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Laparoscopic assistance for peritoneal catheter positioning in adults scheduled for ventriculoperitoneal shunting at the Pavlov First Saint Petersburg State Medical University

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ABSTRACT

Objective. To evaluate the efficacy and safety of laparoscopic assistance for peritoneal catheter implantation in adults scheduled for ventriculoperitoneal shunting.

Material and methods. A prospective study enrolled 38 patients divided into 2 groups: laparoscopic approach (n=18) and mini-laparotomy (n=20). Surgery time, incision length, pain syndrome and catheter position were assessed.

Results. In the main group, surgery time was significantly shorter (40.0 [37.0; 44.0] versus 48.0 [46.0; 50.0] min, p<0.001). The same was true for duration of abdominal stage (10.0 [9.0; 12.0] and 15.0 [14.0; 16.0] min, respectively, p<0.001). The incision length was 15 [14; 16] versus 49 [47; 52] mm (p<0.001). VAS score of pain were lower in the main group (4.5 [4.0; 5.0] versus 5.5 [5.0; 6.0] points; p=0.048). Pain regression was faster (4.0 [3.0; 5.0] versus 7.0 [6.0; 8.0] days; p<0.001). Laparoscopy ensured accurate catheter positioning in all patients.

Conclusion. Laparoscopic assistance in ventriculoperitoneal shunting reduces surgery time and invasiveness, ensures accurate catheter positioning and reduces pain. This method is effective in complicated and intact abdominal anamnesis, and improves immediate outcomes.

Keywords: *laparoscopy, ventriculoperitoneal shunting, shunt, hydrocephalus.*

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Abbreviations

VAS — visual analogue scale
VPS — ventriculoperitoneal shunt
BMI — body mass index

Introduction

Hydrocephalus is characterized by enlarged brain ventricles under low, normal or high intracranial pressure [1—3]. The overall annual incidence of hydrocephalus in adults is estimated at 17 cases per 100.000. Of these, hydrocephalus with concomitant cerebrovascular diseases accounts for 45% of cases, brain tumors — 30%, normal pressure hydrocephalus — 11%, post-meningitis hydrocephalus — 5.5%, posttraumatic hydrocephalus — 4.6%, pseudotumor cerebri — 3.5% [4].

In most cases, the disease causes irreversible severe neurological impairment. Despite numerous causes of hydrocephalus, many acute and chronic symptoms of this disease are common: disorientation, headache, cognitive impairment, developmental changes, visual and sleep disturbances, gait disturbance. These symptoms can regress after effective surgical treatment [5, 6]. Over 200.000 CSF shunting procedures are performed worldwide each year.

Primary surgical treatment for non-occlusive hydrocephalus is CSF shunting procedure for cerebrospinal fluid drainage from appropriate brain spaces into other cavities

***Table*. Demographic and clinical characteristics of patients.**

Variable	Main group (*n*=18)	Control group (*n*=20)	p
Age, years [Me]	70.0 [66.0; 73.0]	69.5 [65.0; 74.0]	0.956*
Gender, *n* (%)			0.741**
Male	8 (44.4)	11 (55.0)	
Female	10 (55.6)	9 (45.0)	
BMI, kg/m² [Me]	29.5 [28.0; 31.0]	29.0 [28.0; 31.0]	0.772*
Previous abdominal surgery, *n* (%)			
Cholecystectomy	3 (16.7)	4 (20.0)	1.000**
Appendectomy	4 (22.2)	5 (25.0)	1.000**
Type of hydrocephalus, *n* (%)			
Idiopathic normal pressure hydrocephalus	17 (94.4)	17 (85.0)	0.608**
Hypertensive hydrocephalus	1 (5.6)	3 (15.0)	

Note: data are presented as median [25th; 75th percentiles] or absolute number (percentage). BMI — body mass index; * — Mann-Whitney U-test for independent samples; ** — Fisher's exact test.

