LAPORAN AKHIR PROJEK PENYELIDIKAN
R & D JANGKA PENDEK

"Localization of the spinal nucleus of accessory nerve in the albino rat."

Investigators:

Prof. Madya Muzammil Ullah
Prof. Othman Mansor
Dr. Zul Izhar Mohd. Ismail

Grant No: 304 / PPSP / 6131212

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USM J/P- 06

BAHAGIAN PENYELIDIKAN & PEMBANGUNAN
CANSELORI
UNIVERSITI SAINS MALAYSIA

Laporan Akhir Projek Penyelidikan Jangka Pendek

1) Nama Penyelidik: **Prof. Madya Muzammil Ullah**

Nama Penyelidik-Penyelidik Lain (Jika berkaitan) **Prof. Othman Mansor**

Dr. Zul Izhar Mohd. Ismail

2) Pusat Pengajian/Pusat/Unit **Pusat Pengajian Sains Perubatan**

3) Tajuk Projek:. **Localization of the spinal nucleus of accessory nerve in the albino rat.**

4) (a) Penemuan Projek/Abstrak

(Perlu disediakan makluman di antara 100 – 200 perkataan di dalam Bahasa Malaysia dan Bahasa Inggeris. Ini kemudiannya akan dimuatkan ke dalam Laporan Tahunan Bahagian Penyelidikan & Pembangunan sebagai satu cara untuk menyampaikan dapatan projek tuan/puan kepada pihak Universiti).

SEPARATE SHEETS ARE ATTACHED.

Penentuan lokasi nukleus spinal saraf aksesori pada tikus albino

MUZAMMIL ULLAH, OTHMAN MANSOR DAN ZUL IZHAR MOHD. ISMAIL

ABSTRAK

PENGENALAN. Nukleus spinal saraf aksesori (SNA) adalah kumpulan somata neuron motor yang membekali otot sternokleidomastoid (SCM) dan trapezius (TRAP). Terdapat banyak pandangan yang berbeza berhubung kedudukan memanjang dan topografi SNA walau dalam spesis yang sama. Kitamura & Sakai (1982) dan Matesz & Szekely (1983) telah menemui lokasi SNA pada tikus. Terdapat beberapa percanggahan di antara mereka berhubung kedudukan memanjang SNA dan lokasi somata neuronnya. Percanggahan penemuan tersebut telah mencetuskan penyelidikan ini pada tikus.

TUJUAN PENYELIDIKAN. Tujuan dan objektif penyelidikan ini adalah seperti berikut: (1) Untuk menentukan lokasi nukleus spinal saraf aksesori pada tikus albino, (2) untuk menentukan hubungannya dengan kolum sel yang terletak bersebelahan dengannya, dan (3) untuk menentukan lokasi somata neuron motor yang membekali otot sternokleidomastoid dan trapezius di dalam nukleus tersebut.

KAEDAH. 20 ekor tikus Sprague-Dawley (12 jantan, 8 betina) telah digunakan dalam penyelidikan ini. Tikus-tikus tersebut telah dibahagi kepada dua kumpulan, Kumpulan-I dan Kumpulan-II. Kumpulan I mengandungi 15 ekor tikus, manakala Kumpulan-II mengandungi 5 ekor tikus. Bagi Kumpulan-I, SNA telah ditentukan lokasinya dengan menggunakan teknik pengangkutan aksonal retrograd peroksidase 'horseradish' (HRP). Bagi Kumpulan II, SNA telah ditentukan lokasinya dengan menggunakan teknik degenerasi retrograd menggunakan Tionin sebagai pewarnaan untuk granul Nissl.

KEPUTUSAN DAN KESIMPULAN.

