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Research Paper

ANATOMICAL LOCALIZATION OF MOTOR POINTS IN GASTROCNEMIUS MUSCLE AND IT'S SIGNIFICANCE IN THE TREATMENT OF SPASTICITY

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Spasticity of ankle plantar flexor and the foot invertor are frequently seen in patients with central nervous system disorders and are often disabling. Aim of this study was to identify the anatomic localization of motor points in Gastrocnemius muscle in relation to the bony landmark. The objective of the present study is to describe the distribution and branching pattern of motor nerve and motor points that innervate the gastrocnemius. Thirty lower limb specimens were dissected for morphometric measurements. The tibial nerve was identified and the branch to the gastrocnemius muscle exposed. The distances from the line joining both the epicondyle of the femur to medial motor branch and from the branching point of medial motor branch to the motor point were noted and it was 14.13 ±11.47 mm and 36.87 ±14.35 mm respectively. The distances from the line joining both the epicondyle of the femur to lateral motor branch and from the branching point of medial motor branch to the motor point were noted and it was 19.47mm ±20.28mm and 34.03mm ±9.47mm respectively. The angle between the tibial nerve and the nerves to each of medial and lateral heads of the gastrocnemius muscle were 8.80 ±1.39 and 9.66 ±1.78 respectively.

Keywords: Gastrocnemius, Anatomy, Motor point, Motor branch, Spasticity

INTRODUCTION

Spasticity is a manifestation in many central nervous system disorders, including cerebral palsy. Such spasticity requires adequate treatment because the increased muscle tone inhibits vertical growth of muscle leading to permanent contracture and disability (Ziv I *et al.*, 1984). Spasticity of ankle plantar flexor and the foot invertor are frequently seen in patients with central nervous system disorders and are often disabling (Doute D A *et al.*, 1997). Stroke, spastic diplegic and tetraplegic cerebral palsy, spinal cord injury and traumatic brain injury are the most common causes of spasticity, for this different treatment modalities are adopted. Nerve blocks are one of the most commonly used procedures

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to control localized spasticity in neuro-rehabilitation. Commonly used therapeutic agents range from short acting anesthetic agents to long acting anesthetic agents (Wang G K *et al*., 1996) and neurolytic agents such as alcohol, phenol etc. and recently botulinum toxin is also used for chemodenervation. An electromyographic guidebook is generally used as a reference for botulinum injection sites (Perotto A 1994).

These procedures usually have a lasting effect up to months after treatment, depending on the chosen agent and technique of application (Halpern D *et al*., 1967; Petrillo C R *et al*., 1988; Wainapel S F *et al*., 1984). Regardless of the neurolytic agent used chronic neuro-pathic pain can occur as a result of sensory nerve fiber injury or irritation. Other problems are, pain during injection, tissue destruction, increased risk of thrombophlebitis and lack of selectivity on motor function (Gracies J M *et al*., 1997). Precisely-placing the injecting needle tip to the pure motor branch (muscular branch) which does not contain any cutaneous sensory fiber would help to avoid these complications (Wang G K *et al*., 1986) and at the same time reduce the amount of neurolytic agent injected. So, ability to precisely place the injecting needle tip closest to the motor nerve and motor point will be very valuable for executing such a procedure.

The objective of the present study is to describe the distribution and branching pattern of motor nerve and motor points that innervate the gastrocnemius. Data analysis focused on mean distances and standard deviations from a fixed anatomical reference point, but also on trying to find out techniques for safe needle tip placement closest to the desired motor branches with minimal needle insertions. This knowledge will make the procedures to become more effective and safer.

Aim of this study was to identify the anatomic localization of motor points in Gastrocnemius muscle in relation to the bony landmark.

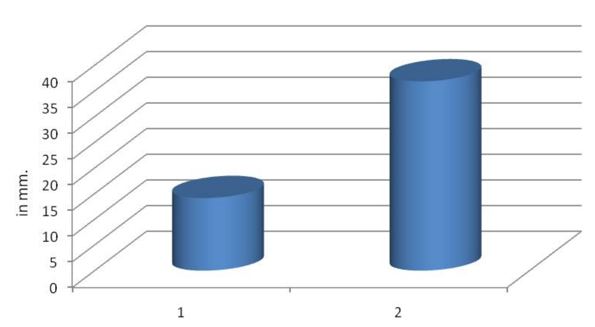
MATERIALS AND METHODS

Thirty lower limb specimens were dissected for morphometric measurements. The popliteal fossa was exposed in the prone position with the hip, femur and knee in the prone position and the fat was carefully removed. The tibial nerve was identified and the branch to the gastrocnemius muscle exposed. The fixed point for measurement was the medial and lateral epicondyles of the femur. The distance from the line joining both the epicondyle of the femur to medial and lateral motor branch and from the motor branch to the medial lateral motor points were measured. Angle made by the tibial nerve and the nerves to each of medial and lateral heads of the gastrocnemius muscle were measured by using goniometer.

