Microsurgical removal of a misplaced intraspinal venous stent in a patient with inferior vena cava atresia

Christoph Schwartz, MD, MHBA,^{1,2} Ahmad Hafez, MD, PhD,¹ Kimmo Lönnrot, MD, PhD,¹ Behnam Rezai Jahromi, MD,¹ Kimmo Lappalainen, MD, PhD,³ Martin Lehecka, MD, PhD,¹ Jari Siironen, MD, PhD,¹ and Mika Niemelä, MD, PhD¹

¹Department of Neurosurgery, Helsinki University Hospital, University of Helsinki, Finland; ²Department of Neurosurgery, University Hospital Salzburg, Paracelsus Medical University Salzburg, Austria; and ³Department of Radiology, HUS Medical Imaging Center, Helsinki University Hospital, University of Helsinki, Finland

Inferior vena cava atresia (IVCA) is a rare vascular condition that may be treated by venous stenting. The authors report on the microsurgical removal of an intraspinally misplaced stent causing nerve root compression and neurological deficits.

A 42-year-old patient with IVCA and painful cutaneous collaterals had been scheduled for treatment by stenting of the ilio caval confluence and associated venous collaterals. Initial stenting of the right iliac vein was successful; however, during recanalization of the left paravertebral plexus, the stent entered the spinal canal via extraspinal-to-intraspinal venous collaterals. Because of the use of monoplane angiography, the stent misplacement was not seen during the procedure. Postinterventionally, the patient experienced a foot elevation weakness (grade 1/5) as well as pain and hypesthesia corresponding to the L5 dermatome. Ultrasonography ruled out a lumbosacral plexus hematoma. CT angiography showed that a stent had entered the spinal canal through the left S1 neuroforamen causing nerve root compression. The intraspinal portion of the stent was removed piecemeal via a left-sided hemilaminectomy. Venous bleeding due to the patient's anticoagulation therapy, the stent's sharp mesh wire architecture, and the proximity to nerve roots complicated the surgery. Postoperatively, the foot elevation improved to grade 4/5.

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KEYWORDS intraspinal stent misplacement; stent removal; nerve root compression; recanalization; inferior vena cava atresia; vascular disorders

INFERIOR vena cava atresia (IVCA) is a rare congenital deep venous anomaly with a reported prevalence of 0.4% in the general population.^{2,5,8} Patients with IVCA are usually diagnosed during early adulthood and are at significant risk of developing recurrent deep venous thrombosis (DVT) of the lower extremities.^{2,6,8} Moreover, patients develop large compensatory collaterals to sustain venous circulation.⁶ One possible treatment option for symptomatic patients consists of recanalization and stenting of the ilio caval confluence and associated venous collaterals.^{3,4,7,9}

Here, we present a rare case of a patient with IVCA who had undergone a stenting procedure. Due to the patient's venous angioarchitecture, one stent accidentally entered the lumbar spinal canal, leading to nerve root and dural

sac compression with associated neurological deficits. We provide a detailed description, including a video of the neurosurgical stent removal and discussion of the patient's symptoms, radiological findings, neurosurgical treatment, and postoperative outcome.

Case Report

Patient Presentation and Stenting

A 42-year-old male patient with IVCA and a past medical history of multiple DVTs requiring permanent warfarin treatment developed multiple painful cutaneous collaterals in the summer of 2018. Because of the symptoms' persistence and in order to improve/maintain venous drainage, the patient was recommended for and consented to inter-

ABBREVIATIONS ASA = acetylsalicylic acid; CTA = CT angiography; DVT = deep venous thrombosis; IVCA = inferior vena cava atresia.

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FIG. 1. Angiograms revealing multiple collaterals in the abdomen and pelvic floor (A) as well as paravertebral veins (B). Right-sided stenting was performed without any complications (C).

ventional treatment by stenting of the ilio caval confluence and associated venous collaterals.

The patient was admitted to the Department of Vascular Surgery at the Helsinki University Hospital for the stenting and recanalization procedure to be performed by the interventional radiologists. The procedure was conducted under general anesthesia using a monoplanar angiography system. An initial effort to recanalize the left-sided femoral vein failed but revealed multiple collaterals in the abdomen and pelvic floor (Fig. 1A) as well as paravertebral veins (Fig. 1B). Thus, the right common femoral vein was then punctured, and the catheter was successfully introduced into the superior veins. Subsequently, the entire visualized right-sided pathway was recanalized using 18-mm and 14-mm stents, resulting in good venous flow (Fig. 1C). Afterward, left-sided recanalization of the paravertebral plexus was performed with 14-mm stents. No intraoperative complications were detected. Postinterventionally, acetylsalicylic acid (ASA) was added to the patient's preexisting warfarin medication.