1. Secara memanjang, SNA telah ditemui lokasinya di bahagian kaudal (0.9 hingga 1.2 mm) medula oblongata, serta di sepanjang segmen C-1, C-2, C-3, C-4, C-5 dan satu per empat bahagian rostral segmen C-6 saraf tunjang.
2. Di bahagian kaudal medula oblongata, SNA diwakili oleh kumpulan somata neuron yang terletak ventrolateral kepada fiber piramid yang berlalu di bahagian dorsolateral selepas dekusasi.
3. Di saraf tunjang, somata neuron motor SNA terletak di kolum dorsomedial (DM) dan sentral (CEN) pada C-1, di kolum DM, CEN dan ventrolateral (VL) pada C-2 serta hanya di kolum VL pada C-3, C-4, C-5 dan satu per empat bahagian rostral C-6.
4. Somata neuron motor yang membekali SCM terletak di bahagian kaudal (0.9 hingga 1.2 mm) medula oblongata ventrolateral kepada fiber piramid yang berlalu di bahagian dorsolateral selepas dekusasi. Ia juga terletak di kolum DM dan CEN pada C-1, di kolum DM, CEN dan VL pada C-2 serta hanya di kolum VL di tiga per empat bahagian rostral C-3.
5. Somata neuron motor TRAP terletak hanya di kolum VL di tiga per empat bahagian kaudal C-2, di sepanjang C-3, C-4 dan C-5 serta di satu per empat bahagian rostral C-6.

Localization of the spinal nucleus of accessory nerve in the albino rat

MUZAMMIL ULLAH, OTHMAN MANSOR AND ZUL IZHAR MOHD. ISMAIL

ABSTRACT

INTRODUCTION. The spinal nucleus of accessory nerve (SNA, hereafter) is the group(s) of motor neuron somata that supply the sternocleidomastoid (SCM) and trapezius (TRAP) muscles. There are many conflicting views regarding the longitudinal extent and topography of the SNA even in the same species. Kitamura & Sakai (1982) and Matesz & Szekely (1983) located the SNA in rat. There is some disagreement among them regarding the longitudinal extent of the SNA and location of its neuron somata. These disagreements prompted the present investigation in rat.

AIMS OF THE STUDY. The aims and objectives of the study were as follows: (1) To investigate the location of the spinal nucleus of accessory nerve in albino rat, (2) to find out its relationship with neighbouring cell columns, and (3) to investigate within the nucleus, the locations of motor neuron somata supplying the sternocleidomastoid and trapezius muscles.

MATERIALS AND METHODS. 20 Sprague-Dawley rats (12 males, 8 females) were used in the study.The animals were divided into two groups, Group-I and Group-II. Group-I included 15 rats and Group-II included 5 rats. In Group-I, the SNA was localized by retrograde axonal transport of HRP (Horseradish peroxidase) technique. In Group II, the SNA was localized by Retrograde degeneration technique using Thionine as stain for Nissl granules.

RESULTS AND CONCLUSIONS.

1. Longitudinally, the SNA was located in the caudal part (caudal 0.9 to 1.2 mm) of Medulla oblongata, and the whole lengths of C-1, C-2, C-3, C-4, C-5 and the rostral-fourth of C-6 segments of the spinal cord.

2. In the caudal part of the medulla oblongata, the SNA was represented by a group of neuron somata lying immediately ventrolateral to the pyramidal fibres that were passing dorsolaterally after their decussation.

3. In the spinal cord, the motor neuron somata of SNA were located in dorsomedial (DM) and central (CEN) columns at C-1, in DM, CEN and VL (ventrolateral) columns at C-2 and in VL column only at C-3, C-4, C-5 and rostral-fourth of C-6.

4. The motor neuron somata supplying the SCM were located in the caudal part (caudal 0.9 to 1.2 mm) of medulla oblongata ventrolateral to the pyramidal fibres that were passing dorsolaterally after their decussation. They were also located in DM & CEN columns at C-1, in DM, CEN & VL columns at C-2 and only in VL column at the rostral three-fourths of C-3.

5. The motor neuron somata of TRAP were located in the ventrolateral column (VL) only in the caudal three-fourths of C-2, in the whole lengths of C-3, C-4 and C-5, and in the rostral fourth of C-6.

(b) Senaraikan Kata Kunci yang digunakan di dalam abstrak:

Bahasa Malaysia	Bahasa Inggeris
Nukleus spinal	Spinal nucleus
Saraf aksesori	Accessory nerve
Tikus	Rat
Sternokleidomastoid	Sternocleidomastoid
Trapezius	Trapezius
HRP	HRP
Granul Nissl	Nissl granules
Saraf tunjang	Spinal cord
Medula oblongata	Medulla oblongata

5) Output Dan Faedah Projek

(a) Penerbitan (termasuk laporan/kertas seminar)
(Sila nyatakan jenis, tajuk, pengarang, tahun terbitan dan di mana telah diterbit/dibentangkan).

