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Ventriculoperitoneal shunt malfunction: analysis of abdominal causes

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SUMMARY: **Ventriculoperitoneal shunt malfunction: analysis of abdominal causes.**

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Background. *Ventriculoperitoneal (VP) shunt is the most common neurosurgical procedure to treat obstructive and communicating hydrocephalus in children and adults but failure are frequent. The knowledge of risk factors related to abdominal shunt failure is useful to avoid complications.*

Patients and methods. *We analyze retrospectively 86 adults patients affected by obstructive and communicating hydrocephalus operated for VP shunt at our Institution. Statistical analysis was performed in order to correlate shunt malfunctioning with type of abdominal approach (trocar vs mini-laparotomy), perioperative infective status, sex, bowel distention and length of surgical time.*

Results. *Factors statistically significant for surgical shunt revision were the use of trocar (univariate analisys p=0,029 and multivariate p= 0,035) and high infective risk (univariate analisys p=0,028 and multivariate p= 0,038). No statistical significant association was observed between shunt revision and sex, bowel distension and operative length time.*

Conclusions. *To avoid postoperative shunt malfunctions especially in peritoneum the mini-laparotomy is the approach of choice. Surgery must be performed when infective status is healed.*

KEY WORDS: Ventriculoperitoneal shunt - Hydrocephalus - CSF - Shunt malfunction - Laparotomy - Malabsorption.

Introduction

First described in 1908, ventriculoperitoneal (VP) shunt is the most common neurosurgical procedure to treat obstructive and communicating hydrocephalus in children and adults. Thanks to technological improvement, nowadays mortality and morbidity rate are low though shunt malfunction remains a troublesome complication (1). Shunt malfunction may be due to obstruction, infection, catheter dislocation (both ventricular or peritoneal), over-drainage or under-drainage of cerebrospinal fluid; other complications are disconnection of the device, skin erosion and infection of the device, silicone allergy, inguinal or muscle hernia, peritoneal cyst an seizures (2-5). In patients with defects of the abdominal wall some authors proposed the reconstruction with decellularized derma or other materials (6). Literature reports that the 45-59% percentage of all patients with a VP shunt requires a shunt revision during life (7, 8). Shunt failure in adults after one year follow-up accounts about 29% of all patients; in pediatric population shunt failure is reported about 14% of all patients after one month from surgery (9) and from 40% to 50% after one year follow-up (10, 11). Demographic risk factors for shunt failure are sex, low socioeconomic status and age less than 19 years; finally the obstructive hydrocephalus is associated with higher risk of shunt complications than the communicating type (12).

About 25% of shunt malfunctions are due to abdominal causes (13) divided into mechanical (shunt discontinuity, leak, obstruction and catheter dislocation) and biological ones (infections, abscesses, pseudocyst and muscle hematoma). In many cases, no evident causes of abdominal malfunction can be identified, so a peritoneal malabsorption may be supposed.

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In this study we retrospectively analyze patients with primary and secondary adult hydrocephalus operated with VP shunt, in order to identify some risk factors for abdominal shunt malfunction.

Patients and methods

In the Clinic of Neurosurgery of Ancona (Italy) 89 patients with adult hydrocephalus were operated of VP shunt from 2015 to 2017.

Three patients underwent shunt revision due to encephalic causes and were not included in this study so the sample studied was 86 patients (mean age = 67.42 years). Ventricular catheter was inserted through a right frontal burr hole, choosing left approach for patients with specific impeding causes (pre-existing infection, craniectomy, ecc.). Peritoneal catheter was positioned by mini-laparotomy approach (Figure 1) in 31 patients out of 86 (36%) and by trocar puncture (Figure 2) in 55 patients out of 86 (64%). All patients performed post-operative brain CT scan and abdomen X-ray. Prophylactic antibiotic was done with Cefazoline 2 g e.v. 30-60 minute before surgery and Vancomycin 1 g e.v. for documented penicillin allergy. A Codman Hakim programmable valve was implanted in all patients with a peritoneal catheter 30 cm long. We surgically revised shunts in the following cases: neurological worsening after initial improvement without other medical causes, evidence of cerebrospinal fluid infection (positive colture or cells count > 10/mcl, total protein > 50 mg/dl, glucose level < 40 mg/dl) and radiological X-ray abdomen reports (hematoma, pseudocyst, catheter dislocation, abscesses). In order to identify risk factors for abdominal shunt malfunction we classified patients in following groups: "high and low" infective risk, with or without abdominal bowel distention, long or short operative time (cut-off value of 75 minute). Patients were considered at high infective risk if during the peri-operative period (10 days before and after surgical procedure) they

