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Spinal cord infarction: Clinical and imaging insights from the periprocedural setting

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ABSTRACT

Objective: Describe the range of procedures associated with spinal cord infarction (SCI) as a complication of a medical/surgical procedure and define clinical and imaging characteristics that could be applied to help diagnose spontaneous SCI, where the diagnosis is often less secure.

Methods: We used an institution-based search tool to identify patients evaluated at Mayo Clinic, Rochester, MN from 1997 to 2016 with a periprocedural SCI. We performed a descriptive analysis of clinical features, MRI and other laboratory findings, and outcome.

Results: Seventy-five patients were identified with SCI related to an invasive or non-invasive surgery including: aortic aneurysm repair (49%); other aortic surgery (15%); and a variety of other procedures (e.g., cardiac surgery, spinal decompression, epidural injection, angiography, nerve block, embolization, other vascular surgery, thoracic surgery) (36%). Deficits were severe (66% para/quadriplegia) and maximal at first post-procedural evaluation in 61 patients (81%). Impaired dorsal column function was common on initial examination. Imaging features included classic findings of owl eyes or anterior pencil sign on MRI (70%), but several other T2-hyperintensity patterns were also seen. Gadolinium enhancement of the SCI and/or cauda equina was also common when assessed. Six patients (10%) had an initial normal MRI despite a severe deficit.

Conclusions: Procedures associated with SCI are many, and this complication does not exclusively occur following aortic surgery. The clinical and radiologic findings that we describe with periprocedural SCI may be used in future studies to help distinguish spontaneous SCI from alternate causes of acute myelopathy.

Spinal cord infarction (SCI) results in severe disabling neurologic deficits; although treatment options are limited, it is important to distinguish from other treatable causes of acute myelopathy [1,2]. Clinical signs are nonspecific, there is a broad differential diagnosis, and there is no definitive confirmatory diagnostic test. Given the often challenging diagnosis, it is possible that prior case series with a high number of presumed spontaneous SCI may actually include patients with alternative etiologies of acute myelopathy. This limitation can be reduced by focusing on patients with SCI in the periprocedural setting [3], most commonly as a complication of aortic surgery [3,4], where diagnostic certainty is much higher than with spontaneous SCI. Furthermore, we have encountered many patients with SCI as a complication of other procedures beyond that of aortic surgery. The goal of our study is to determine the range of procedures that can result in SCI and to identify clinical and imaging findings that could be applied to help diagnose spontaneous SCI, where the diagnosis is often less secure [3]. Herein, we describe all periprocedural SCIs at our institution.

1. Patients & methods

1.1. Standard protocol approvals, registrations, and patient consents

The study was approved by the institutional review board of Mayo Clinic, Rochester, MN. All patients in our study consented to the use of their medical record for research purposes.

1.2. Patients

We used an institution-based search tool, the Advanced Cohort Explorer, to identify all patients evaluated at Mayo Clinic, Rochester, MN from 1997 to 2016 with a periprocedural spinal cord infarction. Search terms “vascular myelopathy”, “spinal cord stroke”, “spinal cord

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ischemia", and "spinal cord infarction" were used. We excluded all patients with SCI that were not associated with a procedure performed within 30 days of symptom onset. A medical procedure was defined as any physical intervention on a patient intended for diagnostic or therapeutic purposes of healthcare.

1.3. Neuroimaging

All neuroimaging was retrospectively reviewed by a neuroradiologist (K.N.K.) and two neurologists (N.L.Z. and E.P.F.). Mayo Clinic neuroimaging was performed with 1.5 and 3 T MRI Siemens and General Electric machines. Images from medical centers outside of Mayo Clinic were also reviewed when available. The timing of an imaging finding was documented according to its initial appearance.

1.4. Clinical evaluation

The electronic medical record was reviewed by two of the authors (N.L.Z. and E.P.F.) to verify clinical details, neuroimaging findings, and to confirm the diagnosis. Thirty-one patients from this series were included in a previously reported cohort with principle focus on clinical outcomes [3]. All clinical details of onset to nadir deficit (worst neurological function of strength and/or sensory loss either on physical examination or subjectively per the history), symptoms of pain, sensory symptoms, autonomic function, and exam details were provided by the evaluating neurologists' or physical medicine physicians' notes at our facility. Paraplegia was defined as no movement of the lower extremities, and quadriplegia was defined as no movement of all extremities.

