

Bilateral Medial Medullary Syndrome Following Anterior Odontoid Screw Fixation for a Type II Fracture: A Case Report

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Learning Point of the Article:

A normal postoperative CT scan does not exclude significant brainstem ischemia after anterior odontoid screw fixation; MRI with diffusion-weighted imaging should be obtained promptly whenever weaning fails or new neurological signs appear postoperatively, and coexisting atherosclerosis should be sought as a possible contributing mechanism.

Abstract

Introduction: Medial medullary syndrome is an uncommon brainstem stroke, and bilateral involvement is rarer still. It has not, to our knowledge, been described as a complication of anterior screw fixation for a type II odontoid fracture.

Case Report: A 28-year-old man sustained a posteriorly displaced type II odontoid fracture with an associated C2 spinous process fracture in a road traffic accident. He was neurologically intact at admission. Surgery was briefly postponed after a transient episode of anisocoria during induction that resolved without deficit and with a normal computed tomography (CT) angiogram. Halo-ring traction was applied preoperatively for 3 days to achieve gradual fracture reduction, and anterior fixation with two cannulated lag screws was performed uneventfully. Weaning from ventilation was prolonged and complicated; cerebral CT was unremarkable, but magnetic resonance imaging (MRI) showed acute bilateral medial medullary ischemia. He developed a bilateral incomplete tetraparesis, predominantly left-sided, with pyramidal signs and a right hypoglossal palsy (American Spinal Injury Association [ASIA] C)]. Tracheostomy, gastrostomy feeding, anticoagulation, antiplatelet therapy, and early rehabilitation were instituted. Severe atherosclerosis of the bilateral vertebral and basilar arteries, in a patient with hypertension, dyslipidemia, and long-standing smoking, was the only etiological factor identified. At 6-month follow-up, he had improved to ASIA D and was ambulating short distances with a cane.

Conclusion: Postoperative brainstem ischemia should be suspected whenever weaning fails or new deficits appear after upper cervical spine surgery, even with a normal CT; MRI with diffusion-weighted sequences is required to confirm the diagnosis. Perioperative manipulation of the cervical spine in a patient with underlying atherosclerosis may be an under-recognized mechanism for this rare complication.

Keywords: Odontoid fracture, medial medullary syndrome, anterior screw fixation, brainstem infarction, cervical spine trauma, atherosclerosis.

Introduction

Type II odontoid fractures are among the most common injuries of the upper cervical spine, and anterior odontoid screw fixation is a widely used technique because it preserves atlantoaxial

rotation while achieving direct fracture stabilization [1,2,3,4,5]. The procedure is generally regarded as safe, although dysphagia, screw back-out and non-union are recognized complications [5,6,7,8,9]. Vascular or brainstem injury following this operation

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Figure 1: Cervical computed tomography (CT) imaging. (a) Preoperative CT showing the displaced type II odontoid fracture. (b) Postoperative CT showing satisfactory reduction and correct positioning of the two odontoid screws.

is exceptional and, to our knowledge, has not previously been reported.

Medial medullary syndrome results from infarction of the paramedian medulla, an area supplied by perforating branches of the vertebral and anterior spinal arteries, and classically produces contralateral limb weakness, contralateral loss of proprioception, and an ipsilateral hypoglossal palsy [10-13]. Bilateral involvement is considerably rarer and has mainly been reported in association with vertebral artery dissection, atherosclerosis, or arteritis [12,14]. We describe a patient who developed bilateral medial medullary syndrome after anterior

fixation of a type II odontoid fracture and discuss a possible mechanistic link to perioperative manipulation of the cervical spine.

Case Report

Presentation and initial imaging

A 28-year-old man presented with neck pain after a road traffic accident. Neurological examination at admission was entirely normal. Computed tomography (CT) of the cervical spine demonstrated a posteriorly displaced type II odontoid fracture together with a fracture of the C2 spinous process, and surgery was planned for later the same day.

His vascular risk factors and co-morbidity profile are summarized in Table 1.

Severe atherosclerosis (grade IV plaques in the bilateral vertebral and basilar arteries) was identified on CT angiography performed as part of the etiological work-up.

Perioperative course

During induction of anesthesia, the patient developed anisocoria with left-sided mydriasis. Anesthesia was stopped and urgent CT angiography was performed, which showed no vascular abnormality – in particular, the vertebral artery was normal – and no change in fracture position. Once he had woken, the neurological examination was again normal and the pupillary asymmetry had resolved. Surgery was therefore postponed, and halo-ring traction (5 kg) was applied to allow gradual, controlled reduction of the fracture over the following 3 days.