MANUSCRIPT: The attached manuscript is going to be sent for publication in a European Journal, preferably in Journal of Anatomy, London.

PRESENTATION: The work will be presented in the 10th National Conference on Medical Sciences scheduled to be held in May, 2005, in Kampus Kesihatan, USM, Kubang Kerian.

(b) Faedah-Faedah Lain Seperti Perkembangan Produk, Prospek Komersialisasi Dan Pendaftaran Paten.
(Jika ada dan jika perlu, sila guna kertas berasingan)

Not Applicable

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(c) Latihan Gunatenaga Manusia

i) Pelajar Siswazah **Not Applicable**

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ii) Pelajar Prasiswazah: **Not Applicable**

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iii) Lain-Lain : **Not Applicable**

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6. Peralatan Yang Telah Dibeli:

NIL

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UNTUK KEGUNAAN JAWATANKUASA PENYELIDIKAN UNIVERSITI

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T/TANGAN PENGERUSI
J/K PENYELIDIKAN
PUSAT PENGAJIAN

Professor Zabidi Azhar Mohd. Hussin
Chairman of Research & Ethics Committee
School of Medical Sciences
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16150 Kubang Kerian,
KELANTAN, MALAYSIA.

13/4/11

JABATAN BENDAHARI
UNIVERSITI SAINS MALAYSIA

KAMPUS CAWANGAN KELANTAN
GERAN PENYELIDIKAN UNIVERSITI JANGKA PENDEK
PUSAT PENGAJIAN SAINS PERUBATAN
(304/PPSP/6131212)

PENYELIDIK : PROF. MADYA MUZAMMIL ULLAH

NAMA PROJEK : "LOCALIZATION OF THE SPINAL NUCLEUS OF ACCESSORY NERVE IN THE ALBINO RAT"

PENYATA PERBELANJAAN BAGI TEMPOH BERAKHIR PADA 31 JULAI 2004

PECAHAN KEPALA		PERUNTUKAN (RM)	PERBELANJAAN 2003	BAYARAN 2004	TANGGUNGAN	PERBELANJAAN 2004	JUMLAH PERBELANJAAN	BAKI KESELURUHAN
11000	GAJI DAN UPAHAN	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14000	ELAUN LEBIH MASA	0.00	0.00	473.85	0.00	473.85	473.85	(473.85)
15000	BONUS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21000	PERJALANAN & PENGANGKUTAN ORANG	870.00	0.00	0.00	0.00	0.00	0.00	870.00
22000	PENGANGKUTAN BARANG-BARANG	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23000	PERHUBUNGAN DAN UTILITY	300.00	0.00	0.00	0.00	0.00	0.00	300.00
24000	SEWAAN	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25000	BAHAN-BAHAN MAKANAN & MINUMAN	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26000	BEKALAN BAHAN-BAHAN MENTAH & BAHAN PEMBAIKAN	500.00	0.00	0.00	0.00	0.00	0.00	500.00
27000	BEKALAN BAHAN-BAHAN LAIN	12,550.00	12,027.75	3,286.00	0.00	3,286.00	15,313.75	(2,763.75)
28000	PENYELENGARAAN & PEMBAIKAN KECIL YANG DIBELI	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29000	PERKHIDMATAN IKTISAS & LAIN-LAIN PERKHIDMATAN & HOSPITALITI	800.00	50.00	0.00	0.00	0.00	50.00	750.00
35000	LAIN-LAIN HARTA MODAL	1,500.00	0.00	0.00	0.00	0.00	0.00	1,500.00
	JUMLAH BESAR	16,520.00	12,077.75	3,759.85	0.00	3,759.85	15,837.60	682.40

FINAL REPORT

Localization of the spinal nucleus of accessory nerve in the albino rat

MUZAMMIL ULLAH, OTHMAN MANSOR AND ZUL IZHAR MOHD. ISMAIL

ABSTRACT

The spinal nucleus of accessory nerve (SNA, hereafter) is the group(s) of motor neuron somata that supply the sternocleidomastoid (SCM) and trapezius (TRAP) muscles. There are many conflicting views regarding the longitudinal extent and topography of the SNA even in the same species. These disagreements prompted the present investigation.

