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Superselective Anesthesia Functional Examination of the Diaphragm during Endovascular Embolization of Spinal Cord Arteriovenous Malformation

Suparna Bharadwaj[1] Radhakrishnan Muthuchellappan[1]

[1] Department of Neuroanaesthesia and Neuro Critical Care, National Institute of Mental Health and Neurosciences, Bangalore, Karnataka, India

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Address for correspondence Radhakrishnan Muthuchellappan, MD, DM, Department of Neuroanaesthesia and Neuro Critical Care, National Institute of Mental Health and Neurosciences, Bangalore 560029, Karnataka, India (e-mail: mrks1974@gmail.com).

Abstract

Superselective anesthesia functional evaluation (SAFE) is an adjunct to the Wada test. It is performed to rule out unintentional positioning of the tip of the embolization catheter proximal to the origin of a normal artery supplying eloquent region of spinal cord. We report a case of a 36-year-old male with cervical intramedullary spinal cord arteriovenous malformation (SCAVM) at C3 level. In this patient, we monitored motor-evoked potentials (MEPs) of bilateral upper and lower limbs along with diaphragm. Electrodes for compound muscle action potential of diaphragm were placed under fluoroscopy guidance. Through this case, we want to emphasize that intraprocedural diaphragmatic MEPs enhance the safety margin during endovascular embolization of cervical intramedullary SCAVMs. Placement of electrodes under fluoroscopy guidance ensures proper positioning into the diaphragm muscle.

Keywords
- SAFE
- provocative test
- diaphragmatic motor evoked potentials
- cervical intramedullary AVM

Introduction

Cervical intramedullary arteriovenous malformation is an infrequent clinical entity.[1] It poses a therapeutic challenge due to the mere location of the lesion within the spinal cord parenchyma and adjacent to the ascending and descending eloquent sensorimotor tracts. Endovascular embolization of the cervical intramedullary arteriovenous malformation (AVMs) is an effective and safe mode of treatment.[2] However, during embolization, it is critical to preserve blood supply to the spinal cord.[3] Provocative test, also called superselective anesthesia functional evaluation (SAFE), can be performed to identify blood supply to eloquent region. SAFE is an auxiliary to the Wada test. It is performed to rule out unintentional positioning of the tip of the embolization catheter proximal to the origin of a normal artery supplying eloquent region of spinal cord.[4] Neurological assessment in an awake patient or monitoring of evoked potentials is a standard technique during SAFE evaluation. We present a case of cervical intramedullary AVM in whom we performed SAFE of diaphragm using motor-evoked potentials (MEPs). Appropriate placement of recording electrodes to capture compound muscle action potential (CMAP) of the diaphragm was a key step in this case.

Case Report

We report a case of a 36-year-old male with cervical intramedullary spinal cord AVM (SCAVM) at C3 level (►**Fig. 1A**). The patient was well preserved neurologically except for numbness in bilateral lower limbs. The diagnostic spinal angiogram showed radiculopial feeders from the C3

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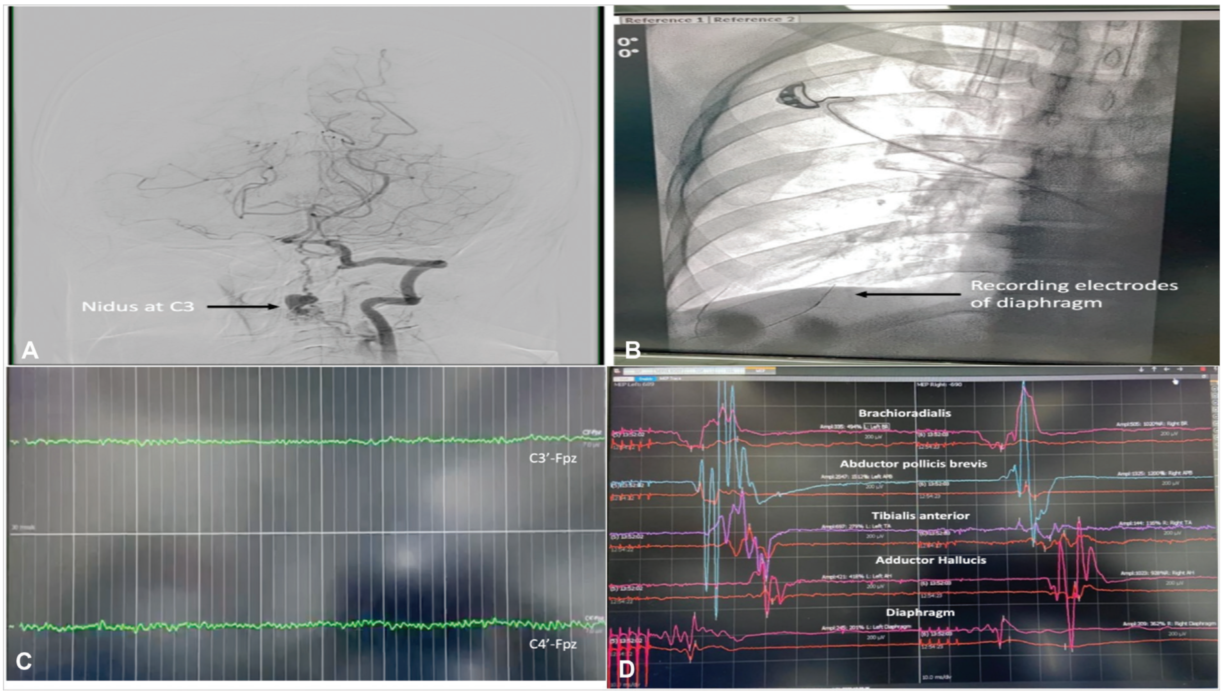

