Review Article

Hepatic pedicle clamping techniques for mini-invasive liver surgery

Vito De Blasi, Alexandre Henrard, Juan Santiago Azagra, Edoardo Rosso

Department of General and Minimally Invasive Surgery (Laparoscopy and Robotic), Centre Hospitalier de Luxembourg, Luxembourg City, Luxembourg

Contributions: (I) Conception and design: A Henrard, V De Blasi; (II) Administrative support: A Henrard, V De Blasi; (III) Provision of study materials or patients: A Henrard, V De Blasi; (IV) Collection and assembly of data: A Henrard, V De Blasi; (V) Data analysis and interpretation: A Henrard, V De Blasi; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Vito De Blasi, MD. Department of General and Minimally Invasive Surgery (Laparoscopy and Robotic), Centre Hospitalier de Luxembourg, 1210 Luxembourg City, Luxembourg. Email: DeBlasi.Vito@chl.lu.

Abstract: The hepatic pedicle clamping during a mini-invasive liver surgery (MILS) limits the perioperative blood loss. The aim of this article is to describe the different types of Pringle maneuver (PM) during a MILS. After a brief review in the literature, we have selected only technical articles written in English who describe PM in MILS and we propose with brief videos our experience. The article was divided in the description of extracorporeal and intracorporeal PM techniques. Extracorporeal technique could be performed using an additional trocar or an additional incision with the use of a thoracic drain. In intracorporeal PM, we show different techniques including the use of a cotton tape, a rubber Foley catheter, a silicon Foley catheter in case of latex allergy, a silicon Penrose drain or a Bull-dog clamp. In case of adhesions related to previous dissection of the hepatic pedicle, we described two solutions. One using a Foley catheter with the aid of a Goldfinger retractor or another one using a laparoscopic Satinsky vascular clamp. No randomized control study have been found in the literature in order to privilege one or another. Each technique present advances or inconvenient and the use of one more than another is actually related to the surgeon's habits.

Keywords: Pringle maneuver (PM); mini-invasive liver surgery (MILS); hepatobiliary surgery

Received: 31 December 2021; Accepted: 23 March 2022; Published: 30 June 2022.

doi: 10.21037/dmr-21-107

View this article at: https://dx.doi.org/10.21037/dmr-21-107

Introduction

Mini-invasive liver surgery (MILS) reduce the postoperative complications for both minor and major liver resections when compared with open liver procedure (1).

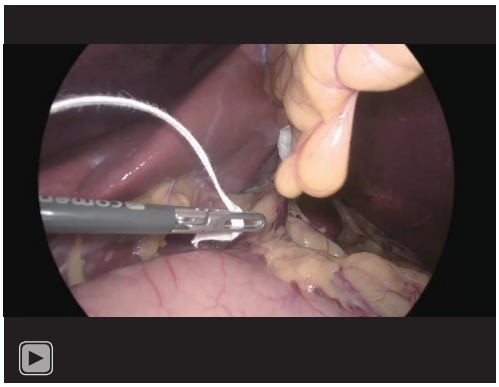
Actually, the uncontrolled blood loos during a MILS procedure is the principal cause of conversion to laparotomy. Moreover it increases post-operative morbidity and mortality (2). The hepatic pedicle clamping or Pringle maneuver (PM), first described in 1908 (3), permits to reduce the inflow of the liver and therefore reduces intraoperative blood loss. The aim of this article is to describe the different types of PM during a MILS. Public on-line database Medline (Pubmed, National Institute of Health) was queried on the 17th of December 2021 by using the following MeSH term "Pringle maneuver" AND "hepatobiliary surgery ". After a brief review in the literature, we have selected only technical articles written in English which describe PM in MILS.

Extracorporeal PM

Extracorporeal PM using a cotton tape

Like described in 2018 by Inoue *et al.* (4), the PM can be done by an extracorporeal approach. A forceps is inserted in

Video 1 Extracorporeal PM using a cotton tape. PM, Pringle maneuver.



Video 2 Intracorporeal PM using a cotton tape. PM, Pringle maneuver.

the foramen of Winslow between the inferior vena cava and the hepatoduodenal ligament toward the direction of the lesser omentum. The pars flaccida of the lesser omentum is open by an energy device and a cotton tape is grasped by the forceps then passed behind the hepatoduodenal ligament. The two edges of the cotton tape are pulled out from the abdomen and are then passed through a vascular occlusion tube (Vessel-clude; Argon Medical Devices, Inc., Dallas, TX, USA) or a 20 French rubber tube for use as a tourniquet to enable a PM. This kind of maneuver could be performed using an additional trocar like Inoue technique or by using a 30 French thoracic drain (*Video 1*).