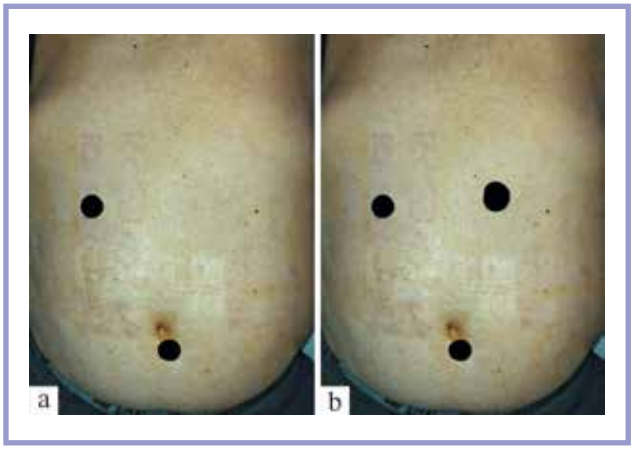


***Fig. 1.* Trocar arrangement.**
a — technique for «intact» abdomen. The first point for laparoscope is below the umbilicus. The second point for peritoneal catheter is in the left mesogastric region; b — technique for «compromised» abdomen with additional port on the opposite side.

(abdominal, pleural, right atrium, etc.) through a special implant (shunt). VPS with distal end of the shunt system in abdominal cavity is the most common [1, 7, 8]. Minilaparotomy is standard approach for inserting the peritoneal end of the shunt [9, 10].

The disadvantages of laparotomy include more severe surgical trauma of anterior abdominal wall compared to laparoscopic technique, especially in obese patients (incision is prolonged to ensure control when inserting catheter to a greater depth), higher risk of damage to abdominal organs or inadequate positioning of peritoneal catheter in patients with abdominal adhesions, insufficient or absent visual control over location and patency of shunt after implantation in abdominal cavity. There are risks of postoperative ventral hernia, infection-induced peritoneal pseudocysts with subsequent wrapping of the omentum around the catheter (8.6%), abdominal abscess (5.7%), intestinal perforation (1.4%), adhesions and peritoneal catheter migration from abdominal cavity [8]. Patients with multiple previous abdominal surgeries have significantly higher risk of these complications. In some cases, peritoneal sclerosis makes implantation of shunt via minilaparotomy impossible [11, 12].

To minimize surgical invasiveness, laparoscopy-assisted implantation was proposed. This technique was first described in 1993 by Armbruster [9], but this approach is still not widespread in Russia. Laparoscopic assistance is a universal technique that can be used in various shunting surgeries (VPS, lumboperitoneal shunting), regardless of the form of hydrocephalus (idiopathic normal-pressure hydrocephalus, secondary normal-pressure hydrocephalus, hypertensive hyporesorptive hydrocephalus, etc.) [3, 7, 13]. The advantages of laparoscopic method include minimal surgical trauma, no difficulties in peritoneal catheter implantation even in patients with abdominal adhesions, visual control of catheter position and lower risk of postoperative complications [1]. Peritoneal catheter dysfunction occurs in 5—47% of cases [2, 13—15]. In this case, laparoscopic exploration is valuable to examine abdominal cavity and, in some cases, identify and eliminate the cause of dysfunction without replacement of the entire system [16].

Material and methods

A prospective single-center study was conducted at the Pavlov First Saint Petersburg State Medical University. There were 38 patients with hydrocephalus aged 27—78 years (mean 70). All patients underwent surgery between September 2023 and March 2024. Thirty-four patients had idiopathic normal-pressure hyporesorptive hydrocephalus (Hakim-Adams syndrome), four patients — hypertensive hyporesorptive hydrocephalus. Fourteen patients had previous abdominal surgery (cholecystectomy in seven cases, appendectomy in nine cases, 2 ones under-

