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Silicone allergy manifestation in pediatric ventriculoperitoneal shunting: navigating diagnostic challenges and customizing therapeutic approaches. Illustrative case

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BACKGROUND A silicone allergy can significantly impact the efficacy of ventriculoperitoneal shunt devices used in hydrocephalus treatment. Its clinical presentation often resembles infectious ventriculitis, characterized by altered cerebrospinal fluid (CSF) parameters, including low glucose levels, elevated protein concentrations, and increased white blood cell counts predominantly comprising eosinophils.

OBSERVATIONS The authors report the case of an 18-month-old male who experienced recurrent shunt malfunction linked to CSF changes indicative of infectious ventriculitis. The patient underwent surgeries for suspected infection management. Notably, he exhibited increased eosinophil counts in both blood and CSF, as well as the development of neoformation tissue. This, along with the absence of microbial infection, indicated silicone hypersensitivity. While navigating medical device scarcity, innovative methods were employed to secure a silicone-free valve, markedly improving the patient's clinical outcome.

LESSONS Clinicians must be vigilant for silicone allergy in patients with ventriculoperitoneal shunts, particularly when elevated serum eosinophil counts and negative microbiological tests are present. This rare condition demands a multidisciplinary approach for timely diagnosis and management to reduce morbidity, unnecessary surgeries, and healthcare costs. The limited availability of non–silicone-based shunts further complicates management. This case emphasizes the need for considering silicone allergy in differential diagnoses, especially in pediatric patients.

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KEYWORDS hydrocephalus; ventriculitis; silicone allergy; hypersensitivity; ventriculoperitoneal shunt

Hydrocephalus is still a controversial pathology in its definition; it corresponds to a disorder of the cerebrospinal fluid (CSF) physiology characterized by an increase in the size of the cerebral ventricles, typically associated with an increase in intracranial pressure. It is a common condition in the pediatric population, and ventriculoperitoneal shunting (VPS) remains one of the most used treatment forms in this age group.[1] In the United States, the condition is estimated to be present in approximately 1 in every 1000 births,[2] but it is likely higher in developing countries.[3] The most frequent etiologies include prematurity hemorrhage, congenital stenosis of the mesencephalic aqueduct, myelomeningocele, and brain tumors.[4,5]

Silicone allergy, a rare condition, lacks detailed epidemiological data. Its association with the use of cochlear implants[6] and breast implants[7,8] and with ophthalmology[9] has been reported. Its association with CSF shunting devices has been rarely reported.[10] The clinical presentation can include recurrent failure of the shunt system, local skin reactions, and serum and CSF eosinophilia, in the absence of positive cultures.[11]

This illustrative case aims to describe the clinical course, diagnosis, and management of silicone allergy related to ventriculoperitoneal shunt devices in an older infant who presented with symptoms of ventriculitis and recurrent shunt failure, with the aim of considering it as a differential diagnosis of infectious ventriculitis. We also demonstrate how treatment was adapted due to unexpected complications and challenging conditions.

Illustrative Case

An 18-month-old male had a history of epilepsy due to central nervous system malformation and hydrocephalus that had been treated

ABBREVIATIONS CSF = cerebrospinal fluid; EVD = external ventricular drainage; IgE = immunoglobulin E; IMV = invasive mechanical ventilation; VPS = ventriculoperitoneal shunting; WBC = white blood cell.

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with a medium-pressure ventriculoperitoneal shunt since the neonatal period. The patient had had a previous hospitalization for ventriculitis without an isolated pathogen, which was managed with external ventricular drainage (EVD) and a complete vancomycin course, followed by a shunt revision, replacing the shunt system on the same side as the previous one (right side). He was discharged with serum eosinophilia, attributed to antibiotic use, and follow-up was advised.