Intracorporeal PM

Intracorporeal PM using a cotton tape

In 2018 Laurenzi *et al.* (5) described their way to create an intracorporeal PM using a cotton tape. They first open the pars flaccida of the lesser omentum with an energy device. A fenestrated forceps is then inserted through a 5-mm trocar on the right mid-axillary line and is passed behind the hepatoduodenal ligament along the omental foramen of Winslow. A 90-cm long cotton tape is then place between the forceps tips and is gently pulled to the other side of the hepatic pedicle. The two ends of the tape are externalized through one of the 10 mm trocar. The tape is next passed through a 5-cm long plastic tube that is pushed into the abdominal cavity. The two tips of the tape are joined with a clip, placed a few centimeter from the tube. The ends of the tape are cut. Finally, the combination of tape and tube is ready to be used as a tourniquet (*Video 2*).

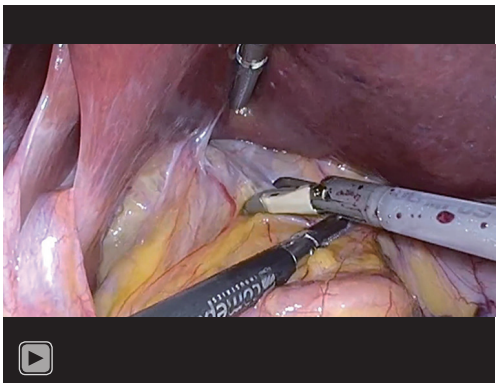
Intracorporeal PM using a Foley catheter

As describe by Huang in 2018, we currently use a Huang's loop technique with a 14 French Foley catheter with side-hole on the tip which is shortened to 15 cm and made taper (6). The pars flaccida of the lesser omentum is open. The tail of the Foley catheter is passed through the foramen of Winslow and a dissecting forceps is then passed through the side hole at the head end of the Foley tube, grabbing the tail of the catheter. The tail is then pulling through the side hole. When performing the PM, the loop is only tightened.

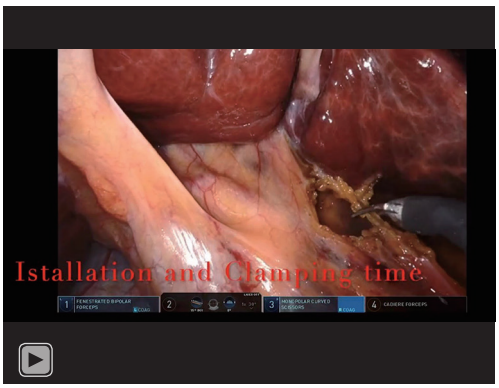
The use of a silicon Foley catheter in place of a rubber catheter may results in an incomplete clamping by progressive untightening which results in an inefficient PM. In case of latex allergy there is another option, we can use for example a silicon Foley catheter which is tightened and the tension is held by one Hem-o-lock clip (Hem-o-lok clips, TFX Medical Ltd., RTP Durham, NC, USA) placed perpendicularly. While releasing the PM, the clip can be easily removed by an energy device such as Thunderbeat (Olympus, Inc., Tokyo, Japan). In case of robotic procedure, the clip is applied or removed using the assistant trocar (*Videos 3*,*4*).

Using a Penrose drain

In 2020 Choi described the use of a Penrose drain (Sewoon Medical, Cheonan, Korea) to achieve an intracorporeal PM. They use a 15-cm silicon Penrose drain tube and create a hole, 1 cm from the edge of the drain tube. First the avascular lesser omentum is open with an energy device. A Goldfinger 5-mm retractor with the silicon Penrose drain tube is inserted through the lesser omentum to pass behind the hepatoduodenal ligament from left to right. Once the



Video 3 Intracorporeal PM using a rubber Foley catheter. PM, Pringle maneuver.



Video 4 Intracorporeal PM using a silicon Foley catheter. PM, Pringle maneuver.

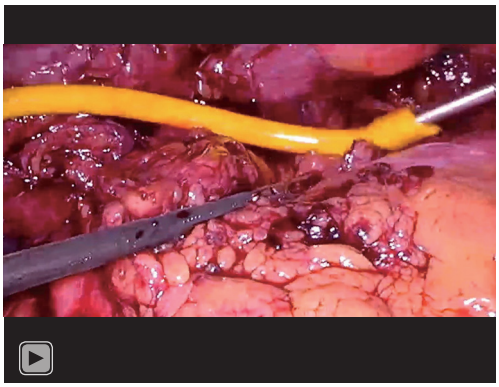
Penrose drain reached the foramen of Winslow, the edge of the drain tube is held with a forceps and is pulled out through the side hole on the other side of the Penrose drain tube. It creates a loop which is tightened and lock with a Hem-o-lok clip to achieve a PM (7).

