Position Statement
American Association of Neuromuscular & Electrodiagnostic Medicine

RISKS IN ELECTRODIAGNOSTIC MEDICINE

Key words: (electromyography, nerve conduction studies, contraindication, infection control, lymphedema, complications, risks)

Abstract

There is a need for practitioners to be knowledgeable about potential complications of nerve conduction studies (NCSs) and needle electromyography (EMG) as well as to know how to reduce the risk of such complications. Since a summary of risks inherent to electrodiagnostic (EDX) medicine was first published over a decade ago, publication of additional literature and technological advances warrant reassessment of this topic. Other relevant practice topics that were initially published independently are unified into this document to provide the reader with updated information on the risks of EDX medicine.

INTRODUCTION AND METHODOLOGY

When electrodiagnostic (EDX) testing is performed on patients with certain underlying medical conditions, the EDX physician should consider the potential risks of the procedure. Literature continues to evolve regarding risks and complications of EDX testing.[1] The following updates the original version of this document published in 1999. It provides information and guidance to approach some common problems encountered by EDX physicians. Ultimately, physician judgment must be utilized to manage individual patient circumstances.

An original search of medical databases (Cochrane Database of Systematic Reviews, PubMed NLM, MEDLINE (1966–2004), and MEDLINE In-Process) was performed in March 2009 by the AANEM Professional Practice Committee. Additional searches were later performed in August 2011, March 2012, October 2019, and July 2025.[2–5] Searches were performed using the terms: "electromyography or EMG or EMG needles or nerve conduction" cross-referenced with "lymphedema or lymph node dissection or lymph node excision," "pregnancy and complication," "pregnancy and standards," "pregnancy and contraindication," "hematoma or bleeding or anticoagulation," "defibrillator or pacemaker," "joint prosthesis or arthroplasty, replacement," and "implantable devices." Additional pertinent articles were obtained through cross-reference of bibliographies of previously identified articles. The search for literature included only articles written in English.

INFECTION CONTROL

Infection control is an important issue in the EDX laboratory. The chances of transmitting bloodborne pathogens from patients to EDX physicians and staff, from EDX physicians and staff to patients, and from EDX equipment to patients must be minimized.

The Occupational Safety and Health Administration (OSHA) has published standards regarding bloodborne pathogens.[6] The rule applies to all persons exposed occupationally to blood or other potentially infectious materials. It outlines preventive measures, such as hepatitis B vaccination (HBV) and universal precautions, and certain methods of control, including engineering and work practice controls, personal protective equipment, and housekeeping procedures. Other preventative measures involve what to do if an exposure incident occurs. Use of masks and gowns may be required depending on the individual case. OSHA also requires the creation of an exposure control plan, whereby employees are informed of hazards associated with bloodborne pathogens, and maintenance of certain medical records. The OSHA document and additional publications from the Centers for Disease Control[7–12] set the standards concerning occupational exposure to blood or other potentially infectious materials.

Transmission of Bloodborne Pathogens Between Patients and Healthcare Workers

Routes of Infection

Routes of transmission of infection with bloodborne pathogens[7–9,13] include percutaneous inoculation or contact between blood or certain other bodily fluids with an open wound, non-intact skin, or mucous membranes. Blood is the single most important potential risk of HIV and viral hepatitis infection in the EDX laboratory.

Universal Precautions

Universal precautions mandated by OSHA consider all patients' blood and certain body fluids to be potentially infectious.[6,9,10]

Use of Protective Barriers

Personal protective equipment worn by healthcare workers, such as gloves and laboratory coats, reduces the risk of exposure of the healthcare worker's skin or mucous membranes to blood and other potentially infective materials.[6,9,10] Personal protective equipment should be removed prior to leaving the work area and should be placed in an appropriately designed area or container for decontamination or disposal. Judgment must be exercised in choosing the type(s) of equipment needed in a given clinical situation. The AANEM recommends that gloves be worn when performing needle EMG. The physician or assistant should minimize touching objects other than the patient and EDX equipment when wearing gloves. Gloves should be changed between patient contacts, when contaminated, or when torn or punctured. Gloves should be taken off before leaving the examination room. Hands should be washed immediately after gloves are removed. Electrodiagnostic physicians should query patients prior to performing the EDX examination if they have a latex allergy and should have access to alternatives, such as vinyl gloves.