Definitive fixation was carried out on day 3, at the completion of the halo-ring traction period. The operative technique is detailed below.

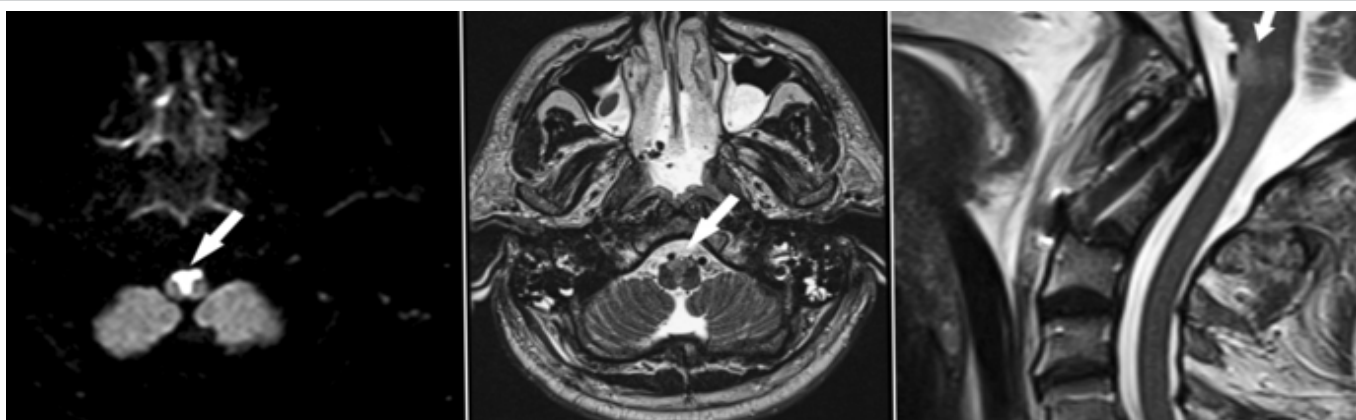


Figure 2: Magnetic resonance imaging after failed weaning. Diffusion-weighted imaging shows restricted diffusion with a high signal in the anterior medulla (left), with a corresponding high T2 signal on axial imaging (middle); the ischemic lesion lies in close proximity to the surgical field and vertebral artery on sagittal imaging (right).

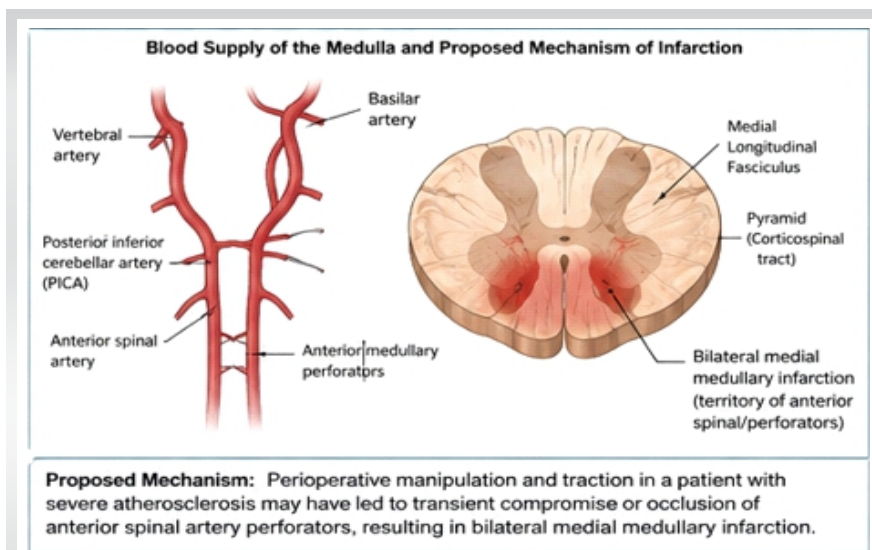


Figure 3: Schematic diagram of the blood supply of the medulla and the proposed mechanism of infarction. The vertebral arteries give rise to the anterior spinal artery through anterior medullary perforators, which supply the paramedian medulla, including the pyramids (corticospinal tracts) and medial longitudinal fasciculus. Perioperative manipulation and traction in a patient with severe atherosclerosis may have led to transient compromise or occlusion of anterior spinal artery perforators, resulting in bilateral medial medullary infarction.

