Cystic dilation of the ventriculus terminalis in adults

Report of 2 cases

PASQUALINO CIAPPETTA, M.D.,1 PIETRO IVO D’URSO, M.D.,1 SABINO LUZZI, M.D.,1 GIUSEPPE INGRAVALLO, M.D.,2 ANTONIA CIMMINO, M.D.,2 AND LEONARDO RESTA, M.D.2

1Section of Neurosurgery, Department of Neuroscience, and 2Section of Neuropathology, Department of Pathology, University of Bari Medical School, Bari, Italy

The ventriculus terminalis (VT) is a small ependyma-lined cavity within the conus medullaris that is in direct continuity with the central canal of the anterior portion of the spinal cord. Although the VT was described for the first time in the 19th century, its characteristics and functions are still not completely clear. Normally, such a cavity is identifiable only histologically in children and adults and can be visualized using common neuroradiological techniques only after dilation. Currently, the mechanisms of isolated dilation are not documented. The present work describes 2 cases of VT in elderly patients. Data from a histological and ultrastructural study of a case of VT dilation are reported, and the results are compared with those obtained from the VT of 5 fetuses to explain the nosological aspects of nontumoral VT lesions. Our data suggest that the site, age, and histological characteristics of the lesion allow us to define VT dilation as a nosological entity distinct from other cystic dilations of the conus medullaris. (DOI: 10.3171/SPI-08/01/092)

KEY WORDS • conus medullaris • cystic dilation • fifth ventricle • ventriculus terminalis

The VT is a small ependymal cavity within the conus medullaris that is in direct continuity with the central canal of the anterior portion of the spinal cord. Although the VT was described for the first time in the 19th century, its characteristics and functions are still not completely clear. Normally, such a cavity is identifiable only histologically in children and adults, and it can be visualized using common neuroradiological techniques only after dilation. Nevertheless, in the literature, persistent cases of a dilated VT have been reported in children < 5 years old. Currently, the mechanisms of isolated dilation are not documented. Various theories have been adopted to explain the etiopathogenesis of such occurrences, among which are congenital disorders, trauma, and ischemia. The incidence rate of such dilation remains unknown, given that it is not often significant. The present work describes 2 cases of VT in elderly patients. The data of a histological and ultrastructural study conducted on a case of VT dilation is reported, comparing the results with those obtained from 5 cases of fetal VT to explain the nosological aspects of nontumoral VT lesions, to identify the histological characteristics of the ependymal lining of the fetal and adult VT, and to investigate any distinct characteristics between the central canal and the VT ependyma to improve our knowledge and understanding of the pathophysiology of the VT.

Case Reports

Case 1

History and Examination. This 78-year-old patient, affected by cauda equina syndrome, was admitted to our hospital with a 3-year history of bilateral sciatic pain and progressive lower-limb weakness. The patient’s medical history was negative for vertebral trauma or vascular incidents. An MR image of the spinal cord showed the presence of cystic dilation of the conus medullaris without impregnation (Fig. 1a).

Operation. The patient underwent a T12-L1 laminectomy. The conus medullaris appeared swollen. The lesion

Abbreviations used in this paper: CK = cytokeratin; CSF = cerebrospinal fluid; EMA = epithelial membrane antigen; GFAP = glial fibrillary acidic protein; MR = magnetic resonance; NSE = neuron-specific enolase; VT = ventriculus terminalis.
was approached where the spinal cord tissue was the thinnest. A dilated cavity was found that was opened and drained. A subarachnoid augmentation was then achieved while performing a subarachnoid membrane dissection. A histological examination revealed the presence of an ependymal covering.

Postoperative Course. Postoperatively, the patient completely recovered from all neurological deficits. An MR image obtained 1 year after the surgical treatment showed the complete regression of the dilation without evidence of relapse or pathological conditions of the conus medullaris (Fig. 1b and c).

Case 2

History and Examination. This 82-year-old female patient was admitted to our hospital with a 6-month history of low-back pain, bilateral sciatic pain, and ingravescent weakness of the lower limbs. One month earlier, she first experienced difficulty walking and sphincter disturbances. The patient’s medical history was negative for risk factors of trauma, ischemic disorders, and congenital disorders. An MR image of the spinal cord showed the presence of a cystic cavity in the conus medullaris, with a cranial caudal extension 55 mm long. The surrounding nerve tissue was compressed and reduced to a thin layer. The cavity appeared in an ovoidal form with regular margins and characteristic signs similar to those of CSF. The lesion’s appearance did not change on imaging (Fig. 2a). The MR imaging examination was extended to all neuraxes to rule out other malformations. The neurological exam showed paraparesis, absence of tendon reflexes of the lower limbs, and anal sphincter incontinence.

