# Safety of Needle Electromyography in Critically Ill Patients

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## ABSTRACT

**Introduction.** To evaluate the safety of needle electromyography (EMG) in critically ill intensive care unit (ICU) patients who are on anticoagulants and have comorbidities that increase the risk of bleeding and infections.

**Methods.** We conducted a retrospective chart review of critically ill patients who underwent needle EMG studies. The most common complications following needle EMG were reviewed and classified based upon common terminology criteria for adverse events (CTAC) criteria. Descriptive statistics were reported using the frequencies and percentages for categorical variables. Mean and interquartile range is used for continuous variables. All analyses were conducted using the Statistical Package for the Social Sciences (IBM SPSS Statistic Version 21, IMB Inc., Chicago, IL.

**Results.** Twenty-nine patients were included. 17 (58.6%) were males with a mean age of 60.8 +/- 16.7 years. The mean PT, PTT, and INR were 15.2 sec, 36.5 seconds, and 1.13, respectively. Fourteen (48.2%) patients in this cohort were treated with low molecular weight heparin (LMWH), and an additional 8 (27.5%) patients were administered subcutaneous (SC) heparin for deep vein thrombosis prophylaxis. Therapeutic heparin was being used in 3 (10.3%) patients and sequential compression devices (SCDs) in 4 (13.7%) patients. A total of 228 muscles were tested. Among them, 38 (16.6%) were deep muscles. There were no major bleeding complications at the time of the procedure and for the next seven days in any of the patients, including those with multiple medical comorbidities. All our patients met the grade 1 scale in the severity of adverse events criteria proposed by CTCAE.

**Conclusion.** Needle EMG is safe in critically ill ICU patients on anticoagulants and multiple comorbidities including those that increase the risk of bleeding and infection.

**Keywords:** *Needle EMG, ICU patients, Electro-Diagnostic Study, Safety of EMG, EMG in Critically Ill.*

## Introduction

Needle electromyography (EMG) is routinely performed in patients with suspected myopathy and peripheral nervous system disorders. The needle EMG portion of the electro diagnostic testing can be a painful and uncomfortable procedure but is generally well tolerated and poses very little risk to patients (1). The rare complications associated with the needle EMG include local bleeding, hematoma, infection, pneumothorax, and nerve injury (2). There are no absolute contraindications to the needle EMG procedure according to the guidelines proposed by the American Association of neuromuscular and electro diagnostic medicine (AANEM). The diagnostic yield of these studies, in many cases, outweighs the risks associated with the procedure in making a definite diagnosis (3). The safety of needle EMG has been studied extensively in a healthy population, patients on antiplatelet medications, and anticoagulant medications such as warfarin and non-vitamin K oral anticoagulants (4). Performing a detailed neurological examination in critically ill patients can be difficult, and electro diagnostic studies provide valuable information in these patients. Patients who are critically ill and in the intensive care unit (ICU) have multiple comorbidities and are sometimes admitted in the ICU for an underlying neuromuscular disorder.

However, the safety of needle EMG in critically ill ICU patients remains unknown. The objective of our study is to determine the safety of needle EMG procedures in critically ill ICU patients.

## Methods

Basic demographic and the coexisting ICU comorbid conditions, coagulation studies such as prothrombin time (PT), partial thromboplastin time (PTT), international normalized ratio (INR) within 24 hours before the needle EMG procedure were reviewed. Thrombocytopenia defined as a platelet count of less than 150,000 (5). Detailed histories, along with the indications for the usage, type of anticoagulation, and the concurrent usage of antiplatelet, were reviewed.

Needle EMG was performed as per the standard protocol and included both superficial and deep muscle groups (we classified muscles as deep if the muscle needed to be reached by traversing through another muscle or located next to a bony prominence) (6).

All the patients in our study underwent nerve conduction studies which include the motor (median, ulnar, tibial and fibular nerves), sensory nerve conduction studies (median, ulnar, superficial fibular and sural nerves), repetitive nerve stimulus, phrenic nerve conduction studies, and needle electromyography as per the standard guidelines proposed by the American Association of neuromuscular & electro diagnostic Medicine (AANEM) (6).