Table 1: Showing the Measurement of Tibial Medial Branch Length in mm

	To Medial Head of Gastrocnemius	
	Line Connecting Epicondyles to Motor Branch (mm)	Motor Branch to Motor Point (mm)
Mean value	14.13	36.87
Std. deviation	11.479	14.352

Figure 1: Medial Head of Gastrocnemius



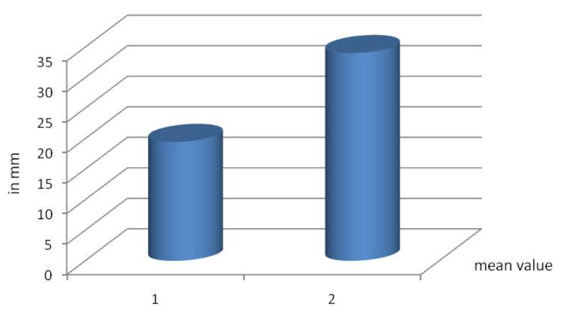
RESULTS

The study reveals the following results among the 30 legs dissected. Length and angle of the branches of the tibial nerve were measured.

Table 2: Showing the Measurement of Tibial Lateral Branch Length in mm

	To Lateral head of Gastrocnemius	
	Line Connecting Epicondyles to Motor Branch (mm)	Motor Branch to Motor Point (mm)
Mean value	19.47	34.03
Std. deviation	20.286	9.474

Figure 2: Lateral Head of Gastrocnemius



1. Mean value of medial branch (line joining the epicondyles to motor branch) in mm.

Table 3: Showing the Mean and Standard Deviation of Angle Between Tibial Nerve and Medial and Lateral Branches

	Medial angle	Lateral angle
Mean value	8.80	9.66
Standard value	1.399	1.789

Table 4: Comparison of Medial and Lateral Branch Length in mm

Name of the study	Year of the study	Line connecting epicondyles to medial motor branch (mm)	Line connecting epicondyles to lateral motor branch (mm)
Woo Kyoung *et al.*	2002	3.68 ± 11.44	4.45 ± 11.96
Present study	2010	14.13 ± 11.479	19.47 ± 20.286

Table 5: Comparison of Medial and Lateral Branch Length (it's Division from Tibial Nerve to Motor Point) in mm

Name of the study	Year of the study	Medial branch	Lateral branch
Woo Kyoung *et al.*	2002	37.79 ±7.80	32.16 ±4.64
Present study	2010	36.87 ±14.35	34.03 ±9.47

Table 6: Comparison of Medial and Lateral Branch Length (It's Division from Tibial Nerve to Motor Point) in mm

Name of the study	Year of the Study	Medial Tibial Branch Angle	Lateral tibial branch angle
Woo Kyoung et al	2002	8.80±1.30°	9.66±1.78°
Present study	2010	8.85±3.15°	9.58 ±2.55°

2. Mean value of medial tibial branch from motor branch to motor point (in mm).

1. Mean value of lateral branch (line joining the epicondyles to motor branch) in mm

2. Mean value of lateral tibial branch from motor branch to motor point (in mm).

DISCUSSION

In the present study, we determined the surface landmarks that may be used to localize the tibial nerve in the popliteal fossa (Rorie D K *et al.*, 1980). Described the tibial nerve as coursing 0.5-1.0 cm medial to the center of popliteal fossa, but only indicated the point where the tibial nerve traverses at the popliteal fossa and provided a limited description of the general course of the nerve.

With precise localization of motor branches (MBs) and motor points (MPs) probing can be minimized, and thus the risk of thrombophlebitis of calf muscles can be reduced. In addition, with knowledge of the precise localization of MBs, selective motor block can be done with a minimal dose of phenol, reducing the risk of sensory symptoms.