Operation. The patient underwent a T11–12 laminectomy. After opening, a dilation of the inferior portion of the spinal cord was found, which was more evident in the conus medullaris. The lesion was approached in reference to the conus medullaris, which appeared thinned from the lesion. After opening the lesion, leakage of a fluid similar to CSF was noted. Furthermore, the lesion appeared in direct continuity with the surrounding nervous tissue. Inspection of the cavity was negative for the presence of tumors (Fig. 3). Tissue samples were taken from the wall of the lesion and sent for histological study and ultrastructural analysis. A subarachnoid augmentation was then achieved while performing a subarachnoid membrane dissection.

![Fig. 1. Case 1. Magnetic resonance images. A preoperative T2-weighted image (a) shows the cystic dilation of the conus medullaris, and postoperative T1-weighted (b) and T2-weighted (c) images obtained 1 year after surgical treatment show regression of the dilation without evidence of relapse.](image1)

![Fig. 2. Case 2. Magnetic resonance images. A preoperative T2-weighted image (a) shows the presence of a cystic cavity in the conus medullaris, with a 55-mm cranial caudal extension. The cavity appeared in an ovoidal form with regular margins and characteristic signs similar to those of CSF. The postoperative T2-weighted image (b) obtained 1 year after surgery reveals a complete regression of the dilation.](image2)
Postoperative Course. Postoperatively, the patient experienced a progressive and complete recovery from the neurological deficits, including sphincter control and gait recovery. An MR image obtained 1 year after the surgery revealed complete regression of the dilation without evidence of relapse (Fig. 2b).

Anatomical and Histological Comparison Materials

To be able to classify the VT from a nosological point of view and to identify distinct histological characteristics, the spinal cords of 5 fetuses were isolated. The sections of the spinal cords that were used were from a part of the dorsal tract to the filum terminale. After deciding that we wanted to identify the distinctive elements between the VT and the ependyma canal, we chose to isolate the fetal VT, because it is better represented than the adult specimen; in this way, the differences were made more obvious.

The fetal and surgical specimens were fixed in 10% neutral-buffered formalin, sampled and embedded in paraffin blocks sectioned at a thickness of 4 mm, and stained with H & E. Additional sections, collected on poly-L-lysine coated slides, were used for the immunohistochemical stains using the avidin–biotin complex method. The sections were incubated with the primary antibodies (anti–GFAP antigen, anti–S100 protein, anti–vimentin, anti–EMA, anti–NSE, and anti–CK pool) overnight at 4°C. Appropriate negative controls, obtained by substituting the primary antibodies with pre-immune serum and positive controls, were included in the procedure.

In contrast, we performed fetal spinal cord fixation using a particular fixative solution (30% formaldehyde, 30% glacial acetic acid, and 40% distilled water) to facilitate specimen handling and extraction and to obtain adequate samples for macroscopic and microscopic observations and immunohistochemical/ultrastructural analysis. After the fetal spinal cord extraction, sequential transverse biopsy specimens from the dorsal region and conus medullaris of the spinal cord were obtained, sampled, and embedded in paraffin blocks sectioned at a thickness of 4 mm and stained with H & E. Finally, only 2 paraffin blocks of each of the 5 fetuses with a central canal of the dorsal spinal cord and VT were selected for immunohistochemistry and ultrastructural analysis.

Specimens from the same paraffin block were reprocessed for electron microscopy. The paraffin-embedded tissue was deparaffinized in xylene, in a 1:1 mixture of xylene and propylene oxide, and soaked in pure propylene oxide. The specimens were successively rehydrated with ethanol solution, postfixed in 1% OsO₄, dehydrated, and embedded in epoxy resin.

The polymerized specimens were sectioned and routinely stained. The 1-mm sections, stained with 0.1% toluidine blue, were observed under the light microscope. Ultrathin sections were cut on an LKB Ultratome, contrast-stained with uranyl acetate and lead-citrate, and examined under a Philips CM-10 electron microscope.

The obtained results were compared with those of the VT as reported in Case 2, with the understanding that variations exist among ependyma of fetuses and adults.

