Case Report

Laparoscopy in a Patient With a Ventriculoperitoneal Shunt: A Case Report and Literature Review

Mohammed Almayouf¹, Tareq AlSabahi², Ahmad Alburakan¹, Thamer Nouh¹

¹Trauma & Acute Care Surgery Unit, Department of Surgery, College of Medicine, King Saud University, Riyadh, Saudi Arabia
²Trauma Surgery, Department of Surgery, Prince Mohammed Bin Abdulaziz Hospital, Riyadh, Saudi Arabia

Objective: This case emphasizes the safety of laparoscopy in patients with ventriculoperitoneal shunts.

Summary of background data: Previously published reports have suggested possible risks associated with laparoscopy in patients with ventriculoperitoneal shunt.

Methods: We report a case of a 17-year-old male with a ventriculoperitoneal shunt inserted 6 years ago to manage hydrocephalus that developed after surgery for medulloblastoma. The patient presented with a 5-day history of abdominal pain. He was diagnosed as having acute biliary pancreatitis. We performed laparoscopic cholecystectomy with the ventriculoperitoneal shunt in place.

Conclusion: The patient had an uneventful recovery with no shunt-related complications.

Key Words: Laparoscopy – Safety – Ventriculoperitoneal shunts

Laparoscopy became the standard approach for many surgical procedures,¹,² with laparoscopic cholecystectomy being the most commonly performed surgical procedures worldwide. There is an increasing need to recommend laparoscopic cholecystectomy to patients with higher risk for complications, including patients with ventriculoperitoneal shunts (VPS). The important aspects that need to be considered when performing laparoscopy on these patients include shunt type, shunt function, potential for shunt malfunction, shunt infection, intraoperative anesthesia monitoring, and shunt manipulation. Here, we report a case of a patient with VPS who developed acute biliary pancreatitis

Corresponding author: Thamer Nouh, MD, FRCSC, FACS, Trauma & Acute Care Surgery Unit, Department of Surgery, College of Medicine, King Saud University, PO Box 7805 (37), Riyadh 11472, Kingdom of Saudi Arabia. ORCID ID: 0000-0002-7118-7453
Tel.: +966555715666; E-mail: tnouh@ksu.edu.sa
and needed to undergo laparoscopic cholecystectomy. We review the literature to provide the best evidence to address relevant clinical points.

Case Report

The patient was a 17-year-old male who was known to have had surgical resection for medulloblastoma, which was diagnosed when he was 12 years old. Surgery was complicated by hydrocephalus; thus, he had a VPS inserted. He subsequently underwent adjuvant chemotherapy. The patient presented to our institution with a 5-day history of epigastric abdominal pain, nausea, vomiting, and fever. Laboratory results were significant for elevated lipase. An ultrasound of his abdomen showed gallstones but no signs of acute cholecystitis or common bile duct dilatation. Computed tomography (CT) of the abdomen displayed a swollen pancreas, with peripancreatic fluid collection and mild-to-moderate bilateral pleural effusion (Modified CT Severity Index score of 6) consistent with moderate pancreatitis. He was admitted with the diagnosis of mild acute biliary pancreatitis.

At our institution, we routinely perform laparoscopic cholecystectomy after managing attacks of acute pancreatitis within the same admission. Routine preoperative workup was done in addition to a neurosurgery consultation, which documented that the shunt was functioning properly. A multidisciplinary decision was made to proceed with the surgery with routine intraoperative monitoring.

A prophylactic antibiotic was administered within 30 minutes of starting the procedure. Accessing the abdomen was achieved using an open technique. A supraumbilical 12-mm port was inserted and gas insufflation was initiated. Inspection showed adhesions at the site of the shunt. The other 3 abdominal ports were placed under direct vision. A routine dissection and removal of the gallbladder was done with no immediate consequences. During the whole procedure that lasted an hour, the abdominal pressure was maintained between 12 and 15 mmHg. Routine anesthesia monitoring was performed and showed no deterioration throughout the surgery. The patient tolerated the procedure well, and the postoperative period was uneventful. The patient was seen in the surgical clinic 2 weeks after discharge and had no complaints.

