

# Pseudarthrosis due to galvanic corrosion presenting as subarachnoid hemorrhage

## ABSTRACT

Two unlike metals near one another can break down as they move toward electrochemical equilibrium resulting in galvanic corrosion. We describe a case of electrochemical corrosion resulting in pseudarthrosis, followed by instrumentation failure leading to subarachnoid hemorrhage. A 53-year-old female with a history of cervical instability and two separate prior cervical fusion surgery with sublaminar cables presented with new onset severe neck pain. Restricted range of motion in her neck and bilateral Hoffman's was noted. X-ray of her cervical spine was negative. A noncontrast CT scan of her head and neck showed subarachnoid hemorrhage in the prepontine and cervicomedullary cisterns. Neurosurgical intervention involved removal of prior stainless steel and titanium cables, repair of cerebrospinal fluid leak, and nonsegmental C1–C3 instrumented fusion. She tolerated the surgery well and followed up without complication. Galvanic corrosion of the Brook's fusion secondary to current flow between dissimilar metal alloys resulted in catastrophic instrumentation failure and subarachnoid hemorrhage.

**Keywords:** Galvanic corrosion, pseudarthrosis, subarachnoid hemorrhage

## INTRODUCTION

Galvanic corrosion can result when two dissimilar metals are in proximity with one another and are submerged in an electrolyte solution. This situation can occur *in vivo* when a spine surgeon uses two metals with a differing electromotive force such as stainless steel and titanium.<sup>[1]</sup> Although this problem has been recognized and addressed with coatings in newer spinal instrumentation, these advances do little to serve patients who already have dissimilar alloys implanted before such metallic treatment methods were used. We describe a unique case of pseudarthrosis in construct resulting from galvanic corrosion presenting with a subarachnoid hemorrhage. To the best of our knowledge, this has never been described before.

## CASE HISTORY

A 53-year-old female with a history of rheumatoid arthritis and two prior posterior fusions with sublaminar cables

presented to the emergency department with new onset of severe neck pain. Physical examination was otherwise unremarkable other than the restricted range of motion of her neck and bilateral Hoffman's. Cranial nerves were intact. She underwent a noncontrast computed tomography (CT) of her head and neck which demonstrated subarachnoid hemorrhage in the prepontine and cervicomedullary cisterns [Figure 1]. The scan also demonstrated nonunion of her C1–C2 fusion but adequate bridging bone between C2 and C3. She was admitted to the neurosurgical intensive care unit and underwent a diagnostic angiogram which

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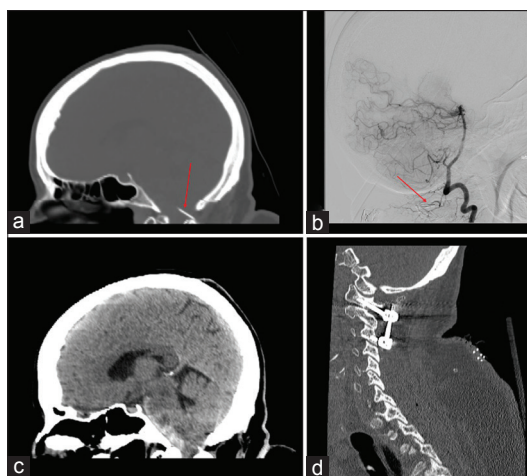
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**Figure 1:** (a) Noncontrast computed tomography head optimized with bone windowing showing cable protrusion into foramen magnum. (b) Angiogram showing proximity of failed cable to the right vertebral artery. (c) Noncontrast computed tomography head optimized with brain windows demonstrating subarachnoid hemorrhage in prepontine and cervicomedullary cisterns. (d) Postoperative image of C1–C3 posterior cervical fusion

did not show any arterial dissection or pseudoaneurysm. This suggested that injury was venous possibly from plexus surrounding vertebral artery. Her dictated operative notes were then obtained from the outside institution. It was noted that patient's first cervical operation consisted of a Brooks C1–C2 fusion for an odontoid fracture utilizing stainless steel cables that was followed shortly thereafter by her second operation, a C2–C3 posterior fusion utilizing titanium sublaminar cables for symptomatic adjacent segment disease.

Our revision surgery consisted of a removal of prior stainless steel and titanium cables, repair of cerebrospinal fluid leak, and a nonsegmental C1–C3 fusion through lateral mass screws at C1 and C3. Intraoperatively, it was noted that there was black material caked over sublaminar cables. We were careful to use only sharp dissection without electrocautery to remove the cables as we did not want to transmit current through the metal. We chose a nonsegmental fixation strategy as C2–C3 had bridging bone and allowed for easier lateral mass screw insertion at C3 rather than a C2 pars screw owing to excessive granulation tissue from prior instrumentation. She progressed well and was discharged to her home where she resumed her normal daily activities. She had follow-up at 4 months where it was noted she was doing well without neck pain. She has not had further subarachnoid hemorrhage and does not have any neurological complaints.

