Burdenko's Journal of Neurosurgery
2024, №6, pp. 88–96
https://doi.org/10.17116/neiro20248806188

# Intracardiac migration of a ventriculoperitoneal shunt. A systematic literature review and case report

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**ABSTRACT**

CSF shunting procedures are common in neurosurgery. A rare complication of these procedures is migration of distal catheter. We present a case of peritoneal catheter migration into the right heart chambers. A systematic review of appropriate literature data was carried out.

**Material and methods.** We present a patient with communicating hydrocephalus after previous penetrating traumatic brain injury. Migration of peritoneal catheter into the right heart chambers occurred in 5 days after ventriculoperitoneal shunting. We performed a systematic review of literature data and analyzed all similar cases of intracardiac migration of ventriculoperitoneal catheter, risk factors of migration, possible complications and surgical treatments.

**Results.** There were 38 articles describing 40 cases of distal catheter migration into the right heart chambers meeting the inclusion criteria. In 65% of patients, catheter migration was diagnosed after ≥2 months. Migration was asymptomatic in 21% of cases. Additionally, less than 50% of patients had no complications. Surgical treatment required complex techniques such as endovascular removal or thoracotomy in nearly 50% of cases.

**Conclusion.** Migration of ventriculoperitoneal catheter into the right heart chambers is a rare and dangerous complication of CSF shunting procedures. Risk factors of this complication should be considered when scheduling surgical treatment and follow-up examinations.

***Keywords:*** *ventriculoperitoneal shunting, catheter migration, shunting system, communicating hydrocephalus.*

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**TO CITE THIS ARTICLE:**
Stanishevskiy AV, Legzdain MA, Saburov NR, Svistov DV, Gavrilov GV. Intracardiac migration of a ventriculoperitoneal shunt. A systematic literature review and case report. *Burdenko's Journal of Neurosergery*. 2024;88(6):88–96. (In Russ.). https://doi.org/10.17116/neiro20248806188

## Introduction

Ventriculoperitoneal shunting (VPS) is used for various types of hydrocephalus. It is one of the most common neurosurgical interventions. A rare postoperative complication is distal catheter migration. The following migrations were described: into the intestine and bladder, through anterior abdominal wall, into the pleural cavity and mediastinum, scrotum, vagina, liver and gallbladder, as well as breast implant [1]. A rare type is migration into the right heart and pulmonary arteries. We present distal catheter migration into the heart and analyze available literature data devoted to this complication.

## Material and methods

We reviewed the eLibrary.Ru, PubMed, Scopus, Web of Science and Google Scholar databases using the keywords: «гидроцефалия», «шунтирование», «миграция», «катетер», «сердце», «вена», «осложнение», "hydrocephalus», "catheter», "migration», "cardiac», "venous», "pulmonary». We enrolled reports describing distal catheter migration into the heart and pulmonary vessels in patients who underwent VPS. Study flowchart is presented in **Fig. 1**.

We analyzed gender and age of patients, indications for VPS, period between VPS and catheter migration, clinical manifestations, mechanisms, risk factors and complications of migration, surgical treatment and outcomes. Predictors of intracardiac catheter migration were assessed considering available articles or X-ray/CT scans.

## Results

A 32-year-old man underwent VPS with Delta Valve constant mean pressure valve (Medtronic, Ireland) for post-traumatic communicating triventricular hydro-