Discussion

Laparoscopic cholecystectomy is the standard of care for patients requiring excision of the gallbladder. Given its less invasiveness, shorter hospital stay, and lower complication rate, laparoscopic cholecystectomy has been increasingly undertaken as the procedure of choice.3-5 There is an increasing need to recommend laparoscopic cholecystectomy to patients with higher risk for complications including patients with VPS. Tables 1 and 2 show case reports of patients with VPS who have had laparoscopic cholecystectomy.

As the number of patients with VPS increases, surgeons will be confronted with more patients with VPS who require laparoscopic surgery. In the following sections, we provide a review of the important special considerations the surgeon should be aware of when deciding to perform laparoscopy in patients with VPS.

Table 1  Case reports of laparoscopic cholecystectomy with shunts

| Author               | Number of cases | Age/sex     | Type of shunt | Duration | Shunt manipulation | Shunt-related complications |
|----------------------|-----------------|-------------|---------------|----------|--------------------|----------------------------|
| Collure et al, 199444 | 4               | 39–74 y/3M, F | VPS           | NA       | No                 | None                       |
| Kerwat et al, 20016  | 1               | 70 years/M  | LPS           | 12 y     | Clipped with clipper | None                       |
| Al-Mufarrej et al, 20057 | 1             | 34 y/F      | VPS           | 32 y     | Clamped with forceps | None                       |
| Hammill et al, 201035 | 1               | 71 y/M      | VPS           | 10 y     | No                 | None                       |
| O. Damrah et al, 201136 | 1             | 64 y/F      | VPS           | 6 y      | No                 | None                       |
| Charalabopoulos et al, 201337 | 1          | 46 y/F      | LPS           | 10 y     | Not mentioned      | None                       |
| Cobianchi et al, 201438 | 1             | 41 y/M      | VPS           | 1 y      | No                 | None                       |
| Albarrak et al, 201539 | 1             | 41 y/M      | VPS           | 3 y      | Not mentioned      | None                       |
| Rumba et al, 201640 | 1               | 41 y/F      | LP            | 1 y      | Not mentioned      | None                       |
| Lykoudis et al, 201741 | 3               | 48–70 y     | VPS           | 5 y      | Not mentioned      | None                       |

F, female; LPS, lumbo-peritoneal shunt; M, male; VPS, ventriculoperitoneal shunt.
Shunt type and shunt manipulation

Different approaches were reported with regard to shunt manipulation to allow for laparoscopic surgery. Some reports manipulated the VPS either by simply clamping/clipping the shunt, and other reports stated extreme measures involving complete externalization and cerebrospinal fluid drainage for several days.\textsuperscript{6–10} These measures were taken to reduce the risk of infection and to avoid the recognized effect of pneumoperitoneum on intracranial pressure (ICP). Although reported in the early experience with laparoscopy in patients having a VPS, most of these reports indicate that there was no clear benefit to clamping the shunts in addition to the possible complications associated with such shunt manipulations, including malfunction, infection, and increased ICP.

The major concern that faces the medical team at the time of laparoscopic surgery is the potential risk of developing pneumocephalus secondary to the pneumoperitoneum. Since the introduction of shunts with valves during the 1960s, most of shunts can be classified broadly into 2 groups: differential pressure and flow-regulated valves.\textsuperscript{11,12} This led to the emergence of comparative studies testing specific endpoints including failure rate; these reports showed no difference in failure rate across miscellaneous types of shunts,\textsuperscript{13–15} which was also confirmed in a recent systemic review.\textsuperscript{12} New shunt systems come equipped with a no-reflow valve, which is not used in traditional shunts. Neale and Falke reported that those modern shunt valves can tolerate pressures of up to 350 mmHg without any retrograde flow.\textsuperscript{16} With these newer shunt systems, proposed negative effects of pneumoperitoneum or bacterial translocation resulting in infection seem less likely. Older shunts might lack the no-reflow valve, and it is in these cases or when the functionality of the valve is questionable that shunt manipulation is still warranted.\textsuperscript{8} Thus, it is important that the medical team is aware of the type of shunt the patient has to determine the safety of laparoscopy.