Engineering and Work Practice Controls

Engineering and work practice controls should be used to eliminate or minimize healthcare worker and patient exposure to bloodborne pathogens.[6,8,9] Workers should wash hands and any other skin with soap and water, or flush mucous membranes with water as soon as feasible following contact with blood or other potentially infectious materials. Eating, drinking, or applying cosmetics are prohibited in work areas where there is a reasonable likelihood of occupational exposure. Food and drink should not be kept in containers (e.g. refrigerators) or on countertops where blood

or other potentially infectious materials are present.

Unless proper gloves are worn, EDX physicians and staff who have exudative lesions or weeping dermatitis on their hands should refrain from all direct patient care and from handling possibly contaminated patient-care equipment until the condition resolves.[10]

Specific guidelines for the use of sharp instruments and electrodes in neurological procedures were adopted with permission from guidelines developed by the American Academy of Neurology AIDS Task Force.[14] All EDX physicians and staff should take precautions to prevent injuries caused by needle electrodes and other sharp instruments. In a survey of EDX physicians, 64% reported at least one needlestick injury,[15] most commonly during a routine procedure, although patient movement and recapping were also identified as common causes. Contaminated needle electrodes should not be bent, sheared, or broken. Recapping through the use of a mechanical device or a 1-handed technique is preferred over a 2-handed technique. As soon as possible after use, contaminated needle electrodes should be placed in appropriate containers until properly processed or discarded. Such containers must meet OSHA standards and should be located as close as feasible to the immediate area where the electrodes are used.

Incidence of Transmission to Patients

A single needle electrode is typically used to make multiple insertions on the same patient during needle EMG testing. There is no evidence to suggest that multiple insertions into the same patient with a single needle electrode increase the risk of infection. Given the availability of inexpensive, single-use, disposable sensory testing devices, there is no role for lapel pins or reusable pinwheels to test sensation.

Needle EMG is not listed in the American Heart Association guidelines as a procedure which requires prophylactic antibiotic treatment to prevent endocarditis in patients with valvular heart disease.[16,17] No data indicate that preparing the skin prior to needle insertion reduces the incidence of transmission to patients; however, alcohol is a simple, rapid, and effective antiseptic. The disadvantage of the stinging discomfort that may occur with alcohol preparation of the skin must be weighed against the possible advantages. Most importantly, skin which is obviously dirty or contaminated must be cleaned with soap and water prior to any studies or before preparing the skin with alcohol. Insertion of needle electrodes through infected skin or sores is contraindicated.

Two reports of soft tissue infections at sites of needle EMG electrode insertion have been published, one involving *staphylococcus epidermidis*[18] and the other involving *mycobacterium fortuitum*.[19] In the outbreak of infections due to *m. fortuitum*, reusable needle electrodes were routinely disinfected with 2% glutaraldehyde and then rinsed with tap water, the probable source of the infecting organism. This outbreak demonstrates that patient infection may be associated with needle EMG electrodes that are not sterilized according to current guidelines.

The transmission of HIV from an infected dentist to patients has been reported.[20,21] The hepatitis B virus (HBV) also has been transmitted to multiple patients in the practices of individual infected healthcare workers during invasive procedures.[22–24] To reduce the small risk of transmission of bloodborne pathogens from the EDX physician or assistant to the patient, care

should be taken to protect the patient from contact with blood from the EDX physician or assistant, particularly through percutaneous injuries.

Disposable needle electrodes are recommended whenever possible. Reusable needle electrodes that are contaminated should not be stored or processed in a manner that requires workers to reach by hand into the containers where they have been placed. Needles should be sterilized with techniques compliant with Joint Commission on Accreditation of Healthcare Organizations (http://www.jointcommission.org), local, and institutional policies, as applicable.

