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A Laparoscopic Fixation of Distal Catheter of the Ventriculoperitoneal shunt with Falciform Ligament in Supra-Hepatic Space by Modified Falciform Technique

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Abstract
Laparoscopy-assisted distal catheter insertion of the Ventriculoperitoneal shunt (VPS) in the abdomen is performed universally and numerous maneuvers have been executed for placement of the distal end of VPS in the peritoneal cavity. Most recently, a falciform ligament of the liver has been utilized as a support for the distal shunt, without clipping or ligation of the catheter. Despite the improvements in shunt procedures, abdominal complication like infection, migration, obstruction/blockage, perforation and pseudocyst still attribute a major part in revision surgeries. We have brought modification in previously described "falciform technique" to overcome the manifestation related to the distal shunt. Twenty-seven patients with hydrocephalus underwent Laparoscopic VPS with the modified falciform technique in Zhong Da Hospital, Nanjing China between June 2013 and November 2016. A threaded strap was formed around the catheter before insertion into the abdominal cavity. A hole was made in a falciform ligament and the distal catheter was clamped with the falciform ligament in supra-hepatic space, using the threaded strap as a holder. All the 27 patients underwent VPS surgery using modified technique. No abdominal complications related to the distal shunt were found except, 3 patients (11%) complained of right upper quadrant abdominal discomfort. Proximal infection (2 cases, 7%) and blockage (1 case, 4%) were the factors contributing to revision surgeries during 471 days of the mean follow-up period. The "Modified Falciform Technique" for emplacement of the distal catheter in supra-hepatic space significantly reduces the rates of postoperative peritoneal complications and revisions of VPS for a longer period of time.
Keywords: Laparoscopic, hydrocephalus, falciform ligament, VPS, catheter.

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1. Introduction

The accumulation of cerebrospinal fluid (CSF) in brain ventricles can cause hydrocephalus, which can lead to brain damage or death [1]. Surgery is the best choice for management of hydrocephalus and different types of shunt systems are used for diversion of CSF [2]. Ventriculoperitoneal shunt (VPS) is the most common surgical procedure for treatment of hydrocephalus since the time VPS has been described in 1908 [3,1]. Laparoscopy-assisted insertion of the distal catheter of VPS in the abdomen is performed universally with the help of general surgeons since the last decade of the 20th century [4,5,6]. Shunt maneuvers has improved a lot and various techniques have been used for the placement of the distal catheter of VPS in abdominal cavity [7,8]. Most recently, falciform ligament of liver has been utilized as a support for distal catheter, without clipping or ligation of the catheter end, whereas, the the procedure of clipping or tethering the distal end directly with a falciform ligament in supra-hepatic space can cause infection and blockage [9,10]. Regardless these improvements, abdominal shunt complications such as infection, migration, obstruction/blockage, perforation, and pseudocyst remain a problem [11,12].

Although shunt moderations have solved the majority of the complications, but, lower end blockage, infection, and migration still prevails a huge concern and attributes a big part in VPS revisions[13,14,9]. Therefore, we have brought modification in previously described "falciform technique"[10] and hypothesized that fixation of the peritoneal shunt with a falciform ligament in supra-hepatic space by "Modified Falciform Technique" could overcome the drawbacks related to the distal shunt.

2. Materials and Methods

2.1 Patients

Between June 2013 and November 2016, 27 patients, 14 male, and 13 female underwent Laparoscopic VPS with the "Modified Falciform Technique" by a single surgeon in Zhong Da Hospital, affiliated with Southeast University, Nanjing China. 16 out of 27 patients were diagnosed with communicating hydrocephalus and 11 had the diagnosis of non-communicating hydrocephalus. At the time of VPS placement, the mean age of the 27 patients was 55 years, ranging from 19-78 years. The average follow-up time was 471 days with minimum 14 and maximum 1273 days, follow-up time started from the day the patient discharged from the hospital.

2.2 Operative Technique

General anesthesia was given using endo-tracheal intubation, while patients were in supine position. All the patients received prophylactic antibiotics as soon as the IV line was inserted. The head was moved to the opposite side of the insertion, the neck and trunk were extended, and a roll was placed underneath the shoulders. The patient's head, neck, chest, and abdomen were prepared and covered in the standard sterile fashion.