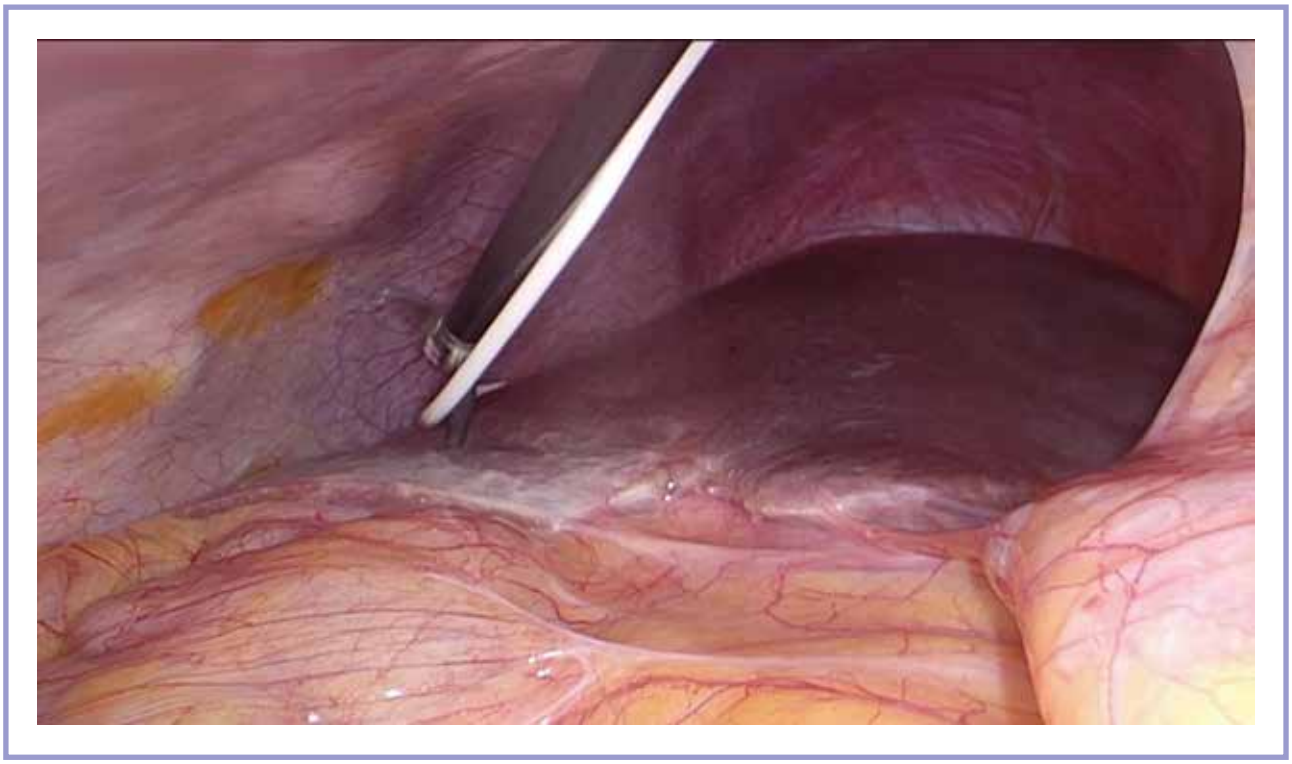


Fig. 2. **Intraoperative image. Distal end of the shunt in the left mesogastric region and positioning in the right subdiaphragmatic space.**

went both surgeries). There were open and laparoscopic procedures in 10 and 4 cases, respectively. Twelve patients had stage III obesity (BMI 42 kg/m²).

Patient allocation to groups was primarily sequential (quasi-randomized). Primary assignment of method was based on clinical assessment and consensus of surgical team. Final allocation depended on technical feasibility of laparoscopic assistance at the time of surgery (availability of abdominal surgeon and necessary equipment). If this was not possible, the patient was assigned to the control group (standard minilaparotomy). All patients were divided into two groups depending on technique of abdominal procedure:

— main group: 18 patients underwent laparoscopic peritoneal catheter placement;
— control group: 20 patients underwent distal catheter placement via standard minilaparotomy.

Both groups were comparable in key demographic and clinical characteristics, such as age, gender, BMI and type of hydrocephalus **(Table)**.

Abdominal surgeon performed laparoscopic manipulation simultaneously with ventricular catheter implantation using endoscopic equipment and laparoscopic instruments.

The following parameters were analyzed: total surgery time, duration of abdominal stage, postoperative wound length (mm), blood loss (ml), hospital-stay after surgery, postoperative abdominal pain syndrome.

Minilaparotomy. A 4-5 cm transverse skin incision was made 2 cm above and lateral to the umbilicus. Skin,



Fig. 3. **Postoperative CT of the abdomen — peritoneal catheter in subdiaphragmatic space.**

subcutaneous fat and anterior wall of the rectus sheath were dissected in layer-by-layer fashion. The rectus abdominis muscle fibers were bluntly retracted, and posterior layer of the sheath and parietal peritoneum were incised. We enlarged the wound using retractors and inserted peritoneal catheter. Peritoneum was closed with a purse-string suture, and soft tissues of anterior abdominal wall were closed in layer-by-layer fashion.