Given that most new shunt systems come equipped with a no-reflow valve, the risk of pneumocephalus and its complications is very low if the shunt system is functioning well. Kestle \textit{et al} recognized the increased risk of shunt failure with time after following a group of pediatric patients with VPS due to hydrocephalus. The trial demonstrated that the number of functioning shunts decreased from 62\% in the first year to 41\% in the fourth year of follow-up.\textsuperscript{17} This highlights the importance of assuring shunt function ahead of any laparoscopic procedure.

Pneumoperitoneum effect on intracranial pressure

Artificial pneumoperitoneum induced for laparoscopy has well known physiologic effects. The acid-base balance is altered when CO\textsubscript{2} is used for inducing pneumoperitoneum in the form of hypercarbia and eventually acidosis, which will be adjusted by necessary hyperventilation in healthy individuals.\textsuperscript{18} The notion of implicating hypercapnia as the main reason for ICP elevation by intracranial vasodilation is intuitive.\textsuperscript{19} Halverson \textit{et al} in his experimental study confirmed the hypothesis that elevated ICP is mainly due to impaired venous drainage because of pneumoperitoneum. Additionally, pneumoperitoneum was found to be independent from other parameters (i.e., pH, partial pressure of CO\textsubscript{2}, partial pressure of O\textsubscript{2}, mean arterial pressure) as the reason for elevating ICP.\textsuperscript{20}

Uzzo \textit{et al} examined ICP in children with VPS during laparoscopic surgery and found that ICP increased to up to 25 mmHg with pneumoperitoneum pressure of 12 mmHg.\textsuperscript{21} Additionally, non-invasive measures were used by quantifying the middle cerebral artery blood flow.\textsuperscript{22,23} Despite the relative low intraabdominal pressure used during the procedure, increase in the pulsatility and the diastolic blood flow were evident during the

| Author               | Number of cases | Age/Sex                  | Type of shunt | Duration | Shunt manipulation                           | Shunt-related complications |
|----------------------|-----------------|--------------------------|---------------|----------|---------------------------------------------|-----------------------------|
| Allam \textit{et al}, 2011\textsuperscript{9} | 23              | Mean: 59 y, 91\% were male | VPS           | Mean: 8 y | 2 shunts externalized, 5 shunts packed, 1 shunt repositioned | 2 shunts with infection     |
| Yoshihara \textit{et al}, 2017\textsuperscript{8} | 4               | 56–79 y/2M, 2F          | 2 VPS, 2 LPS  | 2–18 y   | 3 shunts clamped with forceps               | None                        |

F, female; LPS, lumbo-peritoneal shunt; M, male; VPS, ventriculoperitoneal shunt.
pneumoperitoneum compared to the preoperative baseline readings. These findings could be attributed to anesthetic medications used in surgery, hypercapnia because of the CO\textsubscript{2} insufflation, or most likely (as mentioned previously) to the reduction in venous outflow based on the Monro-Kelly principle.\textsuperscript{21} Regardless, changes in the previously investigated parameters were not significant, and did not have detrimental effects on the shunt functionality or the patients’ condition during the postoperative period. Moreover, Neale and Falk concluded that there is a very low risk of shunt malfunction with pneumoperitoneum, and that very high pressure is required to cause damage in shunts with no-reflow valves.\textsuperscript{16} To our knowledge, only one report mentioned a shunt malfunction after conducting a laparoscopic procedure, and the implication of pneumoperitoneum as a cause was possible.\textsuperscript{24}

**Intraoperative anesthesia monitoring**

Additional monitoring modalities have been proposed to ensure patient safety during laparoscopic procedures in the presence of VPS.\textsuperscript{21} The question is whether these should be routinely or selectively utilized. Jackman et al concluded the redundancy of using monitoring modalities such as invasive intracranial monitoring, and that the complication risks of these invasive modalities outweigh the benefits.\textsuperscript{25} There are multiple reports in the literature detailing risk factors that could be associated with increased ICP during laparoscopic surgery such as prolonged surgical procedures and positioning the patient in a Trendelenburg position. It is in these cases that selective additional monitoring of the ICP is warranted. In these procedures, non-invasive monitoring is clearly preferred to invasive approaches. Measuring the pulsatility index of middle cerebral artery is an intriguing non-invasive option.\textsuperscript{23} Another optional non-invasive monitoring modality is the measurement of optic nerve sheath diameter.\textsuperscript{26–28}