Housekeeping

Contaminated work surfaces should be decontaminated with an appropriate disinfectant after completion of procedures; as soon as feasible when surfaces are overtly contaminated (e.g., after any major spill of blood); and at the end of the work shift if the surface may have become contaminated since the last cleaning.[6,8,9] Reusable electrodes for nerve conduction studies should also be properly cleaned between cases (even if associated risk of infection transmission is low/theoretical). Protective coverings, such as paper used to cover examination table surfaces, should be replaced after each patient. Environmental surfaces such as walls and floors are not associated with transmission of infections to patients or healthcare workers.[8,9] Therefore, extraordinary attempts to disinfect or sterilize these environmental surfaces are not necessary.

Regulated Waste

Regulated waste is defined by OSHA[6] as: liquid or semi-liquid blood or other potentially infectious materials; contaminated items that would release blood or other potentially infectious materials in a liquid or semi-liquid state if compressed; items that are caked with dried blood or other potentially infectious materials and are capable of releasing these materials during handling; and contaminated sharps and pathological and microbiological wastes containing blood or other potentially infectious materials. The actual volume of blood is not the determining factor as to whether a particular material is to be considered regulated waste. Thus, not all materials likely to be contacted by drops of blood in the EDX laboratory (patient gowns, table paper, gauze pads) need be considered regulated waste.

Non-sharp regulated waste, including laundry, should be placed in containers which meet OSHA standards. Disposal of all regulated waste should be in accordance with applicable federal, state, and local regulations.

Lymphedema

Lymphedema is the abnormal accumulation of lymph in an extremity or on the trunk or face. It is commonly seen following lymph node dissection for malignancies or progression of tumor that disrupts lymphatic flow. Lymphedema can also result from a number of other disorders, such as Milroy disease (congenital lymphatic hypoplasia), rheumatologic disorders, and morbid obesity. Lymph node dissection and local irradiation may impair lymphatic flow and increase the risk for cellulitis of the affected limb.[25] Patients with lymphedema or patients at risk for lymphedema are routinely cautioned to avoid percutaneous procedures in the affected extremity, namely venipuncture,[26,27] to prevent development or worsening of lymphedema or cellulitis. Despite the potential risk, the evidence for such

complications subsequent to venipuncture is limited.[27] No published reports exist of cellulitis, infection, or other complications related to EMG performed in the setting of lymphedema or prior lymph node dissection. However, given the unknown risk of cellulitis in patients with lymphedema, the AANEM believes that reasonable caution should be exercised in performing needle examinations in lymphedematous regions to avoid complications.[28] In patients with gross edema and taut skin, skin puncture by needle electrodes may result in chronic weeping of serous fluid. The potential bacterial media of such serous fluid and the violation of skin integrity may increase the risk of cellulitis. Prior to proceeding, the physician should weigh the potential risks of performing the study with the need to obtain the information gained.

Prosthetic joints

Prosthetic joints may become infected postoperatively due to hematogenous spread of bacteria. Bacteria may enter the circulatory system through infections involving the surgical site or other noncontiguous tissues or following procedures that produce bacteremia, including dental procedures and gastrointestinal studies.[29–33] The risk for prosthetic joint infection declines rapidly during the first few postoperative months and continues to decline during the first 2 postoperative years.[34] There are no published reports of complications related to needle EMG in patients with prosthetic joints. Based upon current published literature, it is the opinion of the AANEM that there is no contraindication to needle EMG in patients with prosthetic joints when sterile single patient use or properly autoclaved needle electrodes are utilized and infected spaces are not traversed by the needle electrode.

DISTURBANCES IN HEMOSTASIS

Bleeding and hematoma are potential risks of needle EMG in patients with or without disorders of hemostasis. There have been a number of studies on the incidence of clinically significant bleeding complications from needle EMG in patients who are receiving antiplatelet or anticoagulant therapy, or who suffer from thrombocytopenia. There are many different blood thinning medications now available, in addition to some herbal remedies that have anticoagulant properties.