The cranial and abdominal portions were started simultaneously by two different surgeons. The head portion of the procedure was performed by a neurosurgeon and the abdominal portion was done by a general surgeon. A location under the xiphoid process was chosen for the insertion of the distal catheter into the abdomen. A 10mm incision was made at the skin above this point on the abdominal wall. At that time, the neurosurgeon tunneled the catheter from the head to the abdomen subcutaneously to the point of insertion under the xiphoid process. After extraction of the catheter at incision point, a thread was wrapped and ligated (slightly loose because, if we ligate the catheter firmly then there are more chances of obstruction) and the threaded strap was formed. This strap was used for marking the length and fixation of the distal catheter (**Figure 1A**), thereafter, a neurosurgeon tested the flow of CSF.

A 10mm supraumbilical incision was made and CO_2 was inflated through a veress needle into the abdominal cavity until an intra-abdominal pressure of 12mmHg was achieved. A temporary Valsalva maneuver was induced and a peritoneal trocar was then passed through the fascia, using gentle downward pressure to advance it into the peritoneal space. The laparoscope was inserted through the supraumbilical incision via a 10 mm trocar and connected to the video system. A diagnostic laparoscopy was then performed, with lysis of adhesions if necessary. A 5-mm trocar was placed in the right upper quadrant. Another 10-mm trocar was penetrated at the site of the incision made for extraction of the distal end, gently pushed towards the left direction to ensure that trocar was penetrated into the abdomen, on the left side of the falciform ligament **(Figure 1B).**

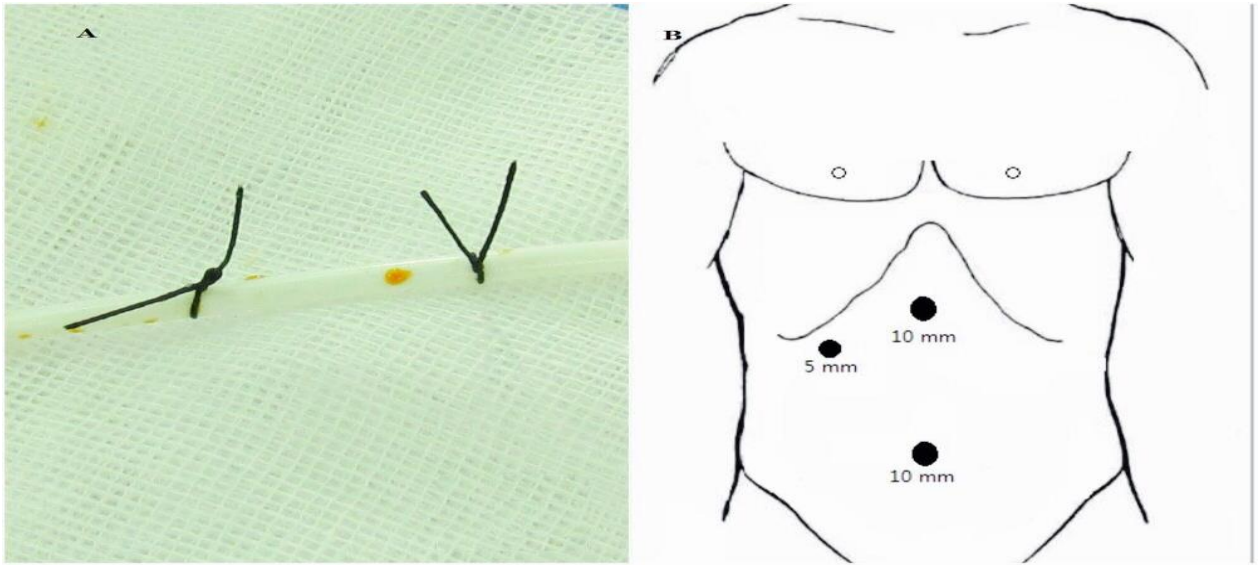

Figure 1: (A) Thread was ligated around the distal catheter and approximately 1 cm was left as remnant forming a threaded strap. **(B)** One 5mm and two 10mm incision sites for trocar insertion.

A Harrison Cripps forceps from the right upper quadrant trocar (5mm) was penetrated into the 10mm trocar intra-abdominally under the laparoscopic visualization (**Figure 2A**), and forceps was brought outside the peritoneal cavity using a 10mm trocar as a pathway (**Figure 2B**). Then the 10mm trocar was removed and the tip of the distal catheter was grasped firmly with Harrison Cripps forceps, after grasping the catheter tip, the forceps was pulled towards abdominal cavity and the catheter tip was released on the left side of the falciform ligament (**Figure 2C**).