The patient was positioned supine on a radiolucent table with the neck in neutral alignment. General anesthesia was induced with orotracheal intubation under fiber-optic guidance, and manual in-line stabilization was maintained throughout. Halo-ring traction (5 kg) was applied, and gentle longitudinal traction with slight neck extension achieved anatomical reduction, confirmed on lateral and open-mouth fluoroscopy. A right-sided Smith–Robinson anterior cervical approach was used at the C1–C2 level; the prevertebral fascia was opened and the longus colli retracted laterally to expose the C2 body. Two 3.5 mm partially threaded cannulated cancellous screws (DePuy Synthes) were inserted anterior-to-posteriorly along the axis of the odontoid under biplanar fluoroscopic guidance, with entry points in the inferior half of the C2 body as a paramedian pair on either side of the midline, directed superiorly and posteriorly to the tip of the odontoid. Screw positions were confirmed on anteroposterior and lateral fluoroscopy, with no canal breach. Intraoperative neuromonitoring (somatosensory evoked potential and motor evoked potential) remained stable throughout. The operative time was 110 min, with an estimated blood loss of <50 mL and no intraoperative complications. Closure was performed in standard layered fashion with a suction drain.

Postoperative course and neurological deterioration

Weaning from ventilation was prolonged and complicated. CT of the head and cervical spine confirmed satisfactory fracture reduction and correct screw positions, with unremarkable brain

parenchyma. Because the clinical course remained unexplained, cerebral and cervical magnetic resonance imaging (MRI) was obtained and revealed acute bilateral ischemia of the medial medulla. Tracheostomy and percutaneous endoscopic gastrostomy were subsequently performed, after which weaning was achieved successfully.

Neurological findings

Examination showed a bilateral incomplete tetraparesis, predominantly left-sided, with pyramidal signs. Cranial nerve examination was otherwise normal apart from deviation of the tongue to the right, in keeping with a right-sided hypoglossal nerve palsy. Formal sensory testing (light touch and pinprick) and anorectal examination were performed once the patient was extubated; voluntary anal contraction and deep anal pressure were both preserved.

Detailed International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) motor and sensory scores, neurological level, and ASIA grade at postoperative day 2 (the time of worst neurological deficit) and at 6-month follow-up are summarized in Table 2.

Table 1: Patient co-morbidity and vascular risk factor profile

Risk factor/co-morbidity	Details
Hypertension	Diagnosed 2 years prior; on amlodipine 5 mg OD.
Dyslipidemia	Total cholesterol 248 mg/dL, LDL 168 mg/dL; on atorvastatin 20 mg nocte
Smoking	Smoker for 10 years, ~10 cigarettes/day
Alcohol	Occasional alcohol use
Diabetes mellitus	No.
Known vascular disease	No prior history.
Family history	Father had myocardial infarction at age 52.
Other	No known autoimmune or coagulation disorders.
Medications at admission	Amlodipine, atorvastatin.
Allergies	None known.

Table 2: ISNCSCI motor and sensory examination, neurological level, and ASIA grade at postoperative day 2 (time of worst neurological deficit) and at 6-month follow-up

Domain	Postoperative (day 2) – at time of worst deficit		6-month follow-up	
	R	L	R	L
Motor examination (key muscles)				
C5 (Elbow flexors)	3	1	5	3
C6 (Wrist extensors)	3	1	5	3
C7 (Elbow extensors)	3	1	5	3
C8 (Finger flexors)	2	0	4	2
T1 (Finger abductors)	2	0	4	2
L2 (Hip flexors)	2	1	4	2
L3 (Knee extensors)	2	1	4	2
L4 (Ankle dorsiflexors)	1	0	3	1
L5 (Long toe extensors)	1	0	3	1
S1 (Ankle plantar flexors)	2	1	4	2
Light Touch (Max: 112)	56/112	32/112	96/112	68/112
Pin Prick (Max: 112)	54/112	30/112	94/112	66/112
Neurological level	C8	C8	C7	C7
ASIA grade	C	C	D	D
Zone of partial preservation	S2–S4	S2–S4	S2–S4	S2–S4
VAC (Anal Contraction)	Present	Present	Present	Present
DAP (Deep Anal Pressure)	Present	Present	Present	Present
R: Right, L: Left, ISNCSCI: International standards for neurological classification of spinal cord injury				

Clinical timeline

The overall sequence of injury, surgery, deterioration, and recovery is summarized in Table 3.