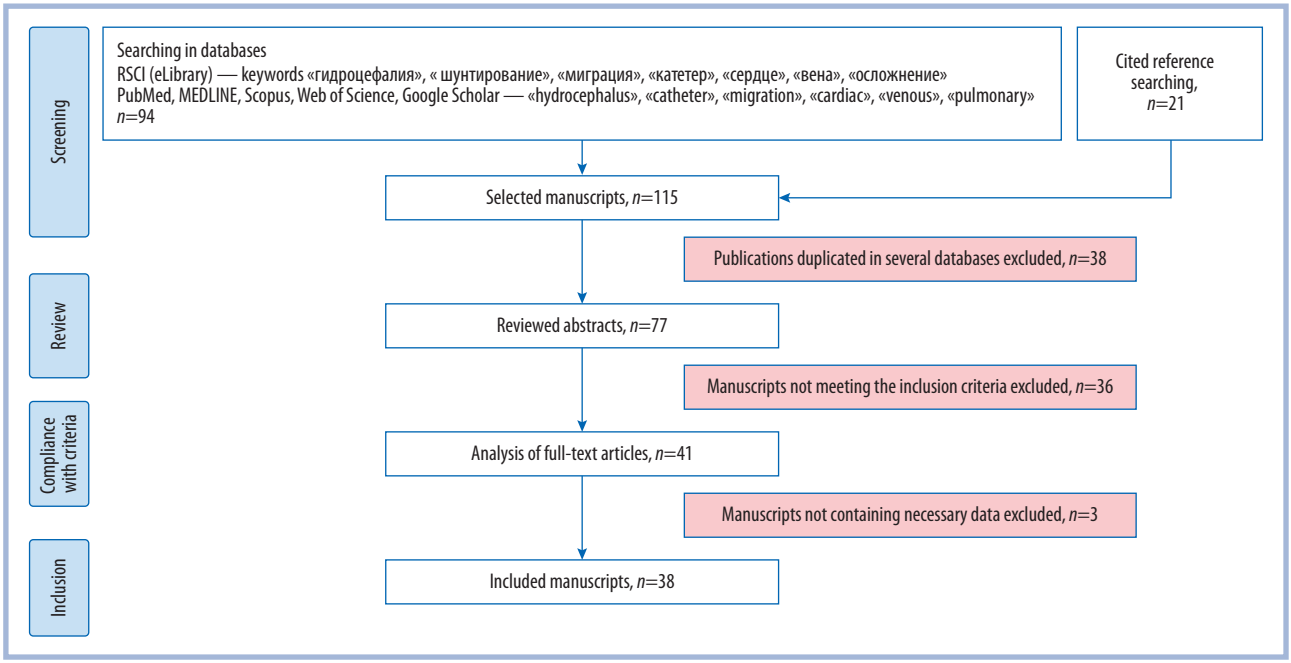



***Fig. 1.*** **Study flowchart.**

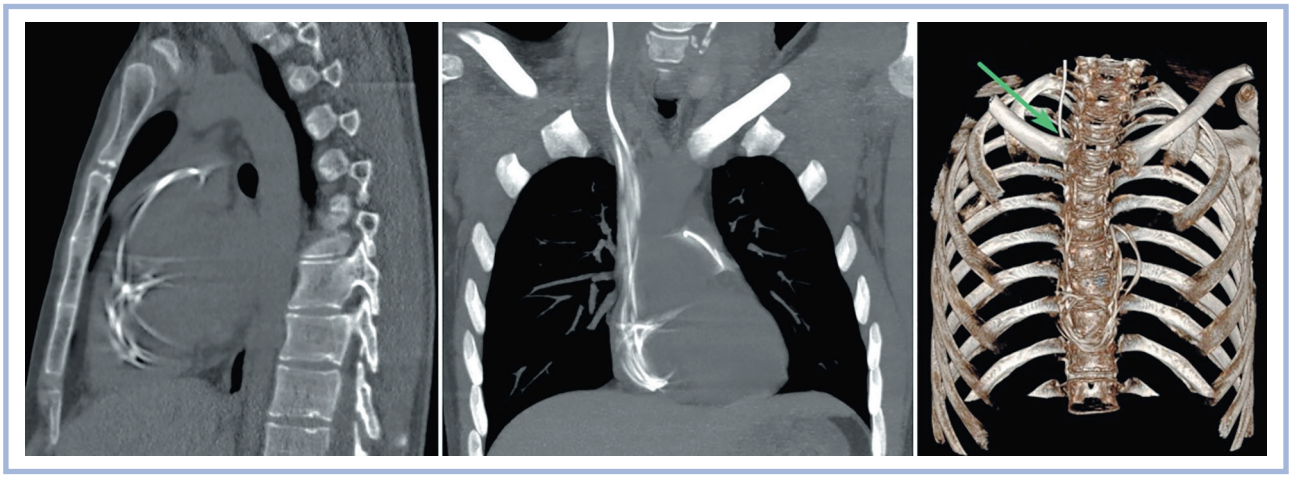


***Fig. 2.*** **Chest CT in 5 days after VPS. Distal catheter migration through internal jugular vein into the right heart and pulmonary artery; passage of distal catheter under the right clavicle in internal jugular vein (green arrow).**

cephalus. Ventricular catheter was implanted into the right lateral ventricle through the occipital horn (Frazier technique). Surgery was uneventful. VPS system dysfunction occurred 6 months later: decreased activity, brain prolapse into post-craniotomy defect, "sticking» of shunt pump. Redo surgery was necessary.