Fig. 1 (**A**) digital subtraction angiogram of left vertebral artery. (**B**) Diaphragm recording electrodes. (**C**) Two-channel electroencephalogram. (**D**) Bilateral upper and lower limb and diaphragm MEP. MEP, motor-evoked potential.

segmental artery. Given the lesion's eloquent location, glue embolization was planned for this patient under total intravenous general anesthesia with neurophysiologic monitoring. Standard American Society of Anesthesiologists' monitors were used during the procedure. Trachea was intubated after induction with injections fentanyl, propofol, and vecuronium. Anesthesia was maintained with air–oxygen mixture and propofol infusion titrated to electroencephalogram (EEG). MEPs were monitored using corkscrew stimulating electrodes at C3 and C4 positions on the scalp as per the 10 to 20 system. For CMAP recordings, needle electrodes were placed in brachioradialis, abductor pollicis brevis, tibialis anterior, adductor hallucis, and diaphragm bilaterally. Recording electrodes of the diaphragm were placed under fluoroscopy guidance (►**Fig. 1B**). A ground electrode was placed in between the stimulating and recording electrodes. Two-channel EEG (C3′-FpZ and C4'-FpZ) was monitored to titrate the anesthetic dose. MEP was monitored every 20 minutes throughout the procedure (►**Fig. 1D**, baseline recording). After positioning, the microcatheter in the artery of interest (radiculopial feeder from C3 segmental artery), for SAFE, 40 mg of preservative-free 2% lignocaine was injected through the catheter. During this time, the MEP was monitored every 10 minutes for 30 minutes. After confirming intact CMAP recordings from bilateral limb muscles and diaphragm during SAFE, 25% N-butyl-2-cyanoacrylate (NBCA) glue was injected into the nidus under angiographic acquisition. Postembolization angiogram showed complete obliteration of the AVM. Postembolization MEPs were similar to baseline. The patient had an uneventful recovery with no new neurological deficits.

Discussion

SAFE with lignocaine is a useful adjunct to SCAVM embolization under general anesthesia. SAFE was essential in our patient to rule out embolization of arterial feeder supplying eloquent region of spinal cord innervating diaphragm (C3, C4, and C5). Both sodium amytal and lignocaine can be used for SAFE during embolization of intramedullary SCAVMs.[5] In this patient, lignocaine was used to detect deterioration of both gray and white matter function in the spinal cord.[2] But the novelty in the present case includes the diaphragm CMAP monitoring and fluoroscopy for positioning recording electrodes into the diaphragm. Lissens previously reported diaphragmatic MEP recordings.[6] In this study, an active electrode was attached at the xiphoid process and a reference electrode on the rib cage's lower border at the midclavicular line. No ultrasonographic or fluoroscopic guidance was used for electrode placement. The described technique in the present case is safe. So far, we have not detected any pitfalls. Subdermal placement of recording electrodes does not pose any risk to patient. In this case, fluoroscopy-guided placement of recording electrodes increased the precision of capturing CMAP from the diaphragm. MEP of the bilateral upper limbs and lower limbs were simultaneously monitored to detect procedure-related morbidities. Evoked potential monitoring is standard of care during surgery of eloquent regions of brain and spinal cord. But the same is not popular during radiological interventions, considering the technical challenges of neurophysiological monitoring in the neuroradiology suite. Through this case, we have highlighted the feasibility of neurophysiological monitoring during endovascular embolization of cervical intramedullary AVM.

Conclusion

To conclude, intraprocedural diaphragmatic MEPs enhance the safety margin during endovascular embolization of cervical intramedullary SCAVMs. Placement of electrodes under fluoroscopy guidance ensures proper positioning into the diaphragm muscle.

Conflict of Interest
None declared.

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