Imaging findings

Preoperative CT confirmed the displaced type II odontoid fracture, and postoperative CT confirmed satisfactory reduction with correctly positioned screws (Fig. 1a and b). MRI obtained after the failed weaning attempts showed restricted diffusion with a high diffusion-weighted imaging (DWI) signal and corresponding high T2 signal in the anterior medulla, consistent with acute bilateral medial medullary ischemia (Fig. 2). The infarcted area lay close to both the surgical field and the vertebral artery.

Treatment and etiological work-up

Enoxaparin (Clexane) 1 mg/kg subcutaneously twice daily was started on postoperative day 2, and aspirin 150 mg once daily was added on postoperative day 3 once a thrombotic vascular

mechanism was considered likely; no unfractionated heparin was used at any stage. The decision to institute this antithrombotic regimen was made after weighing the risk of extending the medullary infarct against the risk of epidural or wound hemorrhage so soon after cervical instrumentation; a prophylactic-dose regimen was chosen for this reason, and no hemorrhagic transformation was seen on subsequent imaging. Neurorehabilitation began promptly, and the tracheostomy was successfully decannulated three months after the injury. Screening for an underlying cause was otherwise unremarkable except for severe atherosclerotic disease, with grade IV atheromatous plaques identified in the bilateral vertebral and basilar arteries on CT angiography (Table 1). Given the patient's young age, dedicated screening for causes of premature vasculopathy – including familial hypercholesterolemia and other inherited dyslipidemias – was undertaken as part of this etiological work-up; no such disorder was identified, and the atherosclerotic risk-factor profile summarized in Table 1 remained the only identifiable contributor.

Outcome

He was discharged from acute care to inpatient rehabilitation 3 weeks after injury, remaining ASIA C at that point, wheelchair-bound, tube-fed, and requiring intermittent catheterization, with

recurrent aspiration pneumonia during this early period. His ISNCSCI grade had improved to ASIA D by 3 months, at which stage he mobilized with a walker and tolerated a soft diet following tracheostomy decannulation. By 6-month follow-up, he was ambulating short distances with a single cane, tolerating a normal diet, voiding volitionally, and had regained independent bowel function, although mild bilateral distal weakness (hand and toe) persisted (Table 2). Detailed functional, mobility, and continence outcomes at each time point are summarized in Table 4.

Discussion

The central lesson of this case is that a normal postoperative CT does not exclude significant brainstem ischemia. Here, the diagnosis only became apparent once MRI with DWI was obtained in response to unexplained weaning failure. We would recommend a low threshold for MRI, including DWI sequences, whenever a patient fails to wean or develops new neurological signs after anterior fixation of an odontoid



Table 3: Clinical timeline from injury to rehabilitation discharge

Time point	Event
Day 0	Road traffic accident; neck pain; neurologically intact. CT: Posteriorly displaced type II odontoid fracture with C2 spinous process fracture. Surgery planned same day.
Day 0	Anisocoria with left mydriasis during anesthetic induction. Anesthesia stopped. CT angiography normal (no vertebral artery pathology, no fracture displacement). Findings resolved after waking; surgery postponed.
Day 3	Anterior odontoid screw fixation performed uneventfully (two 3.5 mm cannulated lag screws) at the end of a 3-day period of preoperative halo-ring traction (5 kg) and fluoroscopic reduction.
Postop (early)	Prolonged and complicated weaning from ventilation. CT head/cervical spine unremarkable apart from confirming good reduction and screw positions.
Postop (early)	Cerebral and cervical MRI obtained because of unexplained course: Acute bilateral medial medullary ischemia identified.
Postop (early)	Tracheostomy and percutaneous endoscopic gastrostomy performed; successful weaning achieved. Enoxaparin 1 mg/kg SC twice daily started (postoperative day 2); aspirin 150 mg once daily added (postoperative day 3); no unfractionated heparin used. Neurorehabilitation initiated.
3 weeks	Discharged from acute care to inpatient rehabilitation. ASIA C; wheelchair-bound; tube feeding; intermittent catheterization.
3 months	Tracheostomy successfully decannulated.
6 months	Discharge from rehabilitation (final follow-up). ASIA D maintained; ambulating short distances with a single cane; normal diet; volitional voiding; independent bowel function; mild residual bilateral distal (hand/toe) weakness.
ASIA: American Spinal Injury Association, CT: Computed tomography, MRI: Magnetic resonance imaging	

fracture, and CT does not account for the deterioration [15,16].