We removed previous VPS system and found obstruction of the valve and catheters with protein deposits. A new ventricular catheter was inserted along the same trajectory. We implanted a Codman Hakim medium-pressure valve, and ventricular catheter was inserted using a metal guidewire and standard technique to right-sided pararectal incision on anterior abdominal wall. There was no bleeding during ventricular catheter insertion. We inserted ventricular catheter into abdominal cavity through mini-laparotomy without its fixation to soft tissues of anterior abdominal wall.

Postoperative period was uneventful. Clinical manifestations of hydrocephalus regressed, and CT of the head verified satisfactory position of ventricular catheter. After 5 days, the patient complained of pain within the wound in the right mesogastric region. Abdominal X-ray found no ventricular catheter in abdominal cavity, while CT revealed its migration into the right cardiac chambers **(Fig. 2)**.

Despite no signs of shunt dysfunction, we preferred emergency surgery for shunt repositioning. A multidisciplinary team included neurosurgeon, vascular surgeon,

cardiac surgeon and specialist in endovascular surgery. Echocardiography verified catheter in the right ventricle without thrombosis. Ultrasound of cervical vessels revealed internal jugular vein perforation site. We incised the neck along the distal catheter and dissected internal jugular vein within perforation site. The catheter was carefully pulled out without resistance. Mild bleeding from the vein was stopped by compression. The distal catheter was tunneled and immersed in abdominal cavity through the wound in the right mesogastric region.

CSF overdrainage in postoperative period required valve adjustment. Hydrocephalus regressed, and no cardiovascular complications were noted. The follow-up period was 1.5 months.

**Systematic review**

The review included 38 case reports describing 40 patients with intracardiac distal catheter migration (2 articles presented 2 patients each). Characteristics of these patients are presented in **Table.**

Distal catheter migration usually occurs in adults (age ⩾16 years). Despite literature data on intracardiac distal catheter migration in children, only one case was described in a patient younger 5 years old. The male-to-female ratio was 2:1. The causes of hydrocephalus were different. There was no reason to believe that underlying disease in any way affected the type of VPS system and features of implantation. In more than 50% of cases, distal catheter migration occurred in long-term period after VPS. Only 35%

***Table*. Characteristics of patients**

| | |
|---|---|
| Age (*n*=40): | |
| range | 8 months — 81 years |
| Me ($Q_1$; $Q_3$) | 38 years (15; 58) |
| adults (⩾16 years) | 30 (75%) |
| Gender (*n*=38): | |
| M (%) | 27 (71) |
| F (%) | 11 (29) |
| Indications for VPS (*n*=37): | |
| congenital hydrocephalus (%) | 3 (8) |
| idiopathic normotensive hydrocephalus (%) | 5 (13.5) |
| secondary communicating hydrocephalus | |
| — after aneurysmal subarachnoid hemorrhage (%) | 7 (19) |
| — after TBI (%) | 4 (11) |
| — after meningitis (%) | 1 (3) |
| — CNS tumor (%) | 4 (11) |
| — unclear cause (%) | 1 (3) |
| occlusive hydrocephalus (%) | 4 (11) |
| pseudotumor cerebri | 3 (8) |
| Chiari malformation type II (%) | 1 (3) |
| meningomyelocele (%) | 2 (5) |
| VPS for cyst (%) | 2 (5) |
| Period between VPS and distal catheter migration (months) (*n*=37): | |
| range | 3 days — 8 years |
| Me ($Q_1$; $Q_3$) | 2.5 (1; 12) |
| ⩾ 2 months, *n* (%) | 24 (65) |
| Clinical symptoms (*n*=39): | |
| asymptomatic (%) | 8 (20.5) |
| shunt dysfunction | |
| — CSF hypodrainage (%) | 16 (41) |
| — CSF overdrainage (%) | 1 (2.5) |
| fever/endocarditis /sepsis (%) | 4 (10) |
| heart failure (%) | 5 (13) |
| local pain syndrome (neck/chest/abdomen) (%) | 7 (18) |
| Mechanism of distal catheter migration (*n*=31): | |
| external jugular vein perforation (%) | 7 (23) |
| internal jugular vein perforation (%) | 16 (50) |
| external jugular vein erosion (%) | 5 (17) |
| internal jugular vein erosion (%) | 2 (7) |
| other (%) | 1 (3) |
| Predictors of distal catheter migration (*n*=20): | |
| medial catheter placement on the neck (%) | 12 (60) |
| deep catheter placement on the neck (%) | 2 (10) |
| previous revision of VPS system (%) | 10 (50) |
| bleeding during catheter insertion (%) | 3 (15) |
| postoperative neck hematoma (%) | 1 (5) |
| COPD (%) | 1 (5) |
| Complications of distal catheter migration (*n*=40): | |
| no adverse events (%) | 17 (42.5) |
| knots (%) | 12 (30) |
| fixation in heart/pulmonary trunk/pulmonary arteries (%) | 7 (17.5) |
| clots on catheter (%) | 3 (7.5) |
| cardiac thrombosis, non-occlusive pulmonary artery thrombosis (%) | 4 (10) |
| rhythm disturbances (including those following removal) (%) | 4 (10) |
| heart valve insufficiency (%) | 2 (5) |
| catheter detachment (%) | 1 (2.5) |
| Removal technique (*n*=39): | |
| pulling out | 7 (18) |
| — through incision behind the ear (%) | 11 (28) |
| — through incision on the neck (%) | 4 (10) |
| endovascular extraction (%) | 2 (5) |
| pulling out → venotomy (%) | 8 (20.5) |
| pulling out → endovascular extraction (%) | 4 (10) |
| thoracotomy/sternotomy, open extraction (%) | 3 (8) |