Three months after his first admission, he was readmitted to the pediatric intensive care unit of our hospital because of vomiting, respiratory distress, cyanosis, fever, and altered consciousness. Aspirative pneumonia was diagnosed, necessitating invasive mechanical ventilation (IMV) and antibiotics. A comprehensive evaluation incorporating brain computed tomography revealed ventricular enlargement indicative of a potential shunt malfunction. Furthermore, brain magnetic resonance imaging disclosed not only ventricular enlargement but also significantly altered brain parenchymal architecture, characterized by cortical and white matter thinning, particularly in the posterior left ventricle. These findings necessitated neuroendoscopic exploration of the ventricular system, as an intraventricular cyst was suspected given the suggesting anatomy on imaging studies as a causative factor for shunt failure. Although no cyst or membrane was encountered, a significant finding during this procedure was obstruction of the shunt catheter (Fig. 1), prompting its replacement on the right side. Following treatment for aspiration pneumonia, IMV was discontinued. Persistent fever, lethargy, nausea, and vomiting occurred despite resolution of the pulmonary infection. CSF analysis via a VPS reservoir puncture revealed increased leukocytes (predominantly polymorphonuclear), reduced glucose, and elevated proteins (Table 1). Cultures and FilmArray PCR Multiplex were negative. Despite negative microbiological findings, vancomycin and ceftazidime therapy was initiated, and the entire VPS device was removed and replaced with an EVD device.

After persistent negative CSF cultures and while receiving parenteral antibiotics, a new VPS device was installed, this time on the left Keen's point. During the 2nd postoperative week, signs and symptoms of shunt malfunction reappeared; blood work showed no leukocytosis but persistent eosinophilia (3990 cells/µL, 27.8% of total white blood cells [WBCs]). CSF analysis continued to indicate infectious ventriculitis, leading to a new antibiotic regimen with linezolid and ceftazidime, removal of the VPS device, and installation of an EVD device. The patient was afebrile; cultures from CSF and blood remained negative, yet antibiotic treatment was completed. A new medium-pressure VPS device (Medtronic CSF-Flow Control, small size, non-antisiphon) was installed on the left Keen's point.

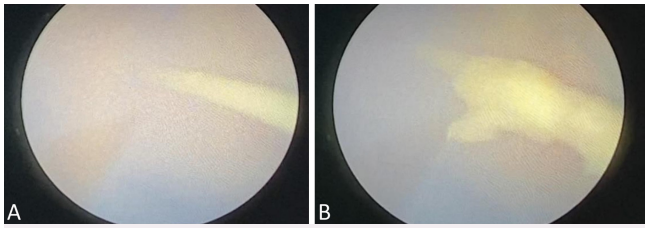

FIG. 1. Neuroendoscopic visualization of the ventricle. **A:** The proximal catheter in the ventricle. **B:** The distal part of the catheter is obstructed with inflammatory tissue surrounding it.

After the installation, the patient developed a fever, despite low levels of infection indicators (C-reactive protein at 1.6 mg/L and procalcitonin at 0.055 ng/mL), showed an increase in eosinophils in the blood, and had negative results from microbiological tests. Physical examination revealed the development of firm, stony tissue adherent to the VPS valve and reservoir system. CSF leukocyte differentiation showed an eosinophil predominance. An allergy to the VPS material was suspected. Latex allergy was ruled out with specific immunoglobulin E (IgE) testing. Immunological studies were normal, other causes of serum and CSF eosinophilia were excluded, and a family history of atopy was noted.

The decision was made to switch to a "silicone-extracted"-type VPS device. While awaiting the device, intravenous chlorphenamine (0.4 mg/kg/day) and a 3-day course of intravenous methylprednisolone (30 mg/kg/day) were administered, showing an immediate response: fever cessation, reduction in the volume and consistency of tissue around the VPS device, decreased serum eosinophilia, and improvement in CSF analysis. Corticosteroid treatment was continued orally with prednisone (2 mg/kg/day), gradually tapering based on clinical progression.

A silicone-extracted ventriculoperitoneal shunt system (Medtronic CSF-Flow Control, extracted, medium pressure), comprising both ventricular and peritoneal catheters, was obtained and installed on the right Keen's point to avoid inflammation and possible coinfection on the left side. The previous device was removed, while a tissue sample from the area surrounding the previous device was collected for histopathological analysis. This analysis revealed the presence of giant cells, lymphocytes, plasma cells, mast cells, fibrosis, a chronic inflammatory reaction, chronic granulation tissue, and eosinophils (Fig. 2).