**Subcutaneous emphysema with pneumoperitoneum**

Schwed et al reported a unique complication in the form of subcutaneous emphysema and distension along the catheter pathway during laparoscopic cholecystectomy in a patient with a recently inserted VPS. It caused a noticeable increased in end tidal carbon dioxide and peak inspiratory pressure. The author suggested allowing the tract to fibrose if possible to prevent air from tunneling in the tract.\textsuperscript{29}

**Shunt infection**

There was a slight variation between reports with regard to antibiotic usage in patients undergoing laparoscopic abdominal procedures with VPS. Most of the patients received preoperative antibiotics, and postoperatively for 24 hours. One report mentioned the administration of additional doses of antibiotics perioperatively.\textsuperscript{9} It seems that the type of the surgical wound is the main factor in deciding antibiotic administration, and presence of the shunt did not affect the decision significantly. As one might expect, shunt infections were observed more commonly in patients with contaminated or dirty wounds (perforation or abscess near the shunt).\textsuperscript{9,30–32} In a group of pediatric patients with VPS and brain tumors who were planned for gastrostomy feeding tube insertion, Gasses et al advised to allow adequate time for the VPS tract to heal before inserting the feeding tube. In addition to the prophylactic antibiotics of the skin flora, this strategy could lower the chance of VPS infection, the potential ascending infection, and meningitis.\textsuperscript{33}

**Conclusion**

An increasing number of studies are reporting that laparoscopic surgery is feasible in patients with VPS. However, specific considerations should still be undertaken in deciding for laparoscopy in such patients. Even though reports showed no differences in failure rate between different types of shunts, neurosurgical consultation and a multidisciplinary approach are advised to determine the shunt type, whether it is functioning properly, and whether shunt manipulation is needed. The surgeon must be especially careful if the shunt is old, has no reflow valve, or has been recently inserted, as these factors will increase the likelihood of developing complications. The surgeon should also be concerned if the surgery is of the contaminated or dirty type, as this might increase the risk of shunt infection and the need for shunt manipulation. Non-invasive monitoring modalities of ICP are available and could be used in addition to the standard anesthesia monitoring in case of long laparoscopic procedures with positions that lead to ICP elevation, that is, Trendelenburg position.
Acknowledgments

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and all due efforts will be made to conceal their identity, but anonymity cannot be guaranteed. The College of Medicine Research Centre, Deanship of Scientific Research at King Saud University supported this research. There are no conflicts of interest and nothing to report. The College of Medicine Research Centre, Deanship of Scientific Research at King Saud University supported this research.