*Note.* TBI — traumatic brain injury; CNS — central nervous system; COPD — chronic obstructive pulmonary disease.

of patients experienced this complication in early postoperative period. Distal catheter migration was symptomatic in most cases (79.5%), and the most common symptom was VPS system dysfunction. In 10% of patients, intracardiac distal catheter migration led to infectious complications, including bacterial endocarditis (1 case) and sepsis (1 case). Pathogenesis of this migration was discussed in 31 cases. The most common mechanism was internal or external jugular vein perforation following distal catheter tunneling during VPS. The main predictors of intracardiac distal catheter migration are previous distal catheter revision and medial placement of catheter in the neck. Combination of risk factors was described in some cases. In less than half of cases, intracardiac distal catheter migration was characterized by uncomplicated course. This event is often complicated by knots, distal catheter fixation in the heart and pulmonary arteries (mainly accompanied by rhythm disturbances following catheter pulling out) and clots on catheter, in cardiac chambers and pulmonary arteries. There are no reports of pulmonary embolism (PE) following intracardiac distal catheter migration. However, there was 1 case of left atrial thrombosis (catheter migration through the patent foramen ovale from the right heart). This patient required thoracotomy and open thrombectomy to prevent distal embolism. In all reports, the authors note that catheter extraction after migration to the heart and pulmonary vessels should be undertaken with involvement of vascular surgeons, cardiac surgeons and specialists in endovascular surgery. Only in 46% of cases, distal catheter extraction allowed its reinstallation into abdominal cavity or system conversion to ventriculoatrial shunt. Almost the same number of patients required venotomy, endovascular removal or open extraction via thoracotomy due to knots on catheter or its fixation in the heart and pulmonary arteries. In less than 20% of cases, endovascular or open retrieval of distal catheter was performed without preliminary attempt to pull it out of jugular vein perforation area. Data on the outcomes after treatment of distal catheter migration are available for 33 (85%) cases. Persistent valvular insufficiency (tricuspid and pulmonary valve) was described in 2 cases. Another patient had the same clinical status after surgical treatment. Regression of clinical manifestations was described in other cases.

## Discussion

VPS has been widely used for various forms of hydrocephalus since the mid-1950s. Nevertheless, Morell et al. [2] first described intracardiac distal catheter migration only in 1994. Harischandra L.S. et al. [2] reported that intracardiac distal catheter migration accounted for about 7% of all cases of similar migrations. The rarity of this phenomenon, unpredictable consequences and no specific treatment algorithm led to publication of several case reports [1, 3, 4—20]. Almost immediately, their authors attempted to systematize available material and identify patterns underlying this complication.