Precise anatomic localization also helps to shorten the procedure time for neurolysis and may reduce the dose of sedatives needed in children. For neurolysis with botulinum toxin, because there were few references on the localization of MPs, an electromyographic guide book is generally used as a reference for injection sites (Petrillo C R *et al*., 1988). With the precise localization of MPs, maximum paralytic effects can be achieved safely (Perotto A *et al*., 1994). The location of MPs and MBs was described in two ways. One method, using the distance of the MB in centimeters from the intercondylar line, was compared with a second method that used relative measures of distances as a proportion of lower leg length. As in the previous study of MBs in the hamstring muscles, (Siedel P M *et al*., 1980) our results indicate no significant difference between these two methods, and either method can be used in localization of MBs and MPs in children. However, because of the small number of cadavers, their study has limited power, and the lack of a significant difference between the two methods of localization method may be inaccurate. The cadavers displayed significant symmetry of the motor nerve branch of the tibial nerve between right and left limbs. In most cadavers, there was only one motor nerve branch to each of the triceps surae muscles, and the most proximal motor nerve branch was that to the medial gastrocnemius muscle. The next branch was to the lateral gastrocnemius muscle, and the most distal motor nerve branch supplied the soleus muscle. Most of the MBs to the medial gastrocnemius muscle arose from the tibial nerve below the intercondylar line, but in seven limbs, the MB originated above the intercondylar line. Therefore, during neurolysis, one should start to search for the MB with a surface stimulator above the intercondylar line (above the knee crease). There has been no controlled study to determine the optimal method of peripheral neurolytic blockade of the triceps surae musculature. Further studies are necessary to investigate clinical correlation and the localization described in this study, and further studies are also necessary to determine localization in children.

Chin *et al*. (2005) investigated the accuracy of intramuscular injection of BTX-A in children with cerebral palsy and showed that the accuracy of manual needle placement in comparison with electric stimulation-guided needle placement was acceptable only for the gastrosoleus (75%). Our data imply that even though the electric stimulation-guided technique could increase the accuracy of needle placement, it could not exclusively select the gastrocnemius, which is the most important target muscle for equinus gait in children with cerebral palsy. In most clinical settings, BTX injection is performed in outpatient clinics under local anesthesia. Electric stimulation-guided techniques might induce more pain and discomfort in children with cerebral palsy. However, in certain clinical conditions, it would be appropriate to increase the accuracy of needle placement by dual-guidance techniques (i.e., by electric stimulation and ultrasonography), for example, when deep-seated or small muscles need to be targeted such as iliopsoas, etc. (Willenborg M J *et al*., 2002). In the present study we have measured the length and angle of the tibial nerve. The tibial nerve was identified and the branch to the gastrocnemius muscle was dissected. The fixed point for measurement was the medial and lateral epicondyle of the femur. The motor branch of the gastrocnemius muscle was defined as the point where the branching nerve left the perineurium of the tibial nerve and the motor point was defined as the point where the motor branch entered the muscle belly.

The nerve to medial head of gastrocnemius muscle in the popliteal fossa was measured initially. First, an imaginary vertical line connecting both the epicondye was drawn on the posterior surface of the calf. Then the distances from the line joining both the epicondyles of the femur to medial motor branch and from the medial motor branch to the medial motor point, was 14.13 ± 11.47 mm and 36.87 ± 14.35 mm respectively (Table 1). The nerve to lateral head of gastrocnemius muscle in the popliteal fossa was measured next i.e. the distances from the line joining both the epicondyle of the femur to lateral motor branch and from the lateral motor branch to the lateral motor point, was 19.47 mm ± 20.28 mm and 34.03 mm ± 9.47 mm respectively (Table 2).

Angle made by the tibial nerve and the nerves to each of medial and lateral heads of the gastrocnemius muscle were measured by using goniometer. The point where the motor branch arise from the tibial nerve was considered as the fixed point of the goniometer. The course of the tibial nerve was considered as the stable arm and the movable arm was used to measure the angle between the tibial nerve and the nerves to each of medial and lateral heads of the gastrocnemius muscle is 8.80 ±1.39 and 9.66 ±1.78 respectively (Table 3). Woo Kyoung Yoo *et al.* (2002) have reported a comparable readings in the length of tibial branch and tibial angles (Tables 4, 5 and 6).

CONCLUSION

We conclude that, the accurate anatomical localization of motor points in gastrocnemius muscle will help the clinicians to inject the neurolytic agents precisely on these points, minimize the complications, regulate it's dosages and maximize the paralytic effect.

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