Differential diagnosis

The transient anisocoria and mydriasis during induction initially raised concern for an occult vertebral or basilar artery injury; however, CT angiography at the time excluded dissection or occlusion of the basilar artery, and the pupillary asymmetry had resolved by the time the patient woke, making it unlikely to be mechanistically linked to the medullary infarction that followed. Isolated basilar artery occlusion was also considered, but this typically produces a broader pattern of cranial nerve, cerebellar, and consciousness disturbance that was not seen here. A demyelinating or inflammatory process was thought unlikely given the acute, vascular-territory-restricted appearance on DWI and the absence of any preceding

systemic illness. The bilateral, paramedian distribution of the lesion, together with its close temporal relationship to surgery, was most consistent with a perioperative ischemic event.

Proposed mechanism

The etiology in this patient remained uncertain, and the only vascular abnormality identified on systematic work-up was advanced, grade IV atherosclerosis of the bilateral vertebral and basilar arteries, identified on CT angiography performed as part of the etiological work-up (Table 1). Given the anatomical proximity of the medullary infarct to both the surgical field and the vertebral artery (Fig. 3), we consider it plausible that perioperative mechanical manipulation of the upper cervical spine – during intubation, positioning, fracture reduction, or sustained traction – contributed to atherothrombotic occlusion of small perforating branches of the vertebral or anterior spinal artery in a vessel already compromised by atherosclerotic disease. Experimental work on cervical manipulation in atherosclerotic animal models has shown that rotational and manipulative forces can destabilize plaque and reduce arterial tensile properties [17,18], and manipulation of the neck has separately been linked to stroke in patients with

underlying vascular disease [19]. Perioperative ischemic stroke is itself a recognized, if uncommon, complication of surgery unrelated to the cervical spine [10,11], which lends further plausibility to a perioperative vascular mechanism in this case.

The specific biomechanical steps used in this case merit closer consideration. Sustained halo-ring traction combined with slight neck extension during fracture reduction and positioning is mechanistically distinct from the head rotation implicated in most manipulation-related vertebral artery injury: Extension preferentially loads the V3 segment of the vertebral artery as it curves around the lateral mass of the atlas, and a systematic review of craniocervical positioning found that combined maximal extension and rotation, more than either movement alone, was associated with a measurable reduction in vertebral artery hemodynamics [20]. Isolated case reports have similarly

Table 4: Functional outcome – objective measures at discharge, 3 months, and 6 months

Parameter	At Discharge (3 weeks post-op)	3 Months	6 Months
ASIA Grade	C	D	D
UEMS (Max 50)	22	36	44
LEMS (Max 50)	18	32	40
10-Meter Walk Test	—	0.38 m/s (with aid)	0.72 m/s (with cane)
Walking Aid	Wheelchair	Walker	Single cane (short distances)
Functional independence measure	64/126	86/126	98/126
Barthel index	45/100	65/100	85/100
Swallowing	Tube feeding	Soft diet	Normal diet
Tracheostomy	Present	Decannulated	Decannulated
Bladder function	Intermittent catheterization	Intermittent catheterization	Volitional voiding
Bowel function	Assisted	Assisted	Independent

ASIA: American Spinal Injury Association

documented reversible positional occlusion of the vertebral artery in extension [21], and intraoperative traction, even within conventional limits, has been implicated in vertebral artery dissection during cervical spine surgery [22]. This combination of sustained axial traction and extension differs

from posterior cervical procedures, in which the neck is generally maintained in a neutral or flexed position and reported vertebral artery injuries are more commonly attributed to direct instrumentation – lateral mass or pedicle screw malposition – than to traction- or extension-related hemodynamic compromise [23]. In a vessel already narrowed by grade IV atherosclerotic plaque, even a modest, sub-critical reduction in flow of the kind described with extension may have been sufficient to precipitate thrombosis of small perforating branches, whereas the same maneuver in a normal artery would be unlikely to have hemodynamic consequences. This distinction has practical relevance for surgical teams managing trauma in vascularly compromised patients: where feasible, minimizing the duration and degree of neck extension during traction and positioning, and maintaining a low threshold to reassess vertebral artery patency if traction is prolonged, may help reduce the risk of this rare but serious complication. The clinical picture – bilateral, left-predominant limb weakness with pyramidal signs and a unilateral (right-sided) hypoglossal palsy – is consistent with bilateral medial medullary infarction, in which the corticospinal tracts on both sides are affected, producing quadriplegia that was more marked on the left, while