A retrospective chart review of commonly reported complications such as infection, bleeding, pneumothorax, compartment syndrome, and necrotizing fasciitis reviewed for seven days following the procedure. The infections during and after the needle EMG in critically ill patients were classified based on the definition of infection in patients with sepsis proposed by the international sepsis forum consensus conference (7). The hemorrhagic complications were classified based on the bleeding academic research consortium definition for bleeding (8). All our patients had a chest x-ray on the following day, the results were reviewed for pneumothorax, and electronic medical records (EMR) were reviewed for the occurrence of compartment syndrome. Finally, the severity of the adverse events was classified based on the common terminology criteria for adverse events (CTCAE) (9).

Descriptive statistics were reported using the frequencies and percentages for categorical variables. The mean and interquartile range is used for continuous variables. All analyses were conducted using the Statistical Package for the Social Sciences (IBM SPSS Statistic Version 21, IMB Inc., Chicago, IL.

## Results

Twenty-nine patients were included in this study. Reason for the exclusion of other patients is described in the figure 1.

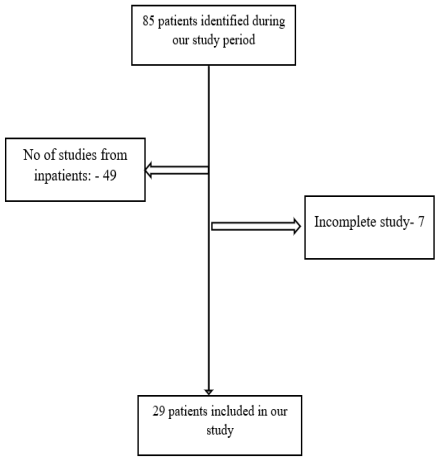


Figure 1: Reason for exclusion

Among them, 17 (58.6%) were males, and 12(41.4%) were females with a mean age of 60.8 +/- 16.7 years (mean +/- SD). The mean prothrombin time (PT) and partial thromboplastin time (PTT) were 15.2 (normal 13.8- 15.8 seconds) and 36.5 seconds (normal 27-37seconds), respectively. The mean International Normalized Ratio (INR) was 1.13 (normal INR- 0.9-1.1) of 23 patients who were on anti-coagulation, excluding the four patients with subcutaneous compression devices. Thrombocytopenia was seen in 7 (23%) patients. Fourteen (48.2%) patients in this cohort were treated with low molecular weight heparin (LMWH), and an additional 8(7.5%) patients were administered subcutaneous (SC) heparin for deep vein thrombosis prophylaxis. Therapeutic Intravenous (IV) heparin was being used in 3 (10.3%) patients and sequential compression devices (SCDs) used in 4 (13.7%) patients. Five (17.2%) patients were on aspirin, and the rest of them were not on any antiplatelet therapy. Twenty (69%) patients had at least one comorbid condition such as cardiovascular disease, malignancy, renal failure, or diabetes mellitus. The most common indication for needle EMG study was a generalized weakness in 21 (72.4%), difficulty to wean off the ventilator in 4 (13.7%), bilateral lower extremity weakness in 2 (6.8%), hemi-facial weakness in 1(3.4%), and neck weakness in 1 (3.4%) patient. Out of 29 patients, 26 underwent upper and lower extremity nerve conduction studies, and three patients exclusively underwent repetitive nerve stimulus along with needle EMG. Among 26 patients, four of them who had difficulty in weaning from the ventilator underwent phrenic nerve conduction studies, MRI of the C-spine, and ultrasound of the diaphragm. At the time of needle EMG study, 8 (33.3%) patients met the definition for the infection proposed by the international sepsis forum consensus conference. A total of 228 muscles were tested. Among them, 38 (16.6%) were deep muscle groups. The muscle groups are summarized in table 1.