References

1. Tsui C, Klein R, Garabrant M. Minimally invasive surgery: national trends in adoption and future directions for hospital strategy. Surg Endosc 2013;27(7):2253–2257
2. Kelley WE Jr. The evolution of laparoscopy and the revolution in surgery in the decade of the 1990s. JSLS 2008;12(4):351–357
3. Schirmer BD, Edge SB, Dix JA, Hyser MJ, Hanks JB, Jones RS. Laparoscopic cholecystectomy. Treatment of choice for symptomatic cholelithiasis. Ann Surg 1991;213(6):665–676; discussion 677
4. Deziel DJ, Millikan KW, Economou SG, Doolas A, Ko ST, Airan MC. Complications of laparoscopic cholecystectomy: a national survey of 4,292 hospitals and an analysis of 77,604 cases. Am J Surg 1993;165(9):9–14
5. Coccolini F, Catena F, Pisano M, Ghesa F, Fagioli S, Di Saverio S et al. Open versus laparoscopic cholecystectomy in acute cholecystitis. Systematic review and meta-analysis. Int J Surg 2015;18:196–204
6. Kerwat RM, Murali Krishnan VP, Appadurai IR, Rees BL. Laparoscopic cholecystectomy in the presence of a lumbo-peritoneal shunt. J Laparoendosc Adv Surg Tech A 2001;11(1):37–39
7. Al-Mufarrej F, Nolan C, Sookhai S, Broe P. Laparoscopic procedures in adults with ventriculoperitoneal shunts. Surg Laparosc Endosc Percutan Tech 2005;15(1):28–29
8. Yoshihara T, Tomimaru Y, Noguchi K, Nagase H, Hamabe A, Hirota M et al. Feasibility of laparoscopic cholecystectomy in patients with cerebrospinal fluid shunt. Asian J Endosc Surg 2017;10(4):394–398
9. Allam E, Patel A, Lewis G, Mushu E, Audisio RA, Virgo KS et al. Cholecystectomy in patients with prior ventriculoperitoneal shunts. Am J Surg 2011;201(4):503–507
10. Walker DH, Langer JC. Laparoscopic surgery in children with ventriculoperitoneal shunts. J Pediatr Surg 2000;35(7):1104–1105.
11. Drake J, Kestle J, Tuli S. CSF shunts 50 years on–past, present and future. Childs Nerv Syst 2000;16(10-11):800–804
12. Ziebell M, Wetterslev J, Tisell M, Glud C, Juhrer M. Flow-regulated versus differential pressure-regulated shunt valves for adult patients with normal pressure hydrocephalus. Cochrane Database Syst Rev 2013(5):CD009706
13. Lund-Johansen M, Svendsen F, Wester K. Shunt failures and complications in adults as related to shunt type, diagnosis, and the experience of the surgeon. Neurosurgery 1994;35(5):839–844
14. Drake JM, Kestle JR, Milner R, Cinalli G, Boop F, Piatt J Jr et al. Randomized trial of cerebrospinal fluid shunt valve design in pediatric hydrocephalus. Neurosurgery 1998;43(2):294–303
15. Pollack IF, Albright AL, Adelson PD. A randomized, controlled study of a programmable shunt valve versus a conventional valve for patients with hydrocephalus. Neurosurgery 1999;45(6):1399–1411
16. Neale ML, Falk GL. In vitro assessment of back pressure on ventriculoperitoneal shunt valves. Is laparoscopy safe? Surg Endosc 1999;13(5):512–515
17. Kestle J, Drake J, Milner R, Sainte-Rose C, Cinalli G, Boop F et al. Long-term follow-up data from the Shunt Design Trial. Pediatr Neurosurg 2000;33(5):230–236
18. Grabowski JE, Talamini MA. Physiological effects of pneumoperitoneum. J Gastrointest Surg 2009;13(5):1009–1016
19. Brian JE. Jr. Carbon dioxide and the cerebral circulation. Anesthesiology 1998;88(5):1365–1386
20. Halverson A, Buchanan R, Jacobs L, Shayan V, Hunt T, Riedel C et al. Evaluation of mechanism of increased intracranial pressure with insufflation. Surg Endosc 1998;12(5):266–269
21. Uzzo RG, Bilsky M, Mininberg DT, Poppas DP. Laparoscopic surgery in children with ventriculoperitoneal shunts: effect of pneumoperitoneum on intracranial pressure–preliminary experience. Urology 1997;49(5):753–757
22. Ravaoherisoa J, Meyer P, Afriat R, Meyer Y, Sauvanet E, Tricot A et al. Laparoscopic surgery in a patient with ventriculoperitoneal shunt: monitoring of shunt function with transcranial Doppler. Br J Anaesth 2004;92(3):434–437