Two techniques were used for laparoscopic approach. The first one was applied for «intact» abdomen (patients without previous abdominal surgery). We created car-

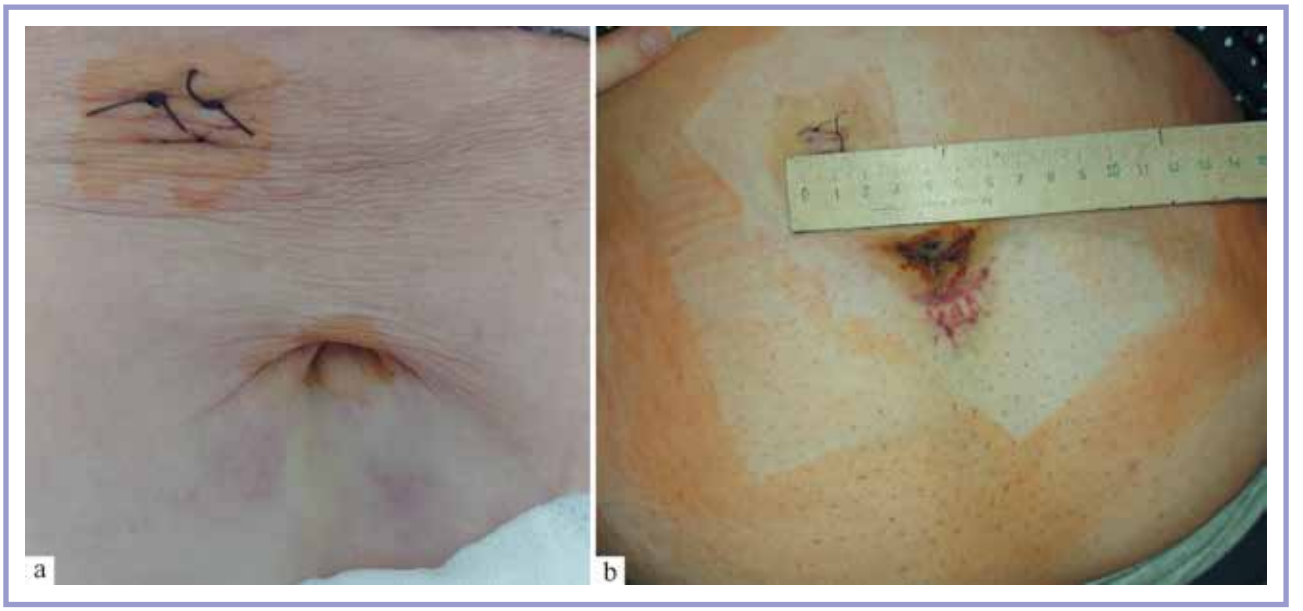


Fig. 4. **Postoperative images of patients with «intact» abdomen.**
a — patient with «intact» abdomen. Two ports were intraoperatively used; b — female patient with «intact» abdomen and severe obesity. Two ports were intraoperatively used.

boxyperitoneum using a Veress needle under a pressure of 8—10 mmHg. Next, we inserted paraumbilical trocar **(Fig. 1a)** and laparoscope. Laparoscopic exploration of abdominal cavity was performed. Under visual control, peritoneal catheter was implanted into the right subhepatic space through additional trocar in the right mesogastric region **(Fig. 2)**.

The 2nd technique was used in patients with previous single or multiple laparoscopic or open abdominal surgeries, including repeat VPS or peritoneal catheter revision. This technique implied additional mesogastric port **(Fig. 1b)** opposite the port for implantation of distal catheter. This allowed for surgical procedures such as dissection of adhesions (3 patients), catheter position correction and removal of non-functional shunt. Adhesiolysis was performed using the principle of sufficiency to ensure adequate catheter positioning in abdominal cavity.

Statistical analysis was performed using IBM SPSS Statistical 29.0 software. Quantitative data were presented as median [Me (Q_{25}—Q_{75})] and compared between groups using the non-parametric Mann—Whitney U-test. Categorical data were presented as absolute and relative frequencies (%) and analyzed using the Fisher's exact test. Differences were significant at $p<0.05$.