Intracorporeal PM using a Bull-dog clamp

During MILS, PM can also be achieve using a laparoscopic Bull-dog clamp which is placed on the hepatic pedicle after the opening of the pars flaccida of the lesser omentum. In case of robotic procedure, the Bull-dog clamp technique requires the use of an assistant trocar.

Difficult PM

In case of adhesions between the inferior vena cava and the hepatoduodenal ligament, due to repeat hepatectomy or previous upper abdominal surgery, PM can be difficult. Therefore as we found in the literature, we can propose other options of PM techniques.



Video 5 Intracorporeal PM using a Foley catheter Goldfinger assisted. PM, Pringle maneuver.

Intracorporeal PM using a Foley catheter Goldfinger assisted

The passage through the foramen of Winslow may be difficult due to adhesion in patient who had a previous liver surgery. In these cases, we use a 5-mm Goldfinger retractor (Artisan Medical Devices, New York, NY, USA) or a 5-mm Lap-Band Passers (Artisan Medical Devices) to facilitate the passage of the Foley catheter around the hepatic pedicle and performed an intracorporeal PM as described above (*Video 5*).

Extracorporeal PM using a laparoscopic Satinsky vascular clamp

In 2021, Onda *et al.* (8) described the use of a laparoscopic Satinsky vascular clamp (K49310 SC, Karl Storz SE & Co.KG, Tuttlingen, Germany) in case of repeat laparoscopic hepatectomy after open hepatectomy. As they describe, if a space behind the hepatoduodenal ligament was dissected from the left side along the caudal edge of the Spiegel lobe, while obstruction of the right side, the laparoscopic Satinsky vascular clamp is introduce laterally from the left on the hepatoduodenal ligament. If the space behind the hepatoduodenal ligament is totally obstructed, the laparoscopic Satinsky vascular clamp is vertically applied.

Discussion

PM as described by Pringle in 1908 (3) permits to reduce the inflow of the liver and therefore reduces intraoperative blood loss during liver parenchymal transection. Since the

development of MILS, PM has had to adapt to a mini-invasive approach.

As far as we know, there is no randomize study done to compare the different types of PM. In this article, we briefly described the different type of PM in MILS. There is no evidence to support one technique more than another.

The external PM, as describe by Inoue *et al.* (4), imply the use of an additional incision or trocar. Moreover it can also restrict the view of the surgical fields or affect the manipulation of instrument (5). Indeed in case of MILS, the presence of an external PM may also interfere with the robotic arm due to the additional trocar. However some surgeon likes to perform an external PM during a laparoscopic liver procedure because it allows to create a traction of the pedicle using the external tourniquet.

On the contrary, the intracorporeal PM does not require an additional incision or trocar and does not interfere with the surgeons' view and operating technique. There is different type of intracorporeal PM as described above.

The intracorporeal PM using a cotton tape may be tricky during the passage through the Winslow foramen due to the soft consistency of the cotton tape.

On the other hands, the use of the rubber Foley catheter is easy and speed compared to the cotton tape because of it semi-rigid nature. It allowed us an effective PM without the necessity of putting a Hem-o-lok. Moreover the presence of a natural side hole over the tip of the Foley catheter facilitate the loop creation. So we only need to shorten it and to make tapered. As describe by Huang (6), when a massive bleeding occurs the yellow color of the Foley catheter different from blood color and the firm consistence of the catheter compare to the cotton tape, allow the achievement of an effective PM. Therefore clamping and unclamping can be performed in few seconds, including in case of life-threatening bleeding.

In case of latex allergy, we use a silicon Foley catheter which is tightened and the tension is held by one Hem-o-lock clip placed perpendicularly. While releasing the PM, the clip can be easily removed by an energy device such as Thunderbeat (Olympus, Inc.). One of the main concerns about the intracorporeal technique is that it can be difficult to correctly position the Hem-o-lok to have a complete occlusion of the hepatic pedicle.

The use of the silicon Penrose technique, as describe by Choi (7), could be sometimes difficult due to the physical characteristic of the Penrose drain who is less rigid than the Foley catheter. In addition, the need to modify the silicon Penrose drain is more time consuming.