Postinterventional Course

After the patient had been extubated, he complained of radiating pain and hypesthesia corresponding to the L5 dermatome of the left leg, and severe weakness in foot elevation (grade 1/5) was noticed. Furthermore, the patient's mobilization failed due to weakness of the gluteus medius and minimus muscles, leading to an additional leg abduction paresis and a positive Trendelenburg sign. No bladder or bowel dysfunction was recorded. An ultrasound examination was conducted, which ruled out a lumbosacral plexus hematoma and showed both femoral veins to be open. Since the patient's symptoms did not significantly improve overnight, MRI including MR angiography was conducted to exclude stent thrombosis as the cause of the patient's symptoms. During the scanning procedure, however, the patient reported painful heat sensations in the low-back as

well as the pelvic region, and the examination had to be prematurely aborted. CT scanning with CT angiography (CTA) was then performed on the 2nd postinterventional day, which eventually revealed the underlying problem. The CTA scan showed that the left-sided stent had entered the lumbar spinal canal via a large extraspinal-to-intraspinal collateral vein through the S1 neuroforamen, leading to a significant intraspinal mass compressing the dural sac and the L5 nerve root. The right stent was correctly placed (Fig. 2). The patient was transferred to the Department of Neurosurgery for further treatment in the late hours of the 2nd postinterventional day.

Neurosurgical Stent Removal and Outcome

After extensive and interdisciplinary consultations with vascular surgery and radiology colleagues, it was decided that we attempt to microsurgically resect the intraspinal portion of the stent since an endovascular removal was not deemed possible. Preoperatively, the warfarin was reversed by prothrombin complex concentrate (Octaplex, Octapharma). A midline approach with a left-sided hemilaminectomy of L5 and flavectomy was performed. Immediately after removal of the ligamentum flavum, a massively protruding dural sac was encountered. To enable safe exposure of the dural sac, the hemilaminectomy had to be extended contralaterally and ultimately slightly crossed the midline. The dural sac was then carefully medialized, revealing a large intraspinal ventrolateral vein containing the implanted stent. The L5 nerve root was identified at the cranial border of the performed flavectomy. It was massively compressed and pushed cranially by the stent. Despite the preoperative warfarin antagonization, diffuse venous oozing was observed. After careful inspection of the intraoperative findings, the vein was incised, and the stent was exposed (Fig. 3A). We initially attempted to carefully dislodge and gently pull the stent out of the vein's lumen using a small hook and microdis-

FIG. 2. Postinterventional axial (**A** and **B**), coronal (**C**), and sagittal (**D–F**) CT angiograms showing that the left-sided stent (arrows) had entered the lumbar spinal canal through the S1 foramen, leading to a significant intraspinal mass compressing the dural sac and the L5 nerve root; the right stent was correctly placed. Figure is available in color online only.

sectors (Fig. 3B and C). This endeavor proved to be too treacherous, however; even a significant amount of applied pulling force could only cause very little movement of the stent, and we feared that a distal, noncontrollable tear of the vessel wall could lead to significant hemorrhage. We

therefore opted to cut the stent's mesh wire and remove all of the intraspinal stent piecemeal, including the portion entering the S1 neuroforamen; eventually, the dural sac as well as the L5 and S1 nerve roots appeared to be completely decompressed (Fig. 3D). Final meticulous he-

FIG. 3. Intraoperatively, the stent massively compressed the dural sac and the L5 nerve root (**A**, arrow). The stent is carefully mobilized and dislodged from the axilla of the L5 nerve root using a microdissector (**B** and **C**, arrows). Eventually, good decompression of the dural sac as well as the L5 and S1 nerve roots was achieved (**D**, arrows). Figure is available in color online only.

FIG. 4. Postoperative axial (A and B), coronal (C and D), and sagittal (E and F) CT angiograms showing the left stent still located in the iliac vein and extending into the S1 neuroforamen; the intraspinal portion of the stent was resected, and there was no further visible compression of the L5 nerve root or the lumbar dural sac (arrows). Figure is available in color online only.

mostasis was performed by bipolar coagulation, saline irrigation, and FLOSEAL (Baxter International) application (Video 1).