Results of Comparison

The analysis of the fetal specimens revealed that the central canal in the conus medullaris enlarges and assumes an egg-shaped conformation (Fig. 4). The slides obtained in Case 2 prepared with H & E showed evidence of the presence of a flat epithelium on the lining (Fig. 5). The immunohistochemistry investigation clarified the nature of the ependyma of such lining. The immunohistochemistry results of the fetal samples and of the case under examination are summarized in Table 1. The data did not show any significant variation in the immunohistochemistry of the fetal and adult specimens, except for NSE, which was slightly positive only in the ependyma of the fetal VT and in Case 2. The positive antiseraums of the CK pool were only present in the specimens obtained in the patient in Case 2 because of morphological and functional modifications of the ependymal cells, secondary to the dilation (Figs. 6–8). Electron microscopy of Case 2 demonstrated cuboidal cells, with roundish nuclei, irregular margins, and the presence of nucleoli. These cells showed cilia, microvilli, and junctional complexes. Below the ependymal cells was
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Discussion

The VT is formed during fetal development. In the normal development of the spinal cord, different stages are recognized as follows: neurulation, canalization, and retrogressive differentiation. During neurulation, which begins at 3 weeks of embryonic development, there is a flexion and closure of the neural plate to form the neural tube. The craniocephalic closure occurs within 23 days of gestation, ending at the anterior neuropore. The caudad closure is complete after approximately 26 days, ending at the posterior neuropore. At about 4–5 weeks of gestation, the caudal end of the neural tube and the notochord combine to become an aggregate of undifferentiated cells, called the caudal cell mass. Small vacuoles develop within this mass, canalize, and form an ependymal-lined tube that usually fuses with most rostral central canals. This cavity is the VT, or fifth ventricle. Finally, during retrogressive differentiation, a major portion of the distal cord involutes to become a glioependymal strand, the filum terminale.

The VT was first described in 1859 by Stilling and was identified as a simple dilation of the central canal. In 1875, Krause identified the VT as an ependymal cell-lined cavity, calling it the “fifth ventricle”; he identified a VT in all adults, noting that it had the tendency to be wider in children and the elderly. In 1924, Kernohan, using postmortem studies, provided a more detailed anatomical evaluation of VT development in the fetus, child, and adult. He demonstrated that the VT is present in all 22-mm fetuses and in the conus medullaris and filum terminale of all examined specimens. The author concluded that the VT was a “true ventricle,” analogous to that of the cerebrum, and communicated with neither the subarachnoid space nor with the central canal of the spinal cord.

The physiological role of the VT is unknown. It is believed that the VT is localized at the point at which the Reissner fiber terminates, accumulating neurosecretory substances. Studies have been published that suggest that the Reissner fiber, which extends from the inferior portion of the subcommisural organ of the epithalamus to the VT, is a secretory product of the cells of the subcommisural organ. It has also been suggested that the Reissner fiber can cross the gap present in the ependymal lining of the filum terminale until it reaches the periependymal tissue, and thus, the subarachnoid space. The possible physiological functions of the Reissner fiber are mechanoreceptor functions, to indicate variations in CSF pressure. This fiber can also regulate the quality of the CSF and supply endogenous peptides.

Few studies on the histological and ultrastructural character of the VT have been published. In 1992, Choi and colleagues performed a histological and ultrastructural study on a series of conus medullaris and filum terminale obtained from the spinal cords of 23 cadavers. The authors demonstrated the presence of neuropil with astroglial and neural components in such structures, confirming a possible functional implication.

The clinical importance of the VT derives from the fact that cases regarding its dilation have been described; therefore, knowledge of the VT’s histological characteristics and physiological role can be utilized for classifying nontumor-

![Fig. 5. Case 2. Photomicrographs of a specimen of the cystic wall showing evidence of the presence of a flat epithelium on the lining. H & E. Original magnification × 40 (a) and × 100 (b).](image)
ous VT lesions from a physiopathological viewpoint. The cases of VT dilation reported in the literature are rare and mostly isolated cases; the data from these cases are summarized in Table 2. In 1956, Poser reexamined 234 cases of syringomyelia and discovered lumbosacral segment dilation of the medulla in only 5 cases. Localized cysts of the medullary cone were also reported in association with trauma, tumors, or vascular diseases. In 1968, Nassar and associates reported 3 cases of cystic dilation of the conus medullaris in adults, and in 1 case the histological exam revealed the presence of an ependymal lining.