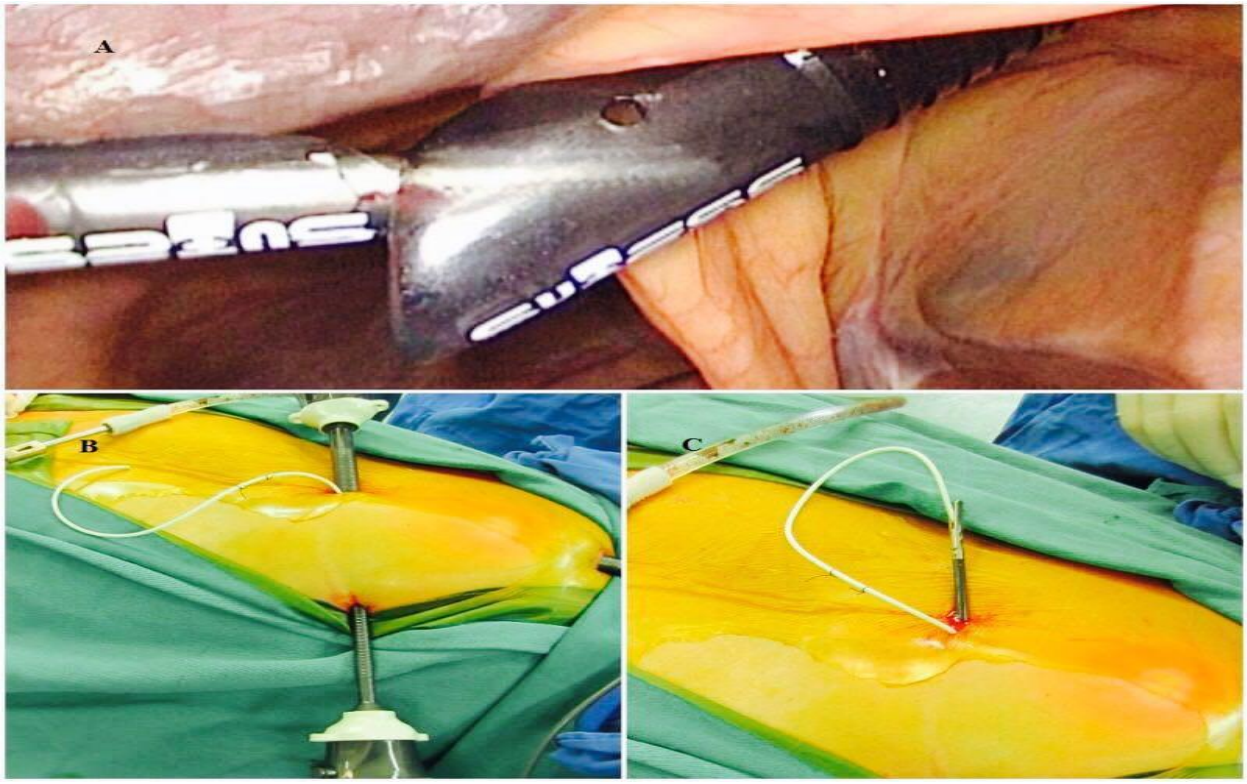

Figure 2: (A) A Harrison Cripp forceps penetration into 10mm trocar intra-abdominally. **(B)** A Harrison Cripp forceps was brought outside the abdominal cavity. **(C)** 10mm trocar was removed and shunt tip was firmly grasped by Harrison Crip forceps for insertion in the peritoneal cavity.

A small hole was created in non-vascular part of the falciform ligament using electrocautery. The distal catheter was placed through the hole in the falciform ligament from the left side to the right side of the falciform ligament and was fixed by clamping the threaded strap as a holder with the falciform ligament **(Figure 3A).** The catheter was draped over the dome of the liver in the supra-hepatic space, and the distal end of the catheter reached the hepatic flexure to drain cerebrospinal fluid. The catheter patency for CSF drainage was examined again by pressing the proximal valve **(Figure 3B)**.

3. Results

Out of 27 patients underwent VPS surgery using modified falciform technique, three (11%) patients required VPS revision surgery during the follow-up period, two (7%) out of three revisions were because of proximal infection, among these two infection cases, one patient had revision in another hospital, the other had to remove VPS due to severe infection. The third revision was due to proximal blockage (4%) and no case of VPS replacement was recorded associated with the distal shunt. Three (11%) patients complained of right upper quadrant abdominal discomfort. Six (23%) patients died during the follow-up duration, therefore, the follow-up time of mortalities was counted from the day of hospital discharge until death. There were no migrations of the peritoneal shunt catheters, and no distal obstructions and infection in all the 27 patients after the average follow-up period of 471 days. None of the patients has reported perforation and pseudocyst formation or other complications that can be attributed to the surgery.