The study was approved by the local ethics committee of the First Pavlov State Medical University (Protocol No. 2025—05 dated March 15, 2025). We performed our trial in accordance with the Declaration of Helsinki (2013). All patients signed an informed consent for this study, surgical interventions and processing of personal data for scientific and educational purposes. Confidentiality of personal information was maintained at all stages of the study.

Results and discussion

Demographic and clinical characteristics of patients are presented in **Table.**

Both groups were comparable regarding demographic and clinical parameters. The groups were homogeneous in age, gender, BMI, abdominal surgical anamnesis and types of hydrocephalus ($p>0.05$). This homogeneity allows us to exclude the influence of these factors on differences in intra- and postoperative outcomes. Thus, these outcomes may be more significantly associated with laparoscopic method.

Intraoperative parameters

Abdominal procedure time in the main group was 10.0 [9.0; 12.0] min, in the control group — 15.0 [14.0; 16.0] min ($p<0.001$), total surgery time — 40.0 [37.0; 44.0] and 48.0 [46.0; 50.0] min, respectively ($p<0.001$). Length of surgical incisions in case of laparoscopic approach was 15 [14; 16] mm, in case of minilaparotomy — 49 [47; 52] mm ($p<0.001$). Intraoperative blood loss was comparable and minimal in both groups (40 [35; 50] ml, $p=0.581$). Postoperative hospital-stay was 4 [3; 5] days.

Postoperative period

The incidence of abdominal pain syndrome in early postoperative period was comparable in both groups (15/18 — 83.3% vs. 16/20 — 80.0%; $p=1.000$). However, VAS scores were significantly lower in the study

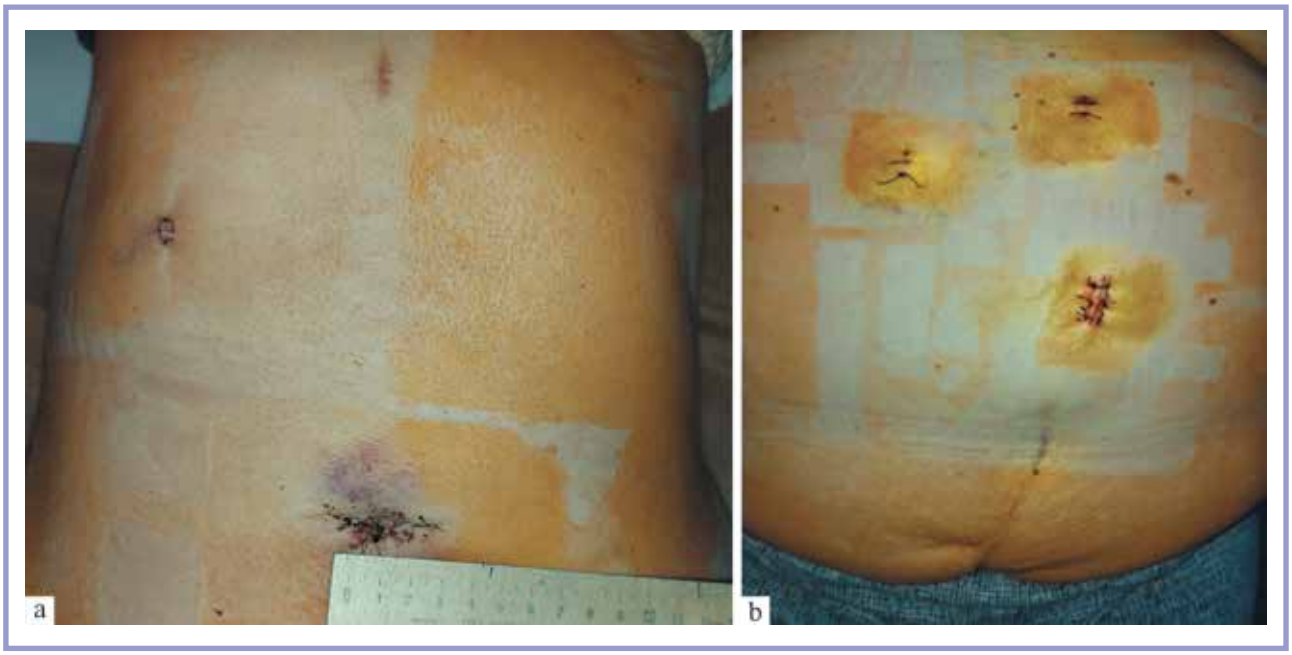


Fig. 5. **Postoperative images of patients with «compromised» abdomen.**
a — patient with «compromised» abdomen after laparoscopic cholecystectomy. Two ports were intraoperatively used; b — patient with «compromised» abdomen after open cholecystectomy. Three ports were intraoperatively used.