TABLE 1. Summary of blood and CSF samples obtained from the patient during hospitalization

Sample	On Admission	On Neuroendoscopy	On EVD Device Removal & VPS Device Installation	On VPS Device Removal & EVD Device Installation	On Installation of Silicone-Extracted VPS Device	On M.blue VPS Device Installation	Ventriculitis (*S. haemolyticus*)	On Silicone-Extracted VPS Device Installation
Blood eosinophils (10^3/µL)/% of WBCs		3170/30%	1810/22.1%					130/0.6%
CSF proteins (mg/dL)	8739	9832	8212	7862	3233	2770	2779	2432
CSF glucose (mg/dL)	1	5	24	41	21	25	33	33
CSF lactate (mmol/L)	7.88	7.86	6.09	6.08	3.2	6.92	6.75	5.65
WBCs in CSF (cells/µL)	35	60	9	65	0	53	20	0

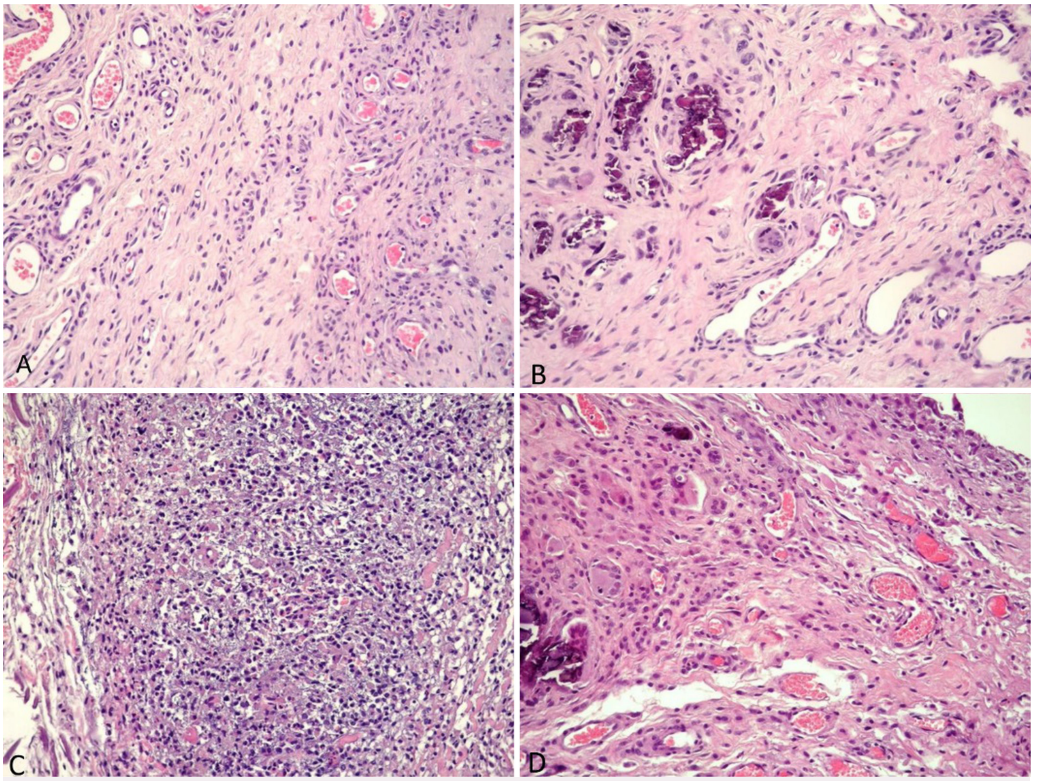

FIG. 2. Histopathological study. Fragment of fibroconnective tissue with proliferation of blood vessels of neoformation, some dilated and hyperemic (**A**). Lymphocytic and plasmacytic inflammatory infiltrate, with some polymorphonuclear neutrophils and scarce mast cells and eosinophils (**A and C**). In the stroma, there are foci of dystrophic calcification and multinucleated giant cells of the foreign body reaction type (**B and D**). Hematoxylin and eosin, original magnification ×10 (A); ×20 (B and D); ×30 (C).

The patient's clinical history was extensively reviewed, revealing that previous episodes of shunt malfunction were accompanied by fever despite the absence of infection, the normal blood infection parameters, and the resolution of symptoms upon addressing the malfunction.