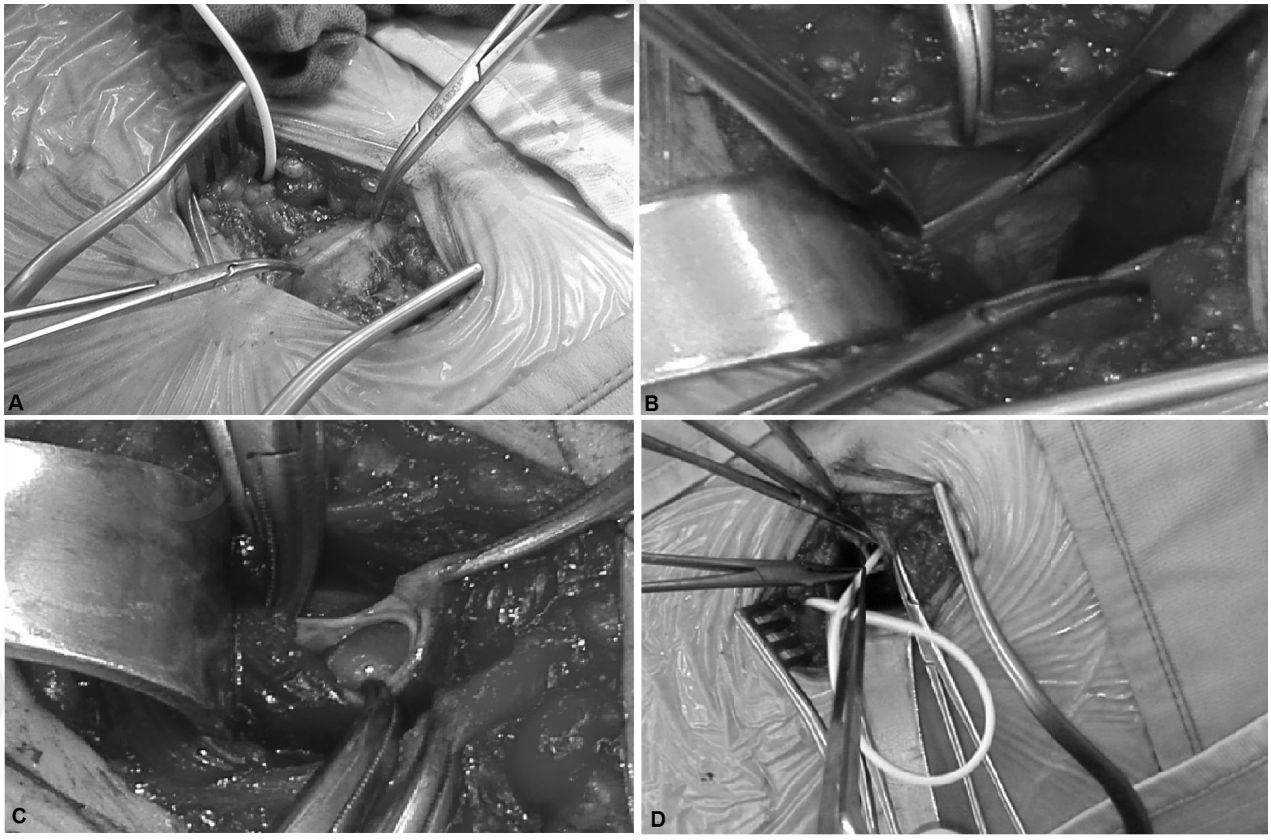

Figure 1 - Mini-laparotomy procedure. A) Isolation of superficial fascia (Scarpa's fascia); B) Isolation of parietal peritoneum; C) Peritoneum opening with evidence of intestinal ansa; D) Catether insertion.