## DISCUSSION

In our review of the literature, we found no cases resembling our own that demonstrate galvanic corrosion resulting in

instrumentation failure presenting with a subarachnoid hemorrhage.

The Brook's style C1–C2 fusion generally has about a 93% fusion success rate.<sup>[2]</sup> The unique aspect of our case was that instrumentation failure was due to corrosive forces between mixed metal alloys. Placing any type of metal implant *in vivo* invites the opportunity for corrosion to occur. This is due to the differing ionic and mechanical properties of the implanted metal when compared with the physiology of the environment it is surrounded by.<sup>[1]</sup> The electrochemical equilibrium of the physiologic system is disturbed when a foreign metal device is introduced and begins to alter the local ionic composition as metallic ions are released. This, in turn, can create a charge flow.<sup>[1]</sup> Each metal material possesses its own inherent electromotive force and thus has the propensity to create a battery when placed near a dissimilar metallic substance as voltage transfers from one metal to the other. This process is performed cyclically as the two materials attempt to achieve a more stable electrochemical state.<sup>[3]</sup> Thus, both metals begin to break down. The least noble of the two metals has the greatest corrosive potential.<sup>[3]</sup> In our case, this was the stainless-steel instrumentation resulting in pseudarthrosis at C1–C2. The clinical application of this phenomenon is not agreed on in the scientific community, as many clinical studies have not shown galvanic corrosion of mixed metals to be clinically significant.<sup>[4–6]</sup> This report, however, argues otherwise.

Many surgeons use mixed metal alloys for joint fusion and stabilization, as was the case with our patient who had both titanium and stainless steel materials within her failed Brook's fusion. Our case is unique in that the etiology of the patient's subarachnoid hemorrhage was galvanic corrosion of the Brook's fusion secondary to current flow established by a potential difference between the two dissimilar metals. This process is dictated by the Nernst equation, as both metals with their respective reduction potentials underwent redox reactions catalyzed by the electrolytes within the physiologic environment leading to the creation of a battery in efforts to achieve a more stable state.

$$\left( E_{\text{cell}} = E_{\text{cell}} - \frac{RT}{nF} \times \ln \frac{[\text{Reduction}]}{[\text{Oxidation}]} \right)$$

Hence, the positive cell potential ( $E_{\text{cell}}$ ) leads to galvanic corrosion, destruction of the instrumentation, and pseudarthrosis.

Finally, it is critical to recognize the superiority that CT imaging offered in terms of greater assessment of pseudarthrosis in the case of our patient. The original surgeons used flexion-extension cervical X-rays to assess for

abnormal listhesis which was not present after the second posterior fusion with sublaminar cables yet it was clear from the CT that pseudarthrosis between C1–C2 had occurred. This brings into question the concept of a stable “fibrous” union in the absence of bridging bone on CT. Previous studies have suggested that CT provides a higher sensitivity and positive predictive value in diagnosing the presence of successful fusion compared to using X-ray.<sup>[7]</sup> There are concerns about extraneous radiation from CT over X-ray, however, we still feel that CT should be a preferential modality for assessing arthrodesis status as demonstrated by this case.

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#### Conflicts of interest

There are no conflicts of interest.

#### REFERENCES

1. Hansen DC. Metal corrosion in the human body: The ultimate bio-corrosion scenario. *Electrochem Soc Interface* 2008;17:31.
2. Mummaneni PV, Haid RW. Atlantoaxial fixation: Overview of all techniques. *Neurol India* 2005;53:408-15.
3. Høl PJ, Mølster A, Gjerdet NR. Should the galvanic combination of titanium and stainless steel surgical implants be avoided? *Injury* 2008;39:161-9.
4. Acevedo D, Loy BN, Lee B, Omid R, Itamura J. Mixing implants of differing metallic composition in the treatment of upper-extremity fractures. *Orthopedics* 2013;36:e1175-9.
5. Serhan H, Slivka M, Albert T, Kwak SD. Is galvanic corrosion between titanium alloy and stainless steel spinal implants a clinical concern? *Spine J* 2004;4:379-87.
6. Venugopalan R, Lucas LC. Evaluation of restorative and implant alloys galvanically coupled to titanium. *Dent Mater* 1998;14:165-72.
7. Ghiselli G, Wharton N, Hipp JA, Wong DA, Jatana S. Prospective analysis of imaging prediction of pseudarthrosis after anterior cervical discectomy and fusion: Computed tomography versus flexion-extension motion analysis with intraoperative correlation. *Spine (Phila Pa 1976)* 2011;36:463-8.