Despite the inherent risk of needle EMG in patients with and without increased bleeding tendencies, since the technique was first developed in the 1960s, there have been only two case reports of compartment syndrome occurring after needle EMG, and in neither case was the patient taking blood thinning medication.[35,36] Similarly, there have been less than 5 reports of symptomatic hemorrhage following needle EMG in patients taking blood thinning medication.[37–40] However, two patients suffered trauma between the time of EMG and diagnosis of the hemorrhage; thus it is not clear that the EMG was the cause.[37,38]

There have been several retrospective studies examining the risk of paraspinal hematoma following needle EMG. An often-quoted study by Caress et al was triggered after an asymptomatic but quite large hematoma was noted in the lumbar paraspinals of a young woman after undergoing needle EMG.[41] The authors then performed an uncontrolled retrospective review of 17 further cases and found 4 other small, asymptomatic hematomas on MRI, but none of these hematomas were diagnosed on the original MRI report. Since then Gertken et al. have published a large case series of 370 patients who underwent paraspinal EMG within the 7

days preceding spine MRI (a total of 431 paraspinal areas were examined with both EMG and MRI).[42] There were no hematomas detected by 2 radiologists who independently reviewed the images. London et al. published a smaller controlled blinded study, comparing paraspinal hematoma rates in patients with and without EMG preceding the MRI.[43] No hematomas were detected in the 29 patients who underwent EMG prior to MRI (many of whom were taking aspirin and/or NSAIDs), and 2 hematomas were found on MRI in control patients who had not undergone EMG prior to the MRI. Gertken et al. has also published a review of the literature to date, in which the total number of muscles imaged post EMG is 1037, including 488 controls, 222 patients taking anticoagulants, 328 taking aspirin or clopidogrel, 35 taking NSAIDs and 3 taking herbal remedies that could affect clotting.[5] There were 10 asymptomatic hematomas found in this group, giving an overall rate of 0.96% risk of hematoma formation post EMG and in the specific subgroups: controls 1.02%, antiplatelet agents 0.61%, anticoagulants 1.35%.

There have also been studies evaluating the risk of hematoma in the limb muscles of patients on an anticoagulation and antiplatelet therapy. Lynch et al. prospectively assessed 51 controls, 57 patients on antiplatelet therapy, and 101 patients on warfarin (INR >1.5) for hematomas in the tibialis anterior with post-procedure ultrasound. There were 3 patients with completely asymptomatic hematomas (INR 3.9, INR 2.9, 325 mg aspirin). There was no statistically significant increase in the rate of hematoma formation in patients who were anticoagulated or receiving antiplatelet therapy.[44] Boon et al. subsequently prospectively studied high risk muscles (paraspinals, tibialis posterior, flexor digitorum longus, flexor pollicis longus, and iliopsoas) in the same 3 patient groups (control, warfarin, antiplatelet therapy) with 70 patients (100 muscles) in the control group, 78 patients (116 muscles) in the antiplatelet group, and 58 patients (107) muscles in the warfarin group. There was one subclinical hematoma in the tibialis posterior muscle (8.8 x 1.2 mm) in the antiplatelet group and one in the flexor pollicis longus muscle (16 x 3 mm) in the warfarin group. There was no significant difference in the hematoma rate between groups on Chi Square analysis.[45]

In addition, Zein et al evaluated the safety of needle electromyography and thrombocytopenic cancer patients with a retrospective review of 124 patients who underwent electrodiagnostic testing with diagnoses of a primary cancer and thrombocytopenia including 32 patients with platelet counts of 30,000/*u*L or less. There were no direct complications related to needle electromyography in these thrombocytopenic patients.[46]

In a survey of the 58 AANEM members, 93% of responders reported performing needle EMG in patients taking novel oral anticoagulants (DOACs, previously known as NOACs) and all responders thought the bleeding risk with DOACs was similar, if not safer, compared to conventional anticoagulants (including warfarin). [47]

In summary, there is a growing body of literature to support the safety of needle EMG, in patients with and without increased bleeding risk. In patients taking anticoagulation medication, including direct oral anticoagulants (DOACs), the thrombotic risk of discontinuing anticoagulation prior to EMG outweighs the risk of the needle examination while on anticoagulation and patients should not be directed to discontinue

antiplatelet medication prior to needle EMG.[48,49]