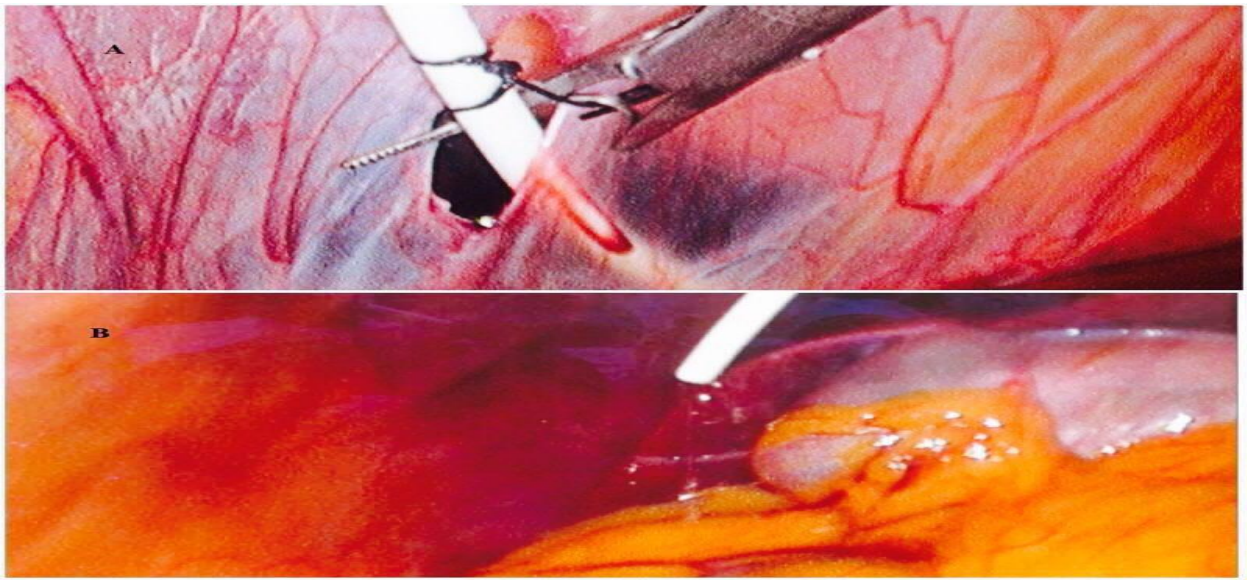

Figure 3: (A) The catheter fixation with the falciform ligament, clamping the threaded strap as a holder**. (B)** CSF flow testing after the fixation of the distal shunt.

Discussion

Up to date, VPS remains the best choice for hydrocephalus management since 1908 [1,3]. Numerous changes has been made in VPS approaches, the most contemporary tactics remained incapable of overcoming the inevitable manifestation of infection (2.6%), obstruction (12.8%), pseudocyst and replacement of VPS (9.5%), because, those approaches involved either, direct clamping or insertion of the distal shunt freely in supra-hepatic space[14,15], therefore, we have brought some developments in previous techniques to control the postoperative complications.

In our study, proximal infection (7%) or blockage (4%) accounted for all the revision causes and (0%) occurrence of distal infection and obstruction, demonstrates a magnificent reduction in abdominal end infection and blockage as compared with already published data(2.6% infection and 12.8% blockage)[14], therefore, this evidence describes, clipping the threaded strap with the falciform ligament can reduce obstruction rate and other postoperative abdominal shunt complications that have been reported 25% in other theories [16].

No migration existed in "Modified Falciform Technique" indicates an impressive betterment and significant decrease in migration in contrast to the 21% dislodgments shown in the procedure of inserting the distal catheter in supra-hepatic space without firm fixation [13], therefore, it clearly reveals that clamping the peritoneal shunt in supra-hepatic space can easily prohibit visceral migration [17].

11% of the patients complained right upper quadrant abdominal discomfort in the follow-up duration, and 23% patients died during the follow-up period. The reasons for these incidences were unknown. No pseudocyst formation and perforation took place, which signals a dramatic change towards the existence of these issues that has occurred frequently [18,19]. No shunt replacement related to distal catheter failure is unarguably massive development as VPS revision stayed a prominent trouble at very high rate of 9.5% [15].

Conclusion

The "Modified Falciform Technique" for emplacement of the distal catheter in supra-hepatic space significantly reduces the rates of postoperative peritoneal complications and revisions of VPS for a longer period of time but improvements are required to avoid upper quadrant abdominal discomfort. We undoubtedly argue that "Modified Falciform Technique" is a suitable procedure in emplacement of the distal end in supra-hepatic space, therefore, suggesting this technique as a better way in the management of hydrocephalus.

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