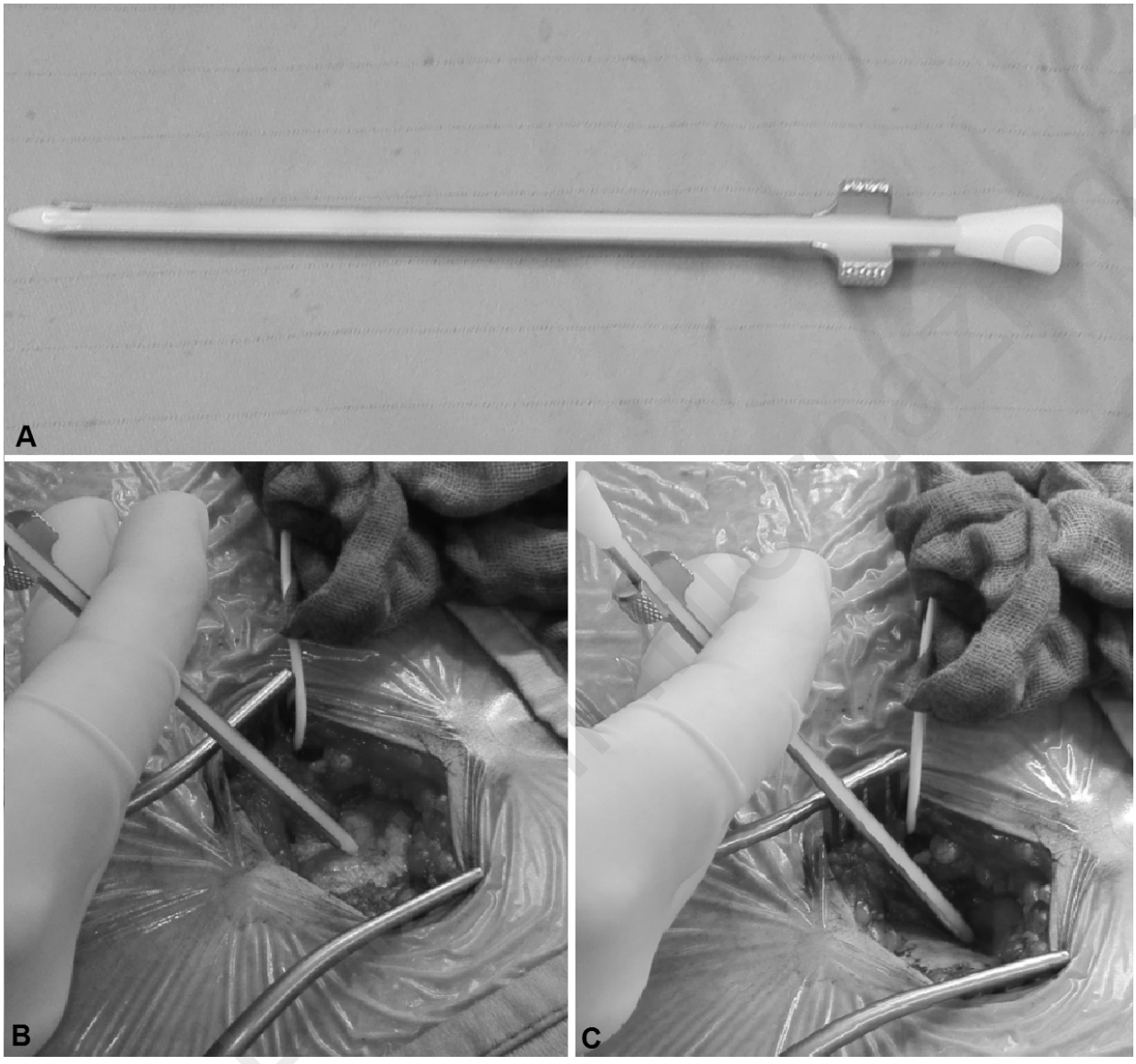

Figure 2 - Trocar procedure (A, B, C).