PM can also be achieve using a laparoscopic Bull-dog clamp which is placed on the hepatic pedicle. As explained above, in case of robotic procedure this technique requires the use of an assistant trocar. Moreover if a massive bleeding occurs, the placement of the Bull-dog clamp may be tricky.

In case of adhesions between the inferior vena cava and the hepatoduodenal ligament, due to repeat hepatectomy or previous upper abdominal surgery, PM can be difficult. Therefore as we found in the literature, we can propose other option of PM.

If the passage through the foramen of Winslow is difficult to found due to adhesion in patient who had a previous liver surgery. We like to perform an intracorporeal PM using a Foley catheter Goldfinger assisted. Indeed the Goldfinger retractor permit to facilitate the passage of the Foley catheter around the hepatic pedicle and to perform an intracorporeal PM using a Foley catheter as described above. In case of difficult adherences, the use of laparoscopic Satinsky vascular clamp, as describe by Onda (8) can be a good option.

In 2018, Lim *et al.* (9) did the first comparative study of intra- *vs.* extracorporeal PM in terms of intra-operative events and post-operative outcomes. This comparison shows no differences in terms of the number of sessions, total time of clamping, blood loss, transfusion requirement and post-operative morbidity. However as explained, their experience-based analysis remains to be confirmed with prospective randomized trials.

Conclusions

The hepatic pedicle clamping during a MILS limits the perioperative blood loss. Here we described the different techniques of PM. Following these advantages, we perform intracorporeal PM using a Foley catheter. There is no evidence to support one technique more than another. In that case, in our experience we prefer to use the rubber Foley catheter easy to position and to reserve the silicon Foley catheter in case of latex allergy and the use of Goldfinger retractor in case of difficult hepatic pedicle. In case of difficult adherences, the use of laparoscopic Satinsky vascular clamp can be a good option.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the editorial office, *Digestive Medicine Research* for the series "Focus on Technical Advancement in Mini-invasive HPB Surgery". The article has undergone external peer review.

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://dmr.amegroups.com/article/view/10.21037/dmr-21-107/coif). The series "Focus on Technical Advancement in Mini-invasive HPB Surgery" was commissioned by the editorial office without any funding or sponsorship. ER and JSA served as the unpaid Guest Editors of the series. ER serves as an unpaid editorial board member of *Digestive Medicine Research* from September 2020 to August 2022. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

doi: 10.21037/dmr-21-107
Cite this article as: De Blasi V, Henrard A, Azagra JS, Rosso E. Hepatic pedicle clamping techniques for mini-invasive liver surgery. Dig Med Res 2022;5:35.

References

1. Sotiropoulos GC, Prodromidou A, Kostakis ID, et al. Meta-analysis of laparoscopic vs open liver resection for hepatocellular carcinoma. Updates Surg 2017;69:291-311.
2. Gheza F, Esposito S, Gruessner S, et al. Reasons for open conversion in robotic liver surgery: A systematic review with pooled analysis of more than 1000 patients. Int J Med Robot 2019;15:e1976.
3. Pringle JH. V. Notes on the Arrest of Hepatic Hemorrhage Due to Trauma. Ann Surg 1908;48:541-9.
4. Inoue Y, Suzuki Y, Fujii K, et al. Laparoscopic Hepatic Resection Using Extracorporeal Pringle Maneuver. J Laparoendosc Adv Surg Tech A 2018;28:452-8.
5. Laurenzi A, Cherqui D, Figueroa R, et al. Totally intra-corporeal Pringle maneuver during laparoscopic liver resection. HPB (Oxford) 2018;20:128-31.
6. Huang JW, Su WL, Wang SN. Alternative Laparoscopic Intracorporeal Pringle Maneuver by Huang's Loop. World J Surg 2018;42:3312-5.
7. Choi YI. The usefulness of the totally intra-corporeal pringle maneuver with Penrose drain tube during laparoscopic left side liver resection. Ann Hepatobiliary Pancreat Surg 2020;24:252-8.
8. Onda S, Haruki K, Furukawa K, et al. Newly-revised Pringle maneuver using laparoscopic Satinsky vascular clamp for repeat laparoscopic hepatectomy. Surg Endosc 2021;35:5375-80.
9. Lim C, Osseis M, Lahat E, et al. Extracorporeal Pringle Maneuver During Laparoscopic and Robotic Hepatectomy: Detailed Technique and First Comparison with Intracorporeal Maneuver. J Am Coll Surg 2018;226:e19-25.