Three weeks later, a pseudomeningocele and migration of the ventricular catheter into the subgaleal space occurred (Fig. 3). It was hypothesized that insufficient shunting, distorted anatomy, and a more pliable bone provoked such expulsion of the catheter outside the skull.[12] A switch to a programmable pressure device was considered. A fully silicone-free programmable device was unavailable at the time due to a worldwide stock shortage in the middle of the COVID-19 pandemic, so after ample discussion with the treating team, it was decided that the M.blue valve (B. Braun), with a titanium valve device and silicone elastomer in the rest of the system, would be used, as it was the available device with the lowest silicone content. The previous silicone-extracted ventricular catheter was retained and connected to the new silicone-extracted peritoneal catheter, on the right side. After installation, programming to the lowest available pressure range was necessary. The patient again developed serum eosinophilia and similar tissue characteristics around the silicone-containing segments of the VPS device (reservoir and connector). This prompted the resumption of full-dose oral antihistamine and steroid therapy and the search for a completely silicone-free, lower-pressure device. Pending this, hospital discharge was decided.

Two weeks later, the patient was readmitted because of a CSF fistula at the previous intervention site on the left side, contralateral to the current VPS device. CSF analysis from the VPS device cultured positive for methicillin-resistant *Staphylococcus haemolyticus*. The parents declined EVD treatment given the patient's mild symptoms, previous prolonged hospitalization, limited mobility, and discomfort.

Treatment with the in situ derivative system for 28 days from the first negative CSF culture was agreed upon. The antibiotic regimen included vancomycin to achieve plasma levels of 15–20 µg/mL combined with rifampicin, aiming for better biofilm penetration. A low-pressure, non-antisiphon extracted valve (Medtronic CSF-Flow Control, extracted, low pressure) and peritoneal catheter were obtained, but a ventricular catheter was again unavailable due to the global stock shortage. During parenteral antibiotic treatment with negative control CSF cultures, the valve device and peritoneal catheter were replaced on the right Keen's point. The ventricular catheter had to be retained, and a suppressive oral linezolid phase (30 mg/kg/day in three divided doses) was initiated after the 28-day intravenous treatment.

At discharge, the patient showed complete symptom remission associated with ventriculitis or shunt malfunction, absence of tissue reactivity to the valve device, decreased serum and CSF eosinophilia, and significant improvement in CSF analysis parameters.

Two years postdischarge, the patient maintained complete symptom remission without the need for more corticosteroids, new hospital admissions, or surgical intervention.

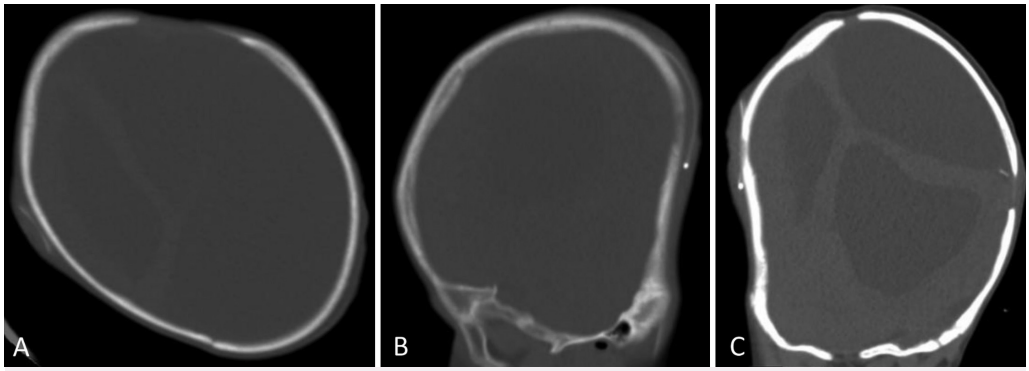

FIG. 3. Axial (**A**), sagittal (**B**), and coronal (**C**) noncontrast CT scans of the head. The ventricular catheter appears outside the cranial vault, in the subgaleal space.

Patient Informed Consent

The necessary patient informed consent was obtained in this study.