Table 5: Literature comparison – bilateral medial medullary infarction

Author (Year)	Age/Sex	Etiology	Vascular Abnormality	Key Neurological Features	Imaging	Treatment	Outcome
Casey <i>et al.</i> (1997) [24]	67/F	Hypertensive vasculopathy	Small vessel disease	Quadriplegia, pseudobulbar palsy	MRI: bilateral medial medullary lesions	Supportive	Partial recovery (ASIA D)
Shibata <i>et al.</i> (2003) [25]	58/M	Vertebral artery occlusion	Left vertebral artery occlusion	Quadriplegia, dysphagia, loss of vibration	MRI: bilateral medial medullary infarction	Antiplatelet	Good recovery
Kwon <i>et al.</i> (2006) [26]	72/M	Atherothrombotic	Basilar artery stenosis	Tetraparesis, respiratory failure	MRI: bilateral medial medullary infarction	Antiplatelet	Partial recovery
Gallo <i>et al.</i> (2012) [27]	61/M	Small vessel disease	No large vessel occlusion	Quadriplegia, dysarthria	MRI-DWI positive	Supportive	Good recovery
Rishi <i>et al.</i> (2017) [28]	55/M	Thromboembolic	Cardioembolic source (Atrial fibrillation)	Quadriplegia, dysphonia	MRI-DWI positive	Anticoagulation	Partial recovery
Sato <i>et al.</i> (2020) [29]	69/F	Hypoperfusion	Severe atherosclerosis	Quadriplegia, ataxia	MRI-DWI positive	Supportive	Partial recovery
Suga <i>et al.</i> (2022) [30]	63/M	Vertebrobasilar insufficiency	High-grade basilar stenosis	Tetraparesis, dysphagia	MRI: bilateral medial medullary infarction	Antiplatelet	Partial recovery
Current Case (2026)	28/M	Post-op after odontoid screw fixation	Severe atherosclerosis (grade IV plaques)	Quadriplegia, respiratory failure, bulbar dysfunction	MRI-DWI: bilateral medial medullary infarction	Aspirin + Enoxaparin 1 mg/kg BD	Improved to ASIA D at 6 months

DWI: Diffusion-weighted imaging, MRI: Magnetic resonance imaging, ASIA: American Spinal Injury Association

hypoglossal fascicular involvement can remain asymmetric depending on the precise distribution of the paramedian lesions [13]. Bilateral disease, as seen here, has previously been reported almost exclusively with dissection, atherosclerosis, or vasculitis as the underlying cause [12,14], rather than as a perioperative event, which is what makes this presentation unusual.

Literature comparison

Table 5 compares the clinical, radiological, and treatment features of this case with previously reported cases of bilateral medial medullary infarction.

Limitations

This report has several limitations. It describes a single patient, and the proposed link between cervical manipulation and medullary infarction is inferential rather than proven; no dedicated imaging of the vertebral artery or its perforating branches was obtained at the presumed time of infarction, so a focal dissection or occlusion at that level cannot be entirely excluded. The relative contribution of each perioperative maneuver – intubation, positioning, fracture reduction, or sustained traction – cannot be separated out from this single

case, and longer-term functional and swallowing outcomes beyond 6 months are not available.

Conclusion

Bilateral medial medullary syndrome is a rare but serious complication that should be considered after anterior screw fixation of a type II odontoid fracture, particularly in patients with vascular risk factors who fail to wean from ventilation or develop new neurological signs postoperatively. Because CT can be falsely reassuring, MRI with DWI is essential for timely diagnosis. Awareness of this possible association may help surgical and anesthetic teams limit unnecessary cervical manipulation in at-risk patients and pursue early MRI when the postoperative course is unexplained.

Clinical Message

In a patient with a normal neurological examination before surgery, a severe brainstem syndrome can still emerge after anterior odontoid fixation. When postoperative weaning fails or new deficits appear and CT is unrevealing, MRI with DWI should be obtained promptly, and coexisting atherosclerosis should be sought as a potential contributing factor.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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