### Pathogenesis of intracardiac distal catheter migration

Internal or external jugular vein perforation is the main factor in pathogenesis of distal catheter migration into the right heart and pulmonary arteries. There is early (up to 2 months) and late catheter migration [21]. Perhaps, early migration is associated with internal or external jugular vein perforation on the neck during distal catheter tunneling. Delayed migration is associated with erosion of thin venous wall following active movements in the neck [7, 11, 16, 19]. In this case, catheter pressure-related erosion is more typical for internal jugular vein in supraclavicular region, since this vein is tightly fixed in soft tissues here [1, 8, 15]. After venous wall penetration, negative pressure in jugular vein contributes to gradual pulling out of distal catheter from abdominal cavity. This process was observed on X-ray images in several patients [20]. In our case, there was intraoperative internal jugular vein perforation after distal catheter tunneling.

### Risk factors of intracardiac distal catheter migration

Considering the above-mentioned mechanisms of intracardiac distal catheter migration, we established the following risk factors of this complication **(Fig. 3)**.

The relationship between intracardiac distal catheter migration and age is still controversial. Wei Q. et al. [20] described complications in children younger 6 years old usually not related to discrepancy between dimensions of instruments for distal catheter tunneling and diameter of jugular veins. Ghaffari S. et al. [7] described intracardiac distal catheter migration through perforation of diaphragm and pericardium in an 8-month-old child.

The main independent predictor of intracardiac distal catheter migration is shunt revision with catheter reinstallation [22]. This risk factor was described in 50% of cases, including our patient. Constitutional risk factors of intracardiac distal catheter migration include conditions characterized by increased gradient between intrathoracic and intra-abdominal pressure, such as obesity or chronic obstructive pulmonary disease.

Intraoperative risk factors of distal catheter migration include medial and deep placement of catheter. In most situations, subcutaneous catheter placement along the midclavicular line is optimal. Importantly, although venous bleeding following distal catheter placement is a risk factor of catheter migration, its absence does not at all indicate the absence of vein damage [12]. A rare but significant risk factor is postoperative soft tissue hematoma on the neck [8].

### Complications of intracardiac distal catheter migration

The most common complication of intracardiac distal catheter migration is formation of loops and knots in cardiac chambers and pulmonary arteries. This sometimes leads to catheter fixation and thrombosis [17]. These com-

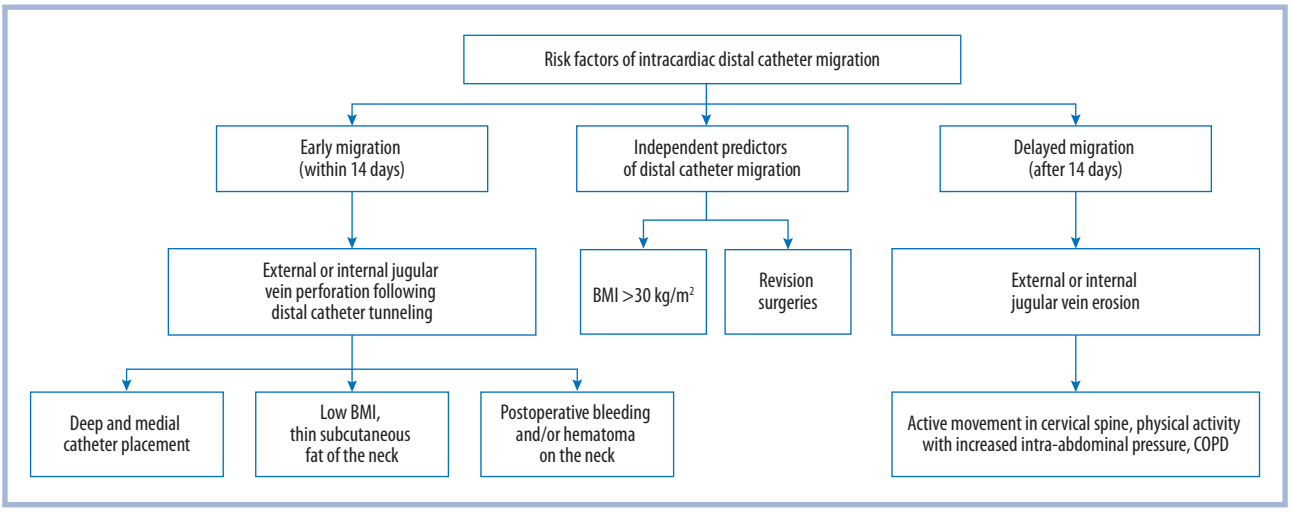



***Fig. 3.*** **Risk factors of intracardiac distal catheter migration. BMI — body mass index; CS — cervical spine; COPD — chronic obstructive pulmonary disease.**