Overall, for needle EMG or SFEMG examination the current available evidence demonstrates it is safe to complete a full electrodiagnostic evaluation including needle electromyography in patients receiving antiplatelet medications, NSAIDs, herbal supplements, or those taking warfarin with an INR <3.0. Patients with INR >3.0 may complete needle electromyography at the discretion of the electromyographer considering the benefit of examining those specific muscles in that individual patient. Needle electromyography in thrombocytopenic cancer patients with platelet counts of less than 30,000 also appears to be safe. Caution in these patients should be exercised by using the smallest caliber needle, using extra pressure/time for hemostasis, and starting with more superficial muscles. However, no data indicate that various needle parameters (e.g. gauge, monopolar vs concentric, etc.) present different risks for bleeding complications.[5,45,47]

ELECTRICAL SAFETY

Patients undergoing EDX studies are exposed to electrical currents from the instrument's stimulator. The "electrically sensitive patient" is a term applied for potentially heightened risk in patients in critical care settings.[28] Two important defenses against electric injury are frequently lost in the critical care setting. First, the high electrical resistance provided by dry, intact skin is often breached by intravenous catheters. Currents applied near these could be conducted more easily to the rest of the body, including the heart.[50–53] Second, the large volume of soft tissue which surrounds the heart dilutes electric current applied to the body and protects the heart from direct electric current application. Central venous lines and intracardiac catheters bypass this large electrical sink and give otherwise harmless currents direct access to the immediate vicinity of the heart (micro shock).[54]

Two common sources of current which might affect the hospitalized patient are applied current from the stimulators of EDX instruments and leakage current from other electric equipment to which the patient is attached.

"Leakage current" is current that passes to the instrument chassis and can be delivered to the connected patient if improper grounding conditions exist. The maximum current allowed to leak from the case or from patient connections is 20μA.[54] Providing proper patient grounding is necessary to protect patients from electric injury. A three-prong power plug and wall receptacle are required for patient safety because it provides a harmless route for any chassis leakage current. The current flows directly to the ground, instead of to the patient. Testing of the instrument's chassis to ground wire integrity and wall receptacle grounds should be performed at regular intervals.[55]

Special safety considerations arise when patients are connected to multiple devices plugged into multiple outlets. Thus, if a patient is connected to equipment supplied from different outlets, one with a functional ground and the other nonfunctional, leakage current may flow from the instrument connected to the nonfunctional outlet ground, through the patient into the functional outlet ground. Thus, it is recommended that the patient be disconnected from all nonessential electric equipment during EDX testing**.** The

remaining equipment should be plugged into the same outlet or outlets in the same vicinity which share a common ground to the circuit breaker panel.

Note that the instrument chassis to wall receptacle ground pathway is not the same as the green wire ground (E0) on the EDX instrument's preamplifier. The E0 preamplifier input is completely separate from the chassis connections and serves as an electrical reference for inputs from the E1 (black) and E2 (red) preamplifier inputs. Proper placement of the E0 lead on the patient impacts signal quality rather than electrical safety.[56]

Electrodiagnostic laboratories should have in place a power outage and surge protection policy. In an effort to assist laboratories in meeting this standard, the AANEM has developed a model policy for Laboratory Accreditation.

Peripheral and Central Intravenous catheters and Implanted Cardiac Devices

Peripheral venous catheters may inhibit access to standard upper limb stimulation sites but do not pose and electrical risk if the insertion site is not leaking fluid. Cardiac pacemakers and implanted cardiac defibrillators (ICDs) both now termed implantable cardiac electronic devices (ICEDs) are increasingly common and there are theoretical concerns that electrical impulses of nerve conduction studies (NCS) could be erroneously sensed by devices and result in unintended inhibition or triggering of output or reprogramming of the device. In general, the closer the stimulation site is to the pacemaker and pacing leads, the greater the chance for inducing a voltage of sufficient amplitude to inhibit the pacemaker.[57–61]

Despite such concerns, no immediate or delayed adverse effects have been reported with routine NCS. Several studies on patients with ICEDs including ones also with central venous catheters found no evidence of cardiac device sensing or malfunctioning with routine NCS utilizing surface stimulation including the left brachial plexus at Erb point or the left spinal accessory nerve showed no evidence of adverse effects on pacing, cardiac device programming or arrhythmia.[57,62] Although percutaneous nerve stimulation may be performed in patients with implanted cardiac pacemakers with little risk,[63] complete inhibition of an older style unipolar pacemaker in conjunction with an interscalene nerve stimulator for regional anesthesia was reported.[64] Routine consultation with the patient's cardiologist is not required.[58–61]

Patients with external cardiac electronic devices (CEDs), the conductive lead, inserted into the heart (usually transvenously) and connected to the external cardiac pacemaker, presents a serious potential hazard of electric injury to the heart.[28] NCS are not recommended in the limb of the external conductive lead.