None of the patients required any immediate intervention to prevent bleeding, and none had visible clinical hematoma following the procedure, including those patients who had thrombocytopenia. Also, none of the patients required a radiological evaluation for hematoma during the next seven days of chart review. Twenty-one (72.5%) patients had no signs of infection, including superficial and deep tissue infections, and this remained unchanged at seven-day follow-up. None of the patients had a pneumothorax (on follow up imaging: chest x-ray) or compartment syndrome. All our patients met the grade 1 scale in the severity of adverse events criteria proposed by CTCAE. Diagnosis of the un-

Table 1: Muscle groups tested in critically ill patients who underwent needle EMG.

| Muscles checked | Frequency of muscles |
|---|---|
| Deltoid | 25 |
| First Dorsal interossei | 25 |
| Biceps | 22 |
| Triceps | 13 |
| Iliopsoas | 8 |
| Trapezius | 5 |
| Cervical paraspinal | 2 |
| Thoracic paraspinal | 2 |
| Lumbar paraspinal | 1 |
| Vastus medialis | 25 |
| Mentalis | 1 |
| Tensor fascia lata | 10 |
| Frontalis | 1 |
| Orbicularis oculi | 1 |
| Gastrocnemius | 24 |
| Pronator teres | 17 |
| Tibialis posterior | 1 |
| Extensor digitorum communis | 9 |
| Tibialis anterior | 27 |
| Rectus femoris | 1 |
| Extensor indicis pollicis | 3 |
| Abductor pollicis brevis | 5 |
| Total | 228 |

derlying neuromuscular condition was made in 93% of the patients that underwent needle EMG study, and the details summarized in table 2.

## Discussion

In this study, we assessed the safety of needle EMG in patients who are critically ill and found the procedure to be relatively safe with only mild complications based on CTCAE criteria. No patients had secondary complications such as infection, hematoma, pneumothorax, compartment syndrome for seven days following the electro diagnostic studies.

Superficial and deep tissue infections are rarely reported in patients who underwent EMG studies, and the risk is estimated to be less than 1/10,000 (2). Burris et al. reported

Table 2: Summary of diagnosis from electrodiagnostic study

| Diagnosis | No. of patient |
|---|---|
| Critical illness neuropathy/ Myopathy | 7(24.1%) |
| Guillain-Barré Syndrome and its variants | 7(24.1%) |
| Generalized Sensory motor Polyneuropathy | 4(13.7%) |
| Motor Neuron disease | 4(13.7%) |
| Myasthenia gravis | 2 (6.9%) |
| Normal | 1(3.4%) |
| Inflammatory Myopathy | 1(3.4%) |
| Vasculitis Neuropathy | 1(3.4%) |
| Inconclusive | 2(6.9) |

the first case of cellulitis after the needle EMG, and another case series described six patients who had skin and soft tissue infection (10, 11). In both studies, EMG was done using a reusable needle. We believe the reported cases of infection may have been due to improper sterilization techniques rather than the standard electro diagnostic procedure itself. The previous practice of performing needle EMG by using a reusable needle has been replaced by using disposable fine concentric needle electrodes. We are unaware of superficial infection after the introduction of disposable needles in clinical practice. In our study, 21 out of 29 who are critically ill with multiple comorbidities underwent needle EMG, and none of them had superficial skin infections or usage of antibiotics on follow up. These findings suggest that needle EMG testing might be safe even in critically ill patients with multiple comorbidities. 8 of the 29 patients were taking antibiotics during needle EMG studies and continued to be on them during follow up. Of the five patients in our study with lymphedema that underwent EMG procedure, none of the patients had an infection or required antibiotics on the follow up.

The AANEM recommends exercising caution while performing needle EMG in patients with platelets counts less than 50,000 IU, INR >1.5-2.0, or PT >1.5-2.0 seconds. (AAEM guidelines, 1999) (3). In our study, seven patients had thrombocytopenia, and their platelet counts ranged between 95,000-1, 40,000 number/ vol. Units, and none of them had immediate bleeding complications. Clinically significant bleeding complications are very rare following needle EMG procedure, and isolated case reports have been