VIDEO 1. Video clip showing removal of the stent via left-sided hemilaminectomy. After opening the vein, the stent is carefully mobilized with microdissectors/hooks, and the stent's mesh wire is then cut and removed by a piecemeal technique. Eventually, good hemostasis is achieved and both the L5 and S1 nerve roots and the dural sac are decompressed. Copyright Department of Neurosurgery, Helsinki University Hospital. Published with permission. Click here to view.

We tried to avoid injecting FLOSEAL directly into the vein's lumen, but rather applied it on top of the opening and then compressed it with cottonoids for a couple of minutes.

On the 1st postoperative day, the patient's foot elevation improved to grade 4/5, the Trendelenburg sign was negative, and the patient could be fully mobilized. Moreover, the L5 pain and numbness resolved completely, and the painful cutaneous collaterals—which led to the initial treatment by the interventional radiologists—had significantly improved at discharge. The patient was started on a regimen of prophylactic low-molecular-weight heparin the day of the surgery, and he was eventually transferred back to the vascular surgery ward. Before discharge, the patient's anticoagulation was changed back to warfarin and additional ASA for 6 months. Postoperative CTA showed the left stent still located in the iliac vein extending into the S1 neuroforamen; the intraspinal portion of the stent was gone, and there was no further visible compression of the L5 nerve root or the lumbar dural sac (Fig. 4). The left iliac stent was found to be closed, and the right-sided stent was open with partial thrombosis.

Discussion

To our knowledge, this case report is the first published case of a neurosurgically removed intraspinal stent leading

to neurological symptomatology. The key aspects which deserve further consideration are 1) the intraoperative imaging during stent placement and postoperative course, and 2) the neurosurgical technique used for stent removal.

Even though the patient's venous anatomy—especially the presence of extensive paravertebral collaterals—was examined and well acknowledged prior to the stenting procedure, stent misplacement occurred, apparently unnoticed, during the intervention. This can most likely be attributed to the fact that monoplane angiography only was utilized for the stenting procedures. The anteroposterior view did not clearly reveal the intraspinal location of the left-sided stent. Multiplanar angiography suites, as utilized by neurointerventionalists/neuroradiologists for intracranial procedures, offer 3D views and would have more easily revealed the exact stent position to the interventional radiologist performing the procedure.¹

The second issue of interest—particularly from a neurosurgical point of view—is the surgical removal of the venous stent. Even though our department is a high-volume academic center, none of the involved neurosurgeons had previously encountered a similar case. In particular, the actual resection of the stent proved to be challenging. After incision of the vein, we initially tried to compress the stent to gain more space and to carefully dislodge the cranial end of the stent out of the vein. We had expected to then be able to carefully “pull” the stent out of the vessel. Due to the stent's internal architecture, however, it immediately regained its initial shape and compression turned out to not be feasible. Furthermore, each manipulation caused venous bleeding from the enlarged vein, requiring the use of FLOSEAL Hemostatic Matrix. We then decided to carefully cut some of the mesh wires and remove the stent piecemeal. Special attention had to be paid to ensure that the pointed and exposed mesh wires did not cause dural tears, since this might have caused additional nerve injury and cerebrospinal fluid flow would have addition-

ally impaired the surgical field overview. Eventually, this technique proved to be a fruitful approach to the problem at hand, and we were able to remove the intraspinal stent. Fortunately, the patient also showed fast and good neurological recovery after the operation.

Conclusions

Intraspinal misplacement of a venous stent in a patient with IVCA is an extremely rare complication. In particular, patients with extensive extraspinal-to-intraspinal venous collaterals seem to be at an increased risk, and patients with postinterventional new neurological symptoms should undergo rapid multiplanar imaging. Based on experience, removal of the stent can best be achieved by carefully cutting the stent's mesh wire and consecutive piecemeal removal.

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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: Schwartz, Hafez, Lönnrot, Rezai Jahromi, Lehecka, Siironen, Niemelä. Acquisition of data: Schwartz. Drafting the article: Schwartz, Hafez, Lönnrot, Rezai Jahromi, Lehecka, Siironen, Niemelä. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Schwartz. Study supervision: Niemelä. Video editing: Hafez.

Supplemental Information

Videos

Video 1. <https://vimeo.com/375665565>.

Correspondence

Christoph Schwartz: Helsinki University Hospital, Helsinki, Finland. ext-christoph.schwartz@hus.fi; c.schwartz@salk.at.