group (5.0 [4.0; 5.0] versus 5.0 [5.0; 6.0] points; p=0.048). Mean time to pain regression was also significantly shorter for laparoscopic approach (4.0 [3.0; 5.0] versus 7.0 [6.0; 8.0] days; p<0.001).

Peritoneal catheter position in subdiaphragmatic space was confirmed by CT in all cases after laparoscopic procedure **(Fig. 3)**. In case of minilaparotomy, position was variable.

Case # 1

The 1st patient presented with hypertensive hyporesorptive hydrocephalus and concomitant obesity (BMI 43 kg/m^2). Lumbar puncture revealed CSF pressure of 270 mm H_2O, and surgery was recommended. VPS was performed. Laparoscopic approach was preferable due to technical difficulties associated with thickness of anterior abdominal wall. Postoperatively, the patient reported local pain in the right hypochondrium. Postoperative wound length was 1.5 cm **(Fig. 4)**, and suture was adequate.

Case # 2

The 2nd patient presented with normal-pressure hydrocephalus (Hakim-Adams syndrome). There was previous open cholecystectomy via inferior midline approach. The patient underwent laparoscopy-assisted VPS. Laparoscopic abdominal exploration revealed massive adhesions with potentially complicated positioning of peritoneal catheter into abdominal cavity via standard minilaparotomy. Three ports were inserted. The distal end of the shunt was placed in the right subphrenic space under visual control, and its function was normal. Surgical wounds (1, 1 and 1.5 cm) were closed with skin sutures **(Fig. 5)**.

Discussion

Laparoscopy-assisted VPS significantly reduces surgery time and duration of abdominal stage compared to standard minilaparotomy. Significant differences (p<0.001 for surgery time and incision length, p=0.048 for pain syndrome) not only confirm the effectiveness of technique but also allow us to evaluate its clinical significance. For example, shorter incision (from 49 to 15 mm) is a more than threefold reduction in damage to anterior abdominal wall. The last one is a direct morphological substrate for reducing pain and earlier rehabilitation [17].

Our data on surgery time (median 40.0 [37.0; 44.0] min) and duration of abdominal stage (10.0 [9.0; 12.0] min) in the main group are consistent with other findings. Thus, Wu J.N. et al. [15] used laparoscopy-assisted method, and mean surgery time was 45.2 min. This result is not different from our data (40.0 [37.0; 44.0] min with overlap of confidence intervals) and confirms reproducibility of outcomes. Naftel R.P. et al. [18, 19] noted significantly shorter surgery time compared to open approach (p<0.001) that is completely consistent with our findings (p<0.001). Less severe postoperative pain in our study (VAS score 4.5 [4.0; 5.0] vs. 5.5 [5.0; 6.0]; p=0.048), although significant, requires cautious interpretation, since 0.6-point difference may be within the minimum clinically important difference (MCID) for VAS scale. However, this trend, consistent with findings by G. Mulvaney et al. (2022) [20], correlates with significantly less trauma to anterior abdominal wall as evidenced by incision length (p<0.001). Another important result is accurate positioning of peritoneal catheter in subdiaphragmatic space under visual control as evidenced by CT da-

ta in all cases. This minimizes the risk of complications such as catheter dysfunction due to its incorrect positioning or obstruction by omentum.

Although the advantages of laparoscopy in obese patients with adhesions are obvious and described in the literature (R.D. Turner et al., 2007 [4]; J.S. Catapano et al., 2020 [21]), our study allows us to highlight its clinically significant advantages in patients with «intact» abdomen. These include: 1) direct visual control of catheter position ensuring its optimal subdiaphragmatic placement, eliminating problems such as migration of catheter loops or its contact with organs, as well as potentially reducing the risk of occlusion; 2) minimal invasiveness: significantly shorter length of incisions in laparoscopy (15 mm) compared to minilaparotomy (49 mm) correlates with faster regression of pain; 3) aesthetic result may be important for young and socially active patients.