plications cannot always be identified in preoperative period. Thus, Patel M.S. et al. [16] described asymptomatic migration of peritoneal catheter into pulmonary artery. The authors found non-occlusive thrombosis of the artery and clots on catheter knot when removing the catheter through open access. Importantly, neither echocardiography nor CT angiography identified complications in our case. These circumstances should be taken into account when planning surgical treatment of distal catheter migration. At the same time, CT with multiplanar reconstruction allows us to identify knots in some cases [3]. In our case, CT did not reveal any signs of knots that influenced the choice of intervention. In addition to difficult catheter extraction, knots and loops can lead to rhythm disturbances and heart valve insufficiency [14]. Intraoperative complications include knots following catheter extraction, rhythm disturbances, catheter detachment, pulmonary embolism, heart valve damage and jugular vein rupture.

### Surgical interventions for intracardiac distal catheter migration

Removal of migrated distal catheter is an emergency intervention considering the risk of severe complications [12]. Interventions for intracardiac distal catheter migration vary from simple pulling out with reinstallation into abdominal cavity or shortening and conversion to ventriculoatrial shunt to sternotomy and open catheter extraction from cardiac chambers. Naturally, surgical intervention in each case should be determined according to characteristics of a particular patient. Considering literature data, we developed an algorithm for decision making in patients with intracardiac distal catheter migration **(Fig. 4)**.

Pulling out a migrated distal catheter avoids more aggressive and complex manipulations in almost half of cases. This method may be advisable if CT and echocardiography found no knots and clots on the catheter. Regardless of nature and period after catheter migration, pulling out should be performed under control of fluoroscopy, ECG and transesophageal echocardiography to detect possible knots, catheter fixation in cardiac chambers or pulmonary arteries and rhythm disturbances [11]. Preliminary insertion of guidewire into the lumen of catheter may be useful. Indeed, this will increase contrast enhancement of catheter during fluoroscopy and reduce the likelihood of knotting during pulling out [14].

There are two incisions to pull out the migrated catheter (behind the ear and on the neck in projection of jugular veins). The first one allows for simultaneous assessment of distal catheter junction with shunt valve. System disconnection can occur in this site after intracardiac distal catheter migration. Neck incision is convenient due to accessible internal jugular vein for venotomy and catheter extraction in case of knotting. In our opinion, the second option is preferable because system disconnection may be diagnosed after radiography or CT.

Endovascular interventions for distal catheter delivery into the common femoral vein and its removal through the guide catheter or venotomy can be used as a basic method or addition to catheter pulling in case of knotting or, especially, catheter detachment.

To prevent pulmonary embolism following catheter removal in any fashion, it is advisable to install anti-embolic protection system in pulmonary arteries [18] and consider perioperative administration of low molecular weight heparin.

Open cardiac surgery is traumatic and difficult. Therefore, these methods are advisable if other minimally invasive approaches are ineffective. Another indication is catheter fixation in pulmonary arteries due to intimal hyperplasia or thrombosis of cardiac chambers with high risk of massive pulmonary embolism.