Discussion

Observations

The pathophysiology and diagnostic criteria of silicone allergy are still not well understood. Clinical manifestations related to VPS devices include symptoms of intracranial hypertension due to shunt malfunction, which can arise from obstruction or infection, abdominal pseudocysts, intestinal perforation, and fibrous cutaneous reactions along the device's path, sometimes even leading to erosion and exposure of the device.[10]

The mechanism of silicone allergy appears to be a type IV hypersensitivity reaction, characterized by delayed hypersensitivity.[13] Histopathological studies have shown eosinophils and giant cells in the tissue surrounding the VPS device.[14] In addition, our patient was also found to have fibroconnective tissue with neovascularization, lymphocytic and plasmacytic inflammatory infiltrate, dystrophic calcification foci, and multinucleated foreign body reaction cells on the biopsy specimen, which adds a novel finding to other reports available on the same topic. The lower-than-expected eosinophil count was attributed to prebiopsy steroid and antihistamine treatment.

For patients suspected of having a silicone allergy, typical diagnostic approaches include complete blood count, serum C-reactive protein, procalcitonin, peripheral blood cultures, and CSF cultures.[10] Elevated eosinophil counts in blood and CSF, alongside inflammatory markers and negative cultures, can suggest a diagnosis.

Lessons

The diagnosis of silicone allergy is considered based on elevated eosinophil counts in the blood and CSF, histopathological studies of tissue developed around the device, negative microbiological studies, and clinical and laboratory response to corticosteroids and antihistamines. Specific IgE testing for silicone elastomers was not available at our center.

CSF eosinophilia has been associated with shunt malfunction,[15] potentially caused by antibiotics like vancomycin and gentamicin, systemic use of nonsteroidal anti-inflammatory drugs or ciprofloxacin, chronic subdural hematomas, or hematological malignancies.[16] These were either absent or ruled out in our case.

Following surgical intervention, an increase in serum eosinophils was noted, prompting consideration of latex allergy. Although latex was not present in the shunt valves, exposure during surgical revisions could predispose to this condition.[10] Latex allergy was ruled out with specific IgE testing.

The delay in diagnosis was attributable to the presence of fever, CSF characteristics suggestive of infectious ventriculitis (Table 1), and the nonroutine differentiation of polymorphonuclear cells in CSF at our center.

This case presents a compelling demonstration of the intricate challenges faced in the management of a patient with a rare silicone allergy complicating ventriculoperitoneal shunt therapy, exacerbated by a global scarcity of appropriate medical devices during the COVID-19 pandemic. The necessity of innovative decisions became paramount when standard devices were unavailable, underscoring the critical need for resourcefulness and adaptability in clinical decision-making, particularly in settings limited in resources. In treating our patient in Chile, options such as polyurethane shunts[17] and silicone-extracted[18] valves were considered, but availability was constrained. This led us to maintain the ventricular catheter and change the valve and peritoneal catheter, thus exploring unconventional therapeutic alternatives to achieve negative cultures and address biofilm presence, even while acknowledging the risk of recurrence. The choice of oral linezolid, due to its excellent bioavailability, safety profile, and efficacy against biofilms,[19,20] exemplifies the need for neurosurgeons to engage in innovative problem-solving and pursue customized patient care strategies. Such strategies ensure patient safety and treatment efficacy despite external constraints, highlighting the importance of adaptability in the face of device shortages and the proactive pursuit of alternative treatment options.

Silicone allergy related to VPS devices is rare and requires high clinical suspicion for diagnosis and multidisciplinary management. Early diagnosis enables timely management, reducing morbidity, hospital readmissions, surgical interventions, and associated healthcare costs.

In patients diagnosed with ventriculitis and with an implanted ventriculoperitoneal shunt who exhibit early and recurrent device failure, the absence of microbiological diagnosis, serum and CSF eosinophilia, or local inflammatory reactions, silicone allergy should be considered as a differential diagnosis.

The availability of specific ventriculoperitoneal shunt devices for patients with silicone allergies can be limited, and production

interruptions may necessitate therapeutic alternatives when replacing segments of the device is not feasible.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Riffo, Rolack, Mohor, Berkhoff, Cerda. Acquisition of data: Araya, Riffo, Rolack, Berkhoff, Monnier, Antonio, Cerda. Analysis and interpretation of data: Araya, Mohor, Berkhoff. Drafting the article: Araya, Riffo, Berkhoff, Antonio. Critically revising the article: Araya, Riffo, Berkhoff, Monnier, Antonio, Cerda. Reviewed submitted version of manuscript: Araya, Berkhoff. Approved the final version of the manuscript on behalf of all authors: Araya. Administrative/technical/material support: Riffo, Rolack, Mohor, Antonio. Study supervision: Riffo, Antonio.

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