23. Staikou C, Tsaroucha A, Mani A, Fassoulaki A. Transcranial Doppler monitoring of middle cerebral flow velocity in a patient with a ventriculoperitoneal shunt undergoing laparoscopy. J Clin Monit Comput 2012;26(6):487–489.
24. Baskin JJ, Vishteh AG, Wesche DE, Rekate HL, Carrion CA. Ventriculoperitoneal shunt failure as a complication of laparoscopic surgery. JSLS 1998;2(2):177–180
25. Jackman SV, Weingart JD, Kinsman SL, Docimo SG. Laparoscopic surgery in patients with ventriculoperitoneal shunts: safety and monitoring. J Urol 2000;164(1):1352–1354
26. Kim MS, Bai SJ, Lee JR, Choi YD, Kim YJ, Choi SH. Increase in intracranial pressure during carbon dioxide pneumoperitoneum with steep trendelenburg positioning proven by ultrasonographic measurement of optic nerve sheath diameter. J Endourol 2014;28(7):801–806
27. Rajajee V, Vanaman M, Fletcher JJ, Jacobs TL. Optic nerve ultrasound for the detection of raised intracranial pressure. *Neurocrit Care* 2011;15(3):506–515
28. Dip F, Nguyen D, Rosales A, Sasson M, Lo Menzo E, Szomstein S et al. Impact of controlled intraabdominal pressure on the optic nerve sheath diameter during laparoscopic procedures. *Surg Endosc* 2016;30(1):44–49
29. Schwed, DA, Edoga JK, McDonnell TE. Ventilatory impairment during laparoscopic cholecystectomy in a patient with a ventriculoperitoneal shunt. *J Laparoendosc Surg* 1992;2(1):57–59
30. Pittman T, Williams D, Weber TR, Steinhardt G, Tracy Jr T. The risk of abdominal operations in children with ventriculoperitoneal shunts. *J Pediatr Surg* 1992;27(8):1051–1053
31. Li G, Dutta S. Perioperative management of ventriculoperitoneal shunts during abdominal surgery. *Surg Neurol* 2008;70(5):492–495; discussion 495–497
32. Mortellaro VE, Chen MK, Pincus D, Kays DW, Islam S, Beierle EA. Infectious risk to ventriculo-peritoneal shunts from gastrointestinal surgery in the pediatric population. *J Pediatr Surg* 2009;44(6):1201–1204; discussion 1204–1205
33. Gassas A, Kennedy J, Green G, Connolly B, Cohen J, Dag-Ellams U, et al. Risk of ventriculoperitoneal shunt infections due to gastrostomy feeding tube insertion in pediatric patients with brain tumors. *Pediatr Neurolsurgery* 2006;42(2):95–99
34. Collure DW, Bumpers HL, Luchette FA, Weaver WL, Hoover EL. Laparoscopic cholecystectomy in patients with ventriculoperitoneal (VP) shunts. *Surg Endosc* 1995;9(4):409–410
35. Hammill CW, Au T, Wong LL. Laparoscopic cholecystectomy in a patient with a ventriculoperitoneal shunt. *Hawaii Med J* 2010;69(4):103–104
36. Damrah O, Naik P, Fusai G, Sharma D. Is laparoscopic cholecystectomy safe for acute cholecystitis in the presence of ventriculo-peritoneal shunt? *Int J Surg Case Rep* 2011;2(6):157–158
37. Charalabopoulos A, Botha AJ. Laparoscopic cholecystectomy in the presence of lumboperitoneal shunt. *Case Rep Surg* 2013;2013:929082
38. Cobianchi L, Dominioni T, Filisetti C, Zonta S, Maestri M, Dionigi P et al. Ventriculoperitoneal shunt and the need to remove a gallbladder: time to definitely overcome the feeling that laparoscopic surgery is contraindicated. *Ann Med Surg (Lond)* 2014;3(3):65–67
39. Albarrak, AA, Khairy S, Ahmed AM. Laparoscopic cholecystectomy for acute calculus cholecystitis in a patient with ventriculoperitoneal shunt: a case report and literature review. *Case Rep Surg* 2015;2015:845613
40. Rumba R, Vanags A, Strumfa I, Pupkevics A, Pavars M. Laparoscopic cholecystectomy for a patient with a lumboperitoneal shunt: a rare case. *Chirurgia (Bucur)* 2016;111(3):263–265
41. Lykoudis PM, Nastos C, Dellaportas D, Vezakis A, Ayiomamitis GD, Papaconstantinou I, et al. Laparoscopic cholecystectomy in patients with ventriculoperitoneal shunts: a case series. *Hellenic J Surg* 2017;89(3–4):163–165