had all together: positive culture isolation (blood, CSF, sputum or urine), leucocytosis (> 10000/mmc) and fever (at least 38°C). Mild leucocytosis (< 13000/mmc) in the first and second day after surgery, was considered procedure related. Anyway we operate only patients without fever for the last 48 hours before surgery. Bowel distention was defined according to radiologic reports of post-operative X-ray (presence of distention or fluid-air levels). Statistical analysis was carried out using multiple regression and Chi-square; a p value < 0,05 was considered statistically significant. The software used for data analyses was SPSS (Version 20).

Results

In this study 86 patients underwent VP shunt positioning and 23 out of 86 (27%) underwent to surgical shunt revision for abdominal causes. The causes of abdominal malfunction were: peritoneal malabsorption 8 patients (35%), 6 patients (26%) infection/abscess, 5 patients (21%) catheter dislocation and 4 patients (17%) muscle hematoma (Table 1). Statistically significant factors for surgical shunt revision were the use of trocar (univariate analisys p=0,029 and multivariate p= 0,035) and high infective risk (univariate analisys p=0,028 and multivari-

TABLE 1 - SUMMARIZING TABLE.

Patients, n	86
Male / Female	45 / 41
Mean age (range), yrs	67.4 (19-86)
Abdominal shunt revision n	23
peritoneal malbsorption	8 (35%)
infection / abscess	6 (26%)
catheter dislocation	5 (21%)
hematoma	4 (17%)
Mean time between implantation and revision (range)	60 days (range 1-16 weeks)
Causes of hydrocephalus, %	
normal pressure (NPH)	46%
subarachnoid hemorrhage (SAH)	15%
traumatic brain injury (TBI)	20%
intracerebral hemorrhage	15%
infectious	1%
neoplasm	1%
other	2%

ate p= 0,038) (Table 2). No statistical significant association was observed between shunt revision and bowel distention, sex and operative length time.

Discussion

Shunt malfunctions are the most common complications in patients treated for hydrocephalus with a prevalence of 30-50% after 3 years follow-up.

Abdominal causes of VP shunt malfunction account about 25% of shunt failure (14). Shunt obstruction may occur at both ventricular or peritoneal catheter. Ventricular catheter obstruction may be due to intraventricular hemorrhage, choroid plexus ingrowth or brain debris (15). The incidence of peritoneal catheter obstruction ranges from 12% to 34% (16, 17). In most patients a mechanical cause of shunt failure can be identified, such as abdominal hematoma, abscess or catheter dislocation; these causes represent the 65% of the whole abdominal shunt failure in our series. In line with data reported by Cozzenss J.W. et al. (18), abdominal causes of shunt malfunction are unknown for 35% of patients in our series. In this group of patients a peritoneal malabsorption may be supposed; in line with these during surgical revision of the peritoneal catheter a correct drainage was documented.

When a peritoneal malabsorption occurs in pediatric population, a peritoneal ascites develops (19) but this is rare in adults and no cerebrospinal fluid ascites were documented in our patients. The etiology of malabsorption are peritoneal, omental inflammation (also subclinical process) or mesenteric

TABLE 2 - STATISTICAL DATA (N, %).