Needle EMG recording does not introduce electrical current into the body and, therefore it poses no risk of interference with implanted cardiac devices.

Deep Brain Stimulators

Deep brain stimulators (DBSs) are increasingly prevalent in patients with Parkinson disease, dystonia, and other disorders. The DBS devices consist of either (1) a single stimulator implanted on either side of the pectoralis muscle which is capable of stimulating the subthalamic nucleus bilaterally through two separate leads or (2) two stimulating devices, one placed on each

side of the chest, stimulating each ipsilateral side. The DBS leads typically traverse subcutaneously from the subclavicular area to the lateral-posterior neck and then over the occiput to penetrate the skull at variable sites in the parietal area.

Electromagnetic interference from medical and household devices may cause DBS devices to switch ON or OFF. Also, some patients may "experience a momentary increase in their perceived stimulation" described as uncomfortable (Medtronic Physician and Hospital Staff Manual; Soletra® & Kinetra® devices). More importantly, NCS pose a theoretical risk of introducing electrical current through the leads, which could be transmitted directly to the brain. The typical stimulation intensity of DBS devices ranges from 12–50 μA, which is far below the current employed in routine NCS (personal communication, Medtronic). The course of the DBS leads through the supraclavicular and occipital areas may pose additional risks to Erb point and cervical root stimulation. As there currently are no studies of the safety of NCS in patients with DBS devices, the physician should evaluate the risks and benefits of EDX testing in each case.

Other Electrical Stimulation Devices

Vagal nerve stimulators (like DBSs) are known to potentially interfere with needle EMG recordings. The associated artifacts may preclude reliable interpretation of the electrodiagnostic data in some muscles. For this reason, it is recommended that there are prior arrangements with the patient and their device specialists to have these devices able to be turned off during the electrodiagnostic study[59]. On a similar basis, it is best that spinal cord stimulators are also be able to be switched off during testing.

Electrodiagnostic testing of pregnant women

No known contraindications exist from performing needle EMG or NCS on pregnant patients. In addition, no complications from these procedures have been reported in the literature. Evoked potential testing, likewise, has not been reported to cause any problems when it is performed during pregnancy.

Elective needle electrode evaluation of chest wall and abdominal musculature

At times, needle nerve stimulation or needle EMG of intercostal muscles or muscles in the supraclavicular region, supraspinatus muscles, serratus anterior, rhomboids, diaphragm or paraspinal muscles (cervical or thoracic) may be indicated. Because of the proximity of these nerves and muscles to the pleura and lung, pneumothorax is a complication that may occur if the needle penetrates these structures. Ultrasound guidance may provide more accurate placement of the needle electrode, including insertion into the diaphragm, but this technique has not yet been proven to reduce risks.[65,66] Peritonitis is a potential hazard following inadvertent penetration of the peritoneum during intercostal or abdominal muscle needle EMG. The EDX physician must use clinical judgment to decide if the value of the data to be obtained is greater than the risk involved.[1,64–69]

Other considerations

In certain circumstances, the performance of needle EMG or NCS may lead to an increased incidence of complications or erroneous results. These may include a patient who is agitated and unable to cooperate, a patient with a very recent myocardial infarction, a patient with hyperesthesia, or a patient with a neuromuscular problem in an edematous

limb. Clinical judgment in each individual circumstance should be used in deciding if the risk of complication is greater than the value of the information to be obtained from an EDX examination.

Disclaimer

This report is provided as an educational service of the AANEM. It is based on an assessment of the current scientific and clinical information. It is not intended to include all possible methods of care of a particular clinical problem or all legitimate criteria for choosing to use a specific procedure. Neither is it intended to exclude any reasonable alternative methodologies. The AANEM recognizes that specific patient care decisions are the prerogative of the patient and his/her physician and are based on all of the circumstances involved.

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