct closure. This technique is the sole method employed for bile duct closure in elective laparoscopic cholecystectomy in my practice, resulting in a limited sample size for comparison with alternative closure techniques. This extracorporeal method enhances surgical efficiency through several key factors:

1. Simplicity of Technique: The extracorporeal knotting method is generally simpler than intracorporeal techniques. It allows for easier manipulation and placement of sutures outside the abdominal cavity, reducing the complexity involved in securing the cystic duct. This simplicity can lead to a more straightforward learning curve for surgeons, particularly those who may be less experienced with laparoscopic suturing techniques.<sup>19,20</sup>

2. Reduced Risk of Complications: Studies indicate that extracorporeal knotting may result in fewer intraoperative complications compared to clip application. For instance, complications such as clip slippage and bile leakage are less common with secure knots, thereby minimizing the need for additional interventions during surgery.<sup>19,21</sup> The potential for complications with clips, such as migration or spillage of stones, can extend the operative time and increase patient risk.<sup>19,22</sup>

3. Cost-Effectiveness: While the initial operative time may be slightly longer for extracorporeal knotting compared to clip application, the overall cost-effectiveness is favorable. The use of sutures eliminates the need for expensive clip devices, which can accumulate significant costs in high-volume surgical settings.<sup>19,21</sup>

4. Secure Closure: The extracorporeal technique allows for a more secure cystic duct closure. The use of a sliding knot ensures that the ligation is tight and stable, reducing the risk of postoperative complications such as bile leaks, which can lead to increased morbidity and additional surgical interventions.<sup>20,21</sup>

5. Time Efficiency with Experience: Although initial reports suggest that extracorporeal knotting may take longer than clip application, as surgeons gain experience with this technique, the time required for closure

decreases significantly. Over time, routine use of this method can lead to improved efficiency and reduced operative times.<sup>21,22</sup>

### Knot tying

The knot used to tie the Extracorporeal knot must be strong and easy to tie. The first and most widespread knot is probably the Roeder knot.<sup>23</sup> It is a strong knot, but in my opinion, it is complicated to tie. Learning to tie it correctly is not easy. So, I chose the Sliding knot, which is equally strong but not complicated, as shown in Figure 3.<sup>24</sup> We can learn how to tie this knot quickly. It takes no more than 30 seconds to tie one knot.

### Phichai's maneuver

One of the critical steps in laparoscopic cholecystectomy (LC) utilizing a knot pusher involves threading a nylon suture through the cystic duct and exteriorizing it through the abdominal wall to facilitate knot formation. Inexperienced surgeons often encounter significant challenges during this phase, particularly when attempting to pass the nylon through the cystic duct. A common issue arises when the nylon suture, once released from the dissector's grip, tends to slip out, leading to frustration and increased operative time.

To address this challenge, I propose a straightforward technique, which I have termed "Phichai's maneuver," as shown in Figure 4. This method involves applying gentle pressure with the fingers on the nylon suture at the edge of the trocar. This stabilization prevents movement of the nylon, as shown in Figure 5, thereby allowing the dissector to securely grasp and easily extract

the suture from the abdominal cavity. This technique not only enhances efficiency but also minimizes potential complications associated with improper handling of the nylon during laparoscopic procedures. By mastering this maneuver, surgeons can improve their proficiency in executing extracorporeal knot-tying techniques, ultimately contributing to safer and more effective surgical outcomes in laparoscopic cholecystectomy.

Significantly, the thickness or width of the cystic duct did not impede the ability to tie knots using the knot pusher technique.

We feel that because the LC is a frequently performed laparoscopic procedure, it is a good practice ground to learn this extracorporeal knot tying, which would be very useful in simplifying cystic duct closure, reducing complication rates, and being cost-effective.



Figure 4 Phichai's maneuver

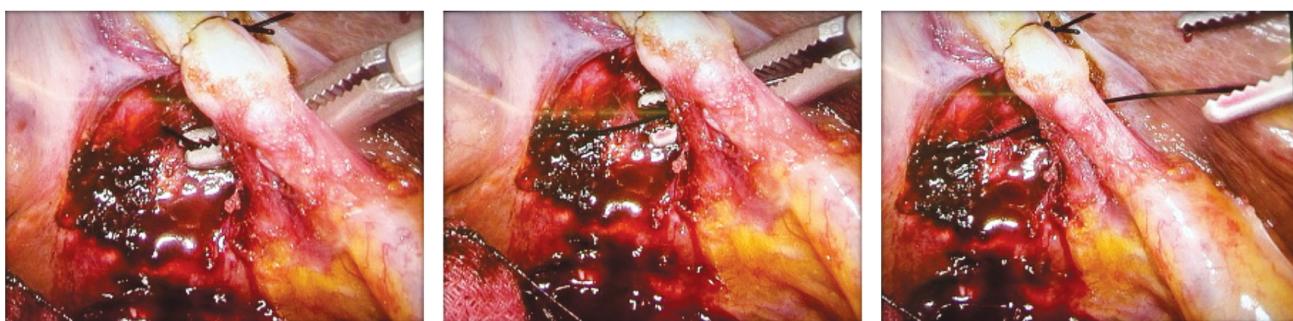


Figure 5 Effect of Phichai's maneuver

## CONCLUSION

Laparoscopic cholecystectomy (LC) utilizing the extracorporeal sliding knot technique with a knot pusher improves the efficiency of cystic duct closure by simplifying the surgical process, reducing complication rates, being cost-effective, ensuring secure closure, and allowing for increased efficiency with practice. It is easy to learn, and the ligation time is only a few minutes more than clipping. These factors collectively contribute to enhanced patient outcomes in laparoscopic cholecystectomy procedures.

Mastering the use of the knot pusher in laparoscopic cholecystectomy requires minimal training. Once proficient, its effectiveness should be studied and compared with alternative methods of bile duct closure.

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