reported in patients on therapeutic anticoagulation (12, 13, 14). The overall incidence of subclinical hematoma identified by ultrasound and other studies involving both superficial and deep muscle groups after a needle EMG procedure ranges between 0.62 and 1.45% (4, 15). Both studies included patients on therapeutic warfarin, antiplatelet agents, and healthy controls. In our study, three patients were on therapeutic anticoagulation at the time of the study. Very limited data is available on the safety of electro diagnostic studies in patients on prophylactic subcutaneous heparin or low molecular weight heparin. Gertken et al. did a retrospective chart review of 370 patients who underwent electro diagnostic studies and magnetic resonance imaging (MRI) of the spine within one week following the procedure. Four of those patients were on prophylactic anticoagulation (2 patients were on heparin while one patient each was on LMWH and dalteparin), and none had a symptomatic or asymptomatic hematoma on follow up imaging (16). In our study, 21 (72.5%) patients were on prophylactic anticoagulation and did not require immediate intervention or evaluation for hematoma following the procedure though, none of them had follow-up imaging for the assessment of hematoma. We believe patients may or may not have had asymptomatic bleeding following needle EMG, and it is consistent with the grade 1 scale in the severity of adverse events criteria proposed by CTCAE.

Compartment syndrome is a very rare complication after the standard needle EMG study. In our literature review, two isolated case reports with compartment syndrome following electro diagnostic studies were identified. In both cases, symptoms started immediately and slowly progressed in the next few hours before it became clinically evident. Accidental damage to the blood vessels might be the potential cause in these patients (17, 18). None of our patients had compartment syndrome even in the presence of multiple comorbidities and lymphedema.

Pneumothorax is a rare and potentially lethal complication after the needle EMG procedure. The high-risk muscle groups include serratus anterior, supraspinatus, rhomboids, diaphragm, trapezius, and cervical paraspinal muscles. Kassardjian et al. retrospectively reviewed 64,490 patients that were diagnosed with pneumothorax over 18 years. Among them, only seven patients had pneumothorax primarily due to electro diagnostic studies. In the same study, 22 patients also had a pneumothorax, which is temporally associated with EMG studies but was believed to be due to other causes such as lung biopsy or thoracoc entesis. In their series, the risk for the development of pneumothorax is higher in the serratus anterior (0.445%) and diaphragm (0.149%) followed by trapezius (0.117%) with the lowest risk from cervical (0.004%) and thoracic (0.003%) paraspinal muscles (19). All of the patients that had symptoms due to the pneumothorax the diagnosis were confirmed within 24 hours following electro diagnostic study. In our study population, we sampled only the trapezius and paraspinal muscles, and none had symptomatic pneumothorax in the follow-up imaging using a chest x-ray.

The following are the limitations of this study. The procedure technique varies between different electromyographers, making it difficult to generalize the conclusions from our findings. It is possible that the patients might have had asymptomatic bleeding secondary to needle EMG during follow-up. Few patients were already on antibiotics for various reasons before the needle EMG, it was difficult to assess for infection rate secondary to the procedure. Finally, it is noteworthy to mention that the authors were not blinded to the patient's condition, i.e., the comorbid conditions and the anticoagulation status. Another limitation is that the diaphragm and serratus anterior was not examined in any patient in this series.

## Conclusion

Needle EMG of commonly tested superficial and deep muscles is safe in critically ill ICU patients who are on anticoagulants and have multiple medical co-morbidities including those that increase the risk of infection and bleeding.

## Summary

Electro diagnostic studies like nerve conduction studies and needle EMG is gold-standard test in the evaluation of peripheral nerve disorders. American Association of Neuromuscular and Electro diagnostic Medicine (AANEM) recommends that there is no absolute contraindication to perform needle EMG. However, they recommend being cautious in patients on medically induced coagulopathy and thrombocytopenia. Patients admitted to ICU have multiple comorbidities and prone to have complications from the medical procedures and diagnostic evaluations. However, the safety of the needle EMG in critically ill is unknown. Our stud evaluated the safety of needle EMG in patients with multiple comorbidities and evaluated for various complications like bleeding, infection, pneumothorax, and compartment syndrome. No major complications are found based on our study. Also, all our patients met the grade 1 scale in the severity of adverse events criteria proposed by CTCAE.

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