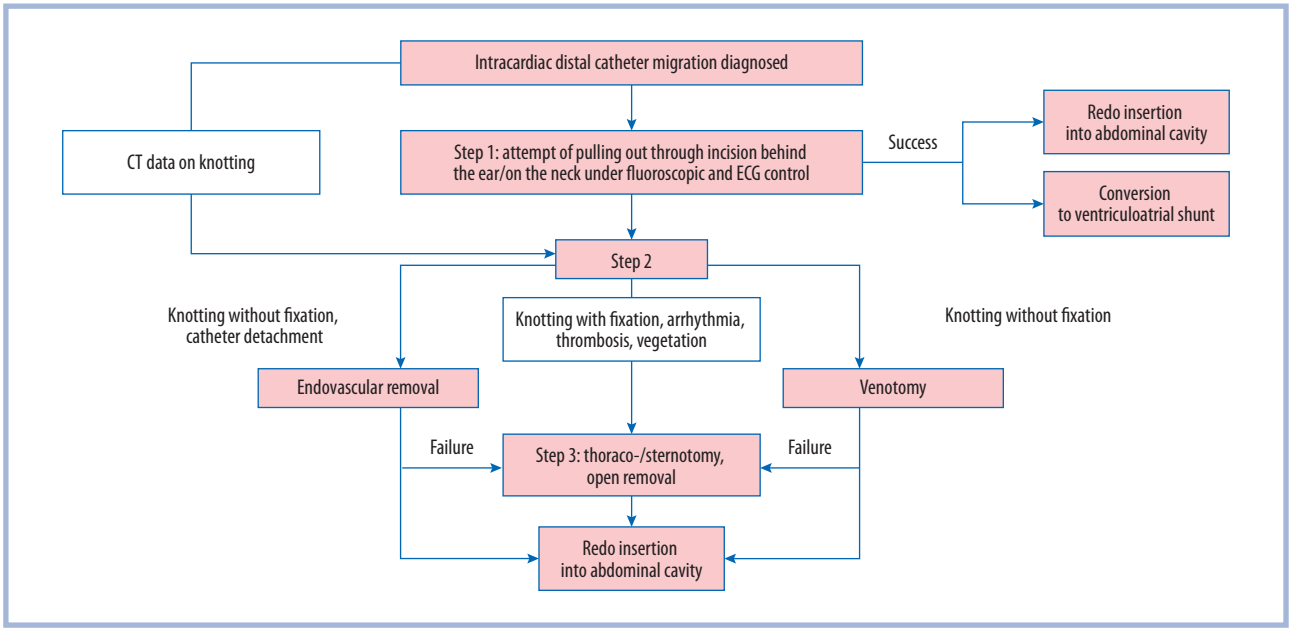



***Fig. 4.*** **Algorithm for decision making in patients with intracardiac distal catheter migration.**

Some authors fix distal catheter to soft tissues of anterior abdominal wall to prevent migration. Imamura H. et al. [9] demonstrated ineffectiveness of this approach.

***Recommendations for prevention of intracardiac distal catheter migration***

1. Preoperative assessment of risk factors of intracardiac distal catheter migration:
   — patient's age;
   — previous surgical revisions;
   — obesity or lung diseases.
2. Intraoperative prevention of intracardiac distal catheter migration:
   — no medial and deep catheter insertion;
   — bleeding following catheter insertion is a risk factor of migration.
3. Postoperative follow-up:
   — patients with risk factors of intracardiac distal catheter migration need for ultrasound of the neck/CT of the head after VPS with neck coverage for timely diagnosis of jugular vein perforation/periodic chest X-ray in early postoperative period;
   — soft tissue hematoma on the neck is a risk factor of migration.

## Conclusion

One should consider the risk factors of intracardiac distal catheter migration when prescribing examinations after VPS and possible complications of migration when planning its surgical treatment.

**Author contribution:**
Concept and design of the study — Stanishevsky A.V.
Collection and analysis of data — Saburov N.R., Legzdain M.A.
Writing the text — Stanishevsky A.V.
Editing — Legzdain M.A., Svistov D.V., Gavrilov G.V.

**The authors declare no conflicts of interest.**

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Received 18.06.2024
Accepted 20.09.2024

## COMMENT

The manuscript is devoted to an extremely rare complication after VPS, i.e. intracardiac distal catheter migration. In addition to description of own clinical observation, Stanishevsky A.V. et al. reviewed available literature data on this complication. The authors estimate potential threats of such a situation (fixation, knotting, thrombosis, rhythm disturbances, heart failure, endocarditis, etc.) and their management including various surgical specialists.

In our department, more than 1 thousand shunt systems have been implanted/reimplanted over the past 24 years. We are aware of only one similar complication, i.e. migration of peritoneal catheter into pleural cavity with subsequent hydrothorax and signs of respiratory failure. These symptoms required surgery. I would like to draw the readers' attention to a similar technical surgical error described in this report. Peritoneal catheter was unintentionally inserted UNDER the clavicle, and not ABOVE it. This is an obvious surgical error. Such a situation obviously increases the risk of damage to organs and tissues near superior thoracic aperture (large vessels, pleura). Therefore, it is worth emphasizing and reminding once again that many complications of VPS can be prevented in case of appropriate attention to technical details of implantation. Moreover, various problems following simple bypass procedure with technical errors in implantation may be life threatening.

I would like to thank the authors for well-illustrated description of a rare case, literature review and description of potential problems in correction of complication. Fortunately for their patient, the most obvious and simple approach was effective and did not require conversion to thoracotomy.

*Kushel Yu.V. (Moscow)*