The mechanism that determines the dilation of the VT is still unclear. An isolated VT dilation could be caused by the absence of communication with the central canal located above. An abnormal closure of the VT could be congenitally based, or the result of trauma or ischemia. This abnormal closure cause could explain the absence of dilation of the ependymal canal. Other explanations could be the existence of a spinal accessory canal that does not communicate with the medullary canal, which leads to a secondary dilation. A possible involvement of the Reissner fiber in the pathogenesis of the VT should not be completely excluded, given that mechanical theory is only partly able to explain such dilation. In this way, a Reissner fiber lesion could involve a localized alteration of CSF composition and dynamics, causing a dilation of the ependymal canal. Nevertheless, other research on the Reissner fiber is ongoing because its functions are not unambiguous and it is difficult to obtain study samples in vitro or in vivo.

Our work was performed on an ultrastructural study of samples obtained from the patient in Case 2. The results were compared with those obtained from the VT of fetuses. Our results show the presence of an ependymal lining and its direct continuity with the surrounding neuropil. Such characteristics permitted us to identify the cystic dilation of the conus medullaris and cauda equina as VT dilation.

Fig. 6. Case 2. Photomicrographic results of immunohistochemical tests of the dilation of the VT using various primary antibodies as follows: vimentin (a); S100 (b); NSE (c); GFAP (d); EMA (e); and CK pool (f). Original magnification × 100.

Fig. 7. Photomicrographic results of immunohistochemical tests of fetal VTs using various primary antibodies as follows: H & E (a); vimentin (b); S100 (c); NSE (d); GFAP (e); and CK pool (f). Original magnification × 100 (a, b, d, and e), × 200 (c), and × 40 (f).
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The histological characteristics of the samples allowed for the differential diagnoses between cysts and a dilated VT, because the cysts appeared as independent dilations of the surrounding nervous tissue. The differential diagnoses between a dilated VT and other central canal dilations are interesting. In the case of hydromyelia, the dilation of the central canal is generally localized above the filum terminalis; in terminal syringomyelia, there is no ependymal lining; and in ependymal tumors, impregnation is noticeable after MR imaging contrast medium administration.

For treatment, it is noted that given the probable dysembryogenetics of such disease it is necessary to distinguish between dilations that remain stable for long periods of time from those that present clinical and radiological evolution. It is possible that a small dilation observed in an adult patient can remain stable or become asymptomatic. Such behavior influences the treatment of choice for these lesions, which in the case of clinical and morphological evolution is approached surgically with drainage of the dilation. From a surgical viewpoint, our strategy aimed to approach the lesion where the dilated VT thinned the neural tissue, and we made a small incision for drainage of the dilated cavity to avoid neurological damage. At the same time, we opened the subarachnoid space to achieve a free CSF flow.

Conclusions

On the basis of the data we obtained, we can confirm that the site, age, and histological characteristics of the VT allow us to define VT dilation as a nosological entity distinct from other conus medullaris dilations. Furthermore, this entity is more common than previously believed.