1.5. Other diagnostic evaluation

Other relevant diagnostic evaluation was performed in some patients and included computed tomography angiography (CTA), cerebrospinal fluid (CSF) analysis, and electromyography (EMG).

2. Results

2.1. Patients

Seventy-five patients met study criteria. The median age of SCI occurrence was 68 years (range 41–85); 49 were men (65%). Evaluation at our facility was at a median post-deficit onset day 1 (range, 0–3007 days); 76% were evaluated within 30 days. Median follow-up at our facility was 6 months (range, 0–157).

2.2. Procedures

All patients were assessed at our institution. However, the procedures that were complicated by SCI were performed at outside facilities or at Mayo Clinic. Aortic aneurysm repair was the most common procedure complicated by SCI, and represented 49% of cases. Additional procedures included other aortic surgery (15%); and a variety of others (e.g., cardiac surgery, spinal decompression, epidural injection, angiography, nerve block, embolization, other vascular surgery, thoracic surgery, others) (36%). Procedures complicated by SCI are listed in Table 1. Notably, one case was related to intercostal nerve block with phenol injection, and we cannot rule out the possibility that this was related to direct phenol toxicity of the spinal cord.

2.3. Maximal neurological deficit

The maximal neurological deficit, or nadir, was present at initial post-procedural assessment in 61 cases (81%). Fourteen patients (19%) with normal neurological function postoperatively subsequently developed neurologic deficits from SCI after a median of 2 days (range 0–30 days) (Table 2); of these, the nadir was reached within 4 h in 10 patients (71%). One patient had stuttering symptoms and reached their nadir 4 days after deficit onset. The maximum deficit reported was paraplegia in 46 patients (61%), quadriplegia in 4 patients (5%), and other deficit in 25 patients (33%). Urinary dysfunction was reported in 62 of 66 patients (94%), and bowel dysfunction was reported in 57 of 66 patients (86%).

Table 1
Procedures complicated by spinal cord infarction.

Procedure	Number of patients (%)
Aortic aneurysm repair	37 (49)
Open repair	25 (33)
Endovascular repair	12 (16)
Aortic dissection repair	7 (9)
CABG (two with concurrent valve repair)	5 (7)
Other aortic surgery	4 (5)
Epidural steroid injection	4 (5)
Spinal decompression surgery	3 (4)
Other	15 (20)
Thoracotomy	1 (1)
Ischemic bowel resection	1 (1)
Kyphoplasty	1 (1)
Popliteal artery bypass	1 (1)
Intra-aortic balloon pump	1 (1)
Intercostal nerve block	1 (1)
Intercostal artery embolization	1 (1)
Interscalene nerve block	1 (1)
Above knee amputation[a]	1 (1)
Epistaxis embolization	1 (1)
Laparotomy with epidural anesthesia	1 (1)
Embolization of retroperitoneal vessel	1 (1)
Coronary angiogram	1 (1)
Celiac nerve block	1 (1)
Bilateral iliac aneurysm repair	1 (1)

Abbreviations: CABG, coronary artery bypass grafting.
[a] Due to thrombus in aorto-bi-external iliac graft.

Table 2
Neurological deficits and ambulatory outcome.

Neurological deficits	Number of patients (%)
Paraplegia at nadir	46 (61)
Quadriplegia at nadir	4 (5)
Time to nadir	
Abnormal immediately post-procedure	61 (81)
Normal post-procedure, then decline	14 (19)
< 4 h	10 (71)
< 12 h	1 (7)
> 24 h	3 (21)
ASIA at initial Mayo evaluation (data available in 68)	
A	17 of 68 (25)
B	21 of 68 (31)
C	16 of 68 (24)
D	14 of 68 (21)
Ambulatory outcome (data available in 67)[a]	
No gait aid	11 of 67 (16)
Cane	4 of 67 (6)
Walker	10 of 67 (15)
Wheelchair	35 of 67 (52)
Remained bed-bound at the time of death	7 of 67 (10)

Abbreviations: ASIA, American Spinal Injury Association Impairment Scale; NOS, not otherwise specified.
[a] Follow-up median 8 months post spinal cord infarction (range 1–200 months).

2.4. Pain

Pain related to SCI was documented acutely in 11 patients (15%): back pain, 8 (severe spasms, aching or sharp); leg pain, 4 (burning, vague or lancinating). Residual neuropathic pain was documented in 19 patients (25%) at a median follow-up of 37 months (range