	Shunt revision (23/86)	Non shunt revision (63/86)	P Value (Chi-square)	P Value (Multiple regression)
Trocar (55/86)	19 (82,6%)	36 (57,1%)	0,029 (< 0,05)	0,035 (< 0,05)
High infective risk (29/86)	12 (52,1%)	17 (26,9%)	0,028 (< 0,05)	0,038 (< 0,05)
Abdomen distension (29/86)	8 (34,7%)	21 (33,3%)	0,899	0,896
Long operative time (35/86)	9 (39,1%)	26 (41,2%)	0,858	0,863
Male sex (45/86)	12 (52,1%)	33 (52,3%)	0,986	0,827

adenitis. A frequent cause of abdominal malfunction is the obstruction of the peritoneal catheter by fibrous tissue around the catheter tip, as described first time in 1954 (20) and later in 1983 (21). In these cases the use of laparoscope is effective in removing fibrous capsule from catheter tip without the need of catheter extraction (22, 23). In our cases, no laparoscopic procedures have been done because we performed in all patients a surgical peritoneal catheter revision.

Abdominal peritoneal catheter may be positioned with open mini-laparotomy, blind trocar puncture or laparoscopy, according to surgical preference and/or specific patient characteristics such as obesity or previous abdominal surgery (24, 25). Major complications such as vascular injury, bowel perforation, muscle hernia, wound infection and extraperitoneal gas due to trocar access are described in gynecologic and abdominal surgery (26). During abdominal catheter positioning for VP shunt, fatal aortic rupture is also described (27). Many studies documented that obstruction of the peritoneal catheter occurs more frequently with trocar technique than open mini-laparotomy (28). In this study we found a statistical significant association between trocar procedure and high risk of abdominal shunt failure. It could be supposed that by blind trocar puncture the catheter tip may contact peritoneal setta, omento or ansa, causing occlusion or sub-occlusion; moreover during the procedure unrecognized minimal bleeding may cause adherence between catheter and peritoneal tissues.

Ventriculoperitoneal shunt infections are the most frequent complications of shunt procedure with high rate of morbidity and mortality (7, 29, 30). Shunt infections account for 3% to 20% of all operated patients. Risk factors are young patients, open neural tube defect and time length of procedure. As concern the surgical time length, considering 75 minutes as cut-off between "long" and "short" procedure, we cannot confirm these data. Infections may present with abscesses, peritonitis or even wound dehiscence at the abdomen or along the subcutaneous catheter, as described for other subcutaneous devices or implants (31). We found a statistical significant association between patients with "high infective risk" (fever, positive microbiologic culture and leukocytosis in perioperative period) and VP shunt abdomen malfunction, independently of causes of failure. Beyond cases of direct infection spread from blood, airway or urinary tract with shunt contamination, it could be supposed that the chronic inflammatory infection status of these patients changes the peritoneal fluid composition favoring occlusion and malabsorption. On the other hand, patients with "high infective risk" are prevalently those with traumatic or post-hemorrhage hydrocephalus, with high number of previous cranial surgical procedure (es. decompressive craniectomy) that represent an independent risk factor for infection and shunt failure even in case of minimally invasive surgical procedure (32-35).

Correct VP shunt drainage require a differential pressure between intracranial pressure (ICP) and intraperitoneal pressure (IAP) that is 0 ± 2 cm H2O. There is a correlation between increased intra-ab-

dominal pressure (IAP) and higher intracranial pressure (ICP), as reported in conditions such as obesity and pregnancy. Thus, constipation is considered a potential cause of abdomen shunt malfunction (36-38). We investigated the potential role of abdomen distention in shunt failure by means of post-operative abdomen X-ray reports but no statistical correlation has been found. It is possible that post-operative abdomen distention is a transient condition without impairment of shunt function. Finally, previous study identified male sex as risk factor for VP shunt failure, but in this study this data was not confirmed.

Conclusion

Abdomen VP shunt failure is a frequent condition and its specific risk factors are not well established. In this study perioperative infective/inflammatory status and the use of trocar are risk factors for abdominal shunt failure. This may be related to abnormal peritoneal fluid composition with reduction of peritoneal absorption or peritoneal catheter fibrosis. Further studies are necessary to elucidate the pathophysiology of peritoneal fluid dynamic in patient with VP shunt.

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