References

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>No. of Cases</th>
<th>Age (yrs), Sex</th>
<th>Symptoms &amp; Signs</th>
<th>Operation</th>
<th>Histological Analysis</th>
<th>Follow-Up Duration; Results</th>
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<tbody>
<tr>
<td>Nassar et al., 1968</td>
<td>1</td>
<td>22, M</td>
<td>low-back pain, weakness in lower extremities, bladder dysfunction; hypoesthesia at L3–S2</td>
<td>laminectomy &amp; drainage</td>
<td>not performed</td>
<td>7 mos; improvement</td>
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<td>1</td>
<td>51, F</td>
<td>rt leg weakness, pain in lt leg; distal weakness in rt leg; absence of Achilles tendon reflex</td>
<td>laminectomy &amp; drainage</td>
<td>biopsy of cyst wall negative for tumors &amp; showed fragments of white matter</td>
<td>1 yr; improvement</td>
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<td>1</td>
<td>16, M</td>
<td>weakness &amp; spasticity in lower extremities, bilat Babinski reflex; hypoesthesia in lower extremities</td>
<td>laminectomy &amp; drainage</td>
<td>layer of ependymal cells on narrow bands of glial tissue</td>
<td>4 yrs; improvement, use of leg brace to walk</td>
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<td>Stewart et al., 1970</td>
<td>1</td>
<td>35, F</td>
<td>weakness in lower extremities, hypoesthesia at T9–L2; poor anal sphincter tone</td>
<td>laminectomy, aspiration, permanent catheter drainage</td>
<td>cytological examination showed no tumor cells</td>
<td>30 mos; improvement</td>
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<td></td>
<td>1</td>
<td>17, M</td>
<td>pain, weakness, &amp; absence of reflexes in lower extremities</td>
<td>laminectomy, aspiration, permanent catheter drainage</td>
<td>cytological examination showed no tumor cells</td>
<td>3 yrs; normal neurological state</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>73, M</td>
<td>paraparesis, hypoesthesia in lower extremities, poor anal sphincter tone; back injury in adult age</td>
<td>laminectomy, aspiration, permanent catheter drainage</td>
<td>cytological examination showed no tumors</td>
<td>22 mos; distal weakness in legs &amp; persistence of bladder dysfunction</td>
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<tr>
<td>Korosue et al., 1981</td>
<td>1</td>
<td>49, M</td>
<td>amyotrophic lateral sclerosis syndrome in lower extremities</td>
<td>laminectomy &amp; drainage</td>
<td>ependymal cell layers on narrow band of glial &amp; connective tissue</td>
<td>16 days; slight improvement, weakness &amp; sensory deficit persistence</td>
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<td>Robertson et al., 1991</td>
<td>1</td>
<td>48, F</td>
<td>lower extremity paresthesias &amp; weakness</td>
<td>laminectomy &amp; drainage</td>
<td>ependymal cyst</td>
<td>2 mos; normal neurological state</td>
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<td>48, F</td>
<td>low-back pain, weakness in lower extremities, urinary dysfunction</td>
<td>laminectomy &amp; drainage</td>
<td>cytological examination showed no tumor cells</td>
<td>unknown; normal neurological state</td>
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<td>Sigal et al., 1991</td>
<td>4</td>
<td>35–62, F</td>
<td>low-back pain, sciatica, bladder; Arnold–Chiari malformation Type I–associated dysfunction in 1 case</td>
<td>drainage in 2 cases; follow-up in the other 2</td>
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<td>not available</td>
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<td>1</td>
<td>34,</td>
<td>low-back pain, bilat sciatica, weakness of dorsiflexion, urinary retention</td>
<td>laminectomy &amp; drainage; internal ependymal-type lining (intraop finding)</td>
<td>not available</td>
<td>14 mos; normal neurological state</td>
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<td>Matsubayashi et al., 1998</td>
<td>2</td>
<td>49 &amp; 58, F</td>
<td>low-back pain, bilat sciatica, weakness in lower extremities, urinary dysfunction</td>
<td>laminectomy &amp; drainage</td>
<td>not performed</td>
<td>postop normal neurological state</td>
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<td>Celli et al., 2002</td>
<td>1</td>
<td>42, F</td>
<td>bladder dysfunction</td>
<td>not performed</td>
<td>not performed</td>
<td>not available</td>
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<td>Dullerud et al., 2003</td>
<td>1</td>
<td>47, F</td>
<td>rt sciatic pain, mild hyperreflexia in lower extremities</td>
<td>laminectomy &amp; drainage</td>
<td>ependymal lining of cyst</td>
<td>unknown; slight motor disturbance on lt leg, bladder dysfunction</td>
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<td></td>
<td>1</td>
<td>42, F</td>
<td>low-back pain, lt sciatica</td>
<td>laminectomy &amp; drainage; internal ependymal-type lining</td>
<td>not performed</td>
<td>2 yrs; no MRI evidence of recurrence</td>
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<td>Vázquez-Sáez et al., 2003</td>
<td>1</td>
<td>41, F</td>
<td>low-back pain, radicular pain in lt leg, paresthesias, hypoesthesia at T12–L2</td>
<td>laminectomy &amp; drainage</td>
<td>not performed</td>
<td>not available</td>
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<td>Liccardo et al., 2005</td>
<td>1</td>
<td>30, F</td>
<td>low-back pain; normal neurological state</td>
<td>not performed</td>
<td>not performed</td>
<td>2 yrs; clinical &amp; MRI evidence of non-evolutionary nature of conus medullaris cyst</td>
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<td>Brisman et al., 2006</td>
<td>1</td>
<td>57, F</td>
<td>cauda equina syndrome</td>
<td>laminectomy &amp; drainage</td>
<td>ependymal cell lining on cyst wall</td>
<td>3 mos; improvement</td>
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