The main disadvantage of this technique is the need for abdominal surgeon and specialized endoscopic video-assisted surgical equipment. This can increase the cost of the procedure and complicate its availability in hospitals without appropriate personnel and technical resources. Furthermore, carboxyperitoneum may cause transient abdominal discomfort in early postoperative period.

An important aspect of our analysis is interpretation of insignificant differences. No significant difference in intraoperative blood loss (p=0.581) and incidence of abdominal pain (p=1.000) indicates that laparoscopic assistance, despite all its advantages, does not increase the risk of these specific complications compared to standard approach. This confirms its safety. Significant differences in pain scores (p=0.048) with similar incidence of pain syndrome may indicate that laparoscopic method primarily affects severity, rather than the likelihood of syndrome. This is also consistent with its mechanism of action (less tissue trauma) [22].

The main limitations of our study are prospective single-center nature and no randomization. These drawbacks could potentially influenced patient allocation to groups. However, consecutive case series and comparability of groups for key demographic and clinical parameters minimize bias and allow us to consider the results representative. Further multiple-center randomized controlled trials are warranted to obtain more significant data.

Conclusion

Our study demonstrates efficacy and safety of laparoscopy-assisted peritoneal catheter implantation for VPS in adults. This method became possible thanks to interdisciplinary collaboration of neurosurgeons and abdominal surgeons.

There are the following advantages of laparoscopic approach compared to standard minilaparotomy:

1) significantly shorter surgery time and duration of abdominal stage;
2) less surgical invasiveness as evidenced by shorter length of incisions;
3) less severe postoperative pain with earlier regression;
4) accurate placement of catheter in subdiaphragmatic space with low risk of its dysfunction;
5) effectiveness of technique not only in patients with complicated abdominal anamnesis (obesity, adhesions), but also in those with intact abdominal cavity.

Despite the need for additional specialist and equipment, laparoscopic assistance is a promising method improving the immediate outcomes of VPS. Further multiple-center randomized trials are advisable to confirm these findings.

Author contribution:
Concept and design of the study — Burmakina M.D., Gavrilov G.V., Abytov S.A., Trushin A.A., Stanishevsky A.V., Cherebillo V.Yu.
Collection and analysis of data — Burmakina M.D.
Statistical analysis — Burmakina M.D.
Writing the text — Burmakina M.D.
Editing — Burmakina M.D., Gavrilov G.V., Stanishevsky A.V., Cherebillo V.Yu.

No conflict of interests to declare.

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COMMENT

The authors present a prospective single-center study evaluating the efficacy and safety of laparoscopy-assisted peritoneal catheter implantation in 38 adults undergoing VPS. Laparoscopic approach (n=18) and standard minilaparotomy (n=20) are compared. Various techniques are described depending on abdominal history («intact» and «compromised» abdomens are compared).

Laparoscopy ensured accurate catheter positioning in subdiaphragmatic space in all patients as confirmed by CT data.

This study demonstrates the feasibility of laparoscopy-assisted peritoneal catheter implantation in adults undergoing VPS in a multi-field hospital with interdisciplinary collaboration between neurosurgeons and abdominal surgeons without any complications.

Scientific significance of this study is determined by filling a gap in Russian-language literature on this issue. In English-language literature, the advantages of laparoscopy-assisted peritoneal catheter implantation have been studied for over 30 years.

Practical significance of this study lies in demonstrating simplicity and safety of laparoscopy-assisted peritoneal catheter implantation in adults in a multi-field hospital, no specific complications and clinically significant advantages of this method in patients not only with complicated abdominal anamnesis (obesity, adhesions) but also with intact abdominal cavity.

Study design is appropriate for purpose. Outcomes (surgery time, incision length, pain and catheter position) are consistent with objectives of assessing the effectiveness and safety of the method. Statistical methods (Mann—Whitney U-test, Fisher's exact test) are appropriate for these data.

The authors' results are consistent with data of other prospective studies (J.N. Wu et al., 2023; R.P. Naftel et al., 2011; G. Mulvaney et al., 2022) that confirms their significance and reproducibility.

Findings and conclusions are substantiated by appropriate data. The authors correctly interpret insignificant differences and note that laparoscopic assistance does not increase the risk of complications (blood loss, pain) compared to standard approach.

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