20 Sprague-Dawley rats (12 males, 8 females) were used in the study. The animals were divided into two groups, Group-I and Group-II. Group-I included 15 rats and Group-II included 5 rats. In Group-I, the SNA was localized by retrograde axonal transport of HRP (Horseradish peroxidase) technique. In Group II, the SNA was localized by retrograde degeneration technique using thionine as stain for Nissl granules.

Longitudinally, the SNA was found to be located in the caudal part (caudal 0.9 to 1.2 mm) of Medulla oblongata, and the whole lengths of C-1, C-2, C-3, C-4, C-5 and the rostral-fourth of C-6 segments of the spinal cord. In the caudal part of the medulla oblongata, the SNA was represented by a group of neuron somata lying immediately ventrolateral to the pyramidal fibres that were passing dorsolaterally after their decussation. In the spinal cord, the motor neuron somata of SNA were located in dorsomedial (DM) and central (CEN) columns at C-1, in DM, CEN and VL (ventrolateral) columns at C-2 and in VL column only at C-3, C-4, C-5 and rostral-fourth of C-6. The motor neuron somata supplying the SCM were located in the caudal part (caudal 0.9 to 1.2 mm) of medulla oblongata ventrolateral to the pyramidal fibres that were passing dorsolaterally after their decussation. They were also located in DM & CEN columns at C-1, in DM, CEN & VL columns at C-2 and only in VL column at the rostral three-fourths of C-3. The motor neuron somata of TRAP were located in the ventrolateral column (VL) only in the caudal three-fourths of C-2, in the whole lengths of C-3, C-4 and C-5, and in the rostral fourth of C-6.

INTRODUCTION

The spinal nucleus of accessory nerve (SNA, hereafter) is the group(s) of motor neuron somata that supply the sternocleidomastoid (SCM) and trapezius (TRAP) muscles.The SNA has been investigated in experimental animals by many workers using different techniques. (e.g. retrograde axonal transport of HRP by Kitamura and Sakai, 1982; retrograde cobalt labeling by Matesz & Szekely,1983; retrograde transport of fluorescent tracer by Clavenzani et al.,1994; retrograde degeneration technique by Ullah & Salman, 1986)

The SNA has also been identified in human embryos by Pearson (1938) and in human cadavers by Routal and Pal (2000) but their works lack experimental support.

There are many conflicting views regarding the longitudinal extent and topography of the SNA even in the same species. Flieger (1964) in sheep, Augestine and White (1986) in Japanese baboon, Ueyama et al. (1990) in monkey, Ullah and Salman (1986) in rabbit etc. have localized the SNA in the caudal part of medulla oblongata and upper cervical segments of spinal cord. Satomi et al. (1985) in cat, Jenny et al. (1988) in monkey, Clavenzani et al. (1994) in sheep etc. have localized the SNA in the upper cervical segments of spinal cord only.

Dubois and Foley (1936), Holomanova et al. (1972), Augustine & White (1986) etc. have found that the SNA in made of only one group of neuron somata. Flieger (1964), Szteyn (1961), Clavenzani et al. (1994) etc. have found that the SNA is made of two groups of neuron somata, (dorsal and ventral groups). Liinamaa et al. (1997) have found three groups of motor neuron somata in SNA.

Kitamura & Sakai (1982) and Matesz & Szekely (1983) located the SNA in rat. There is some disagreement among them regarding the longitudinal extent of the SNA and location of its neuron somata. Kitamura & Sakai (1982) found them in the upper cervical region of spinal cord forming three longitudinal columns, column M, column L and column 5. Matesz and Szekely (1983) located them in the caudal part of the medulla oblongata and in C-1 to C-6 segments of spinal cord forming three columns, medial, lateral and ventral. These disagreements prompted the present investigation in rat.

AIMS OF THE STUDY

The aims and objectives of the study were as follows: (1) To investigate the location of the spinal nucleus of accessory nerve in albino rat, (2) to find out its relationship with neighbouring cell columns, and (3) to investigate within the nucleus, the locations of motor neuron somata supplying the sternocleidomastoid and trapezius muscles.

MATERIALS AND METHODS

20 Sprague-Dawley rats (12 males, 8 females) were used in the study. The animals were divided into two groups, Group-I and Group-II. Group-I included 15 rats and was further divided into three sub-groups, IA, IB and IC of 5 rats each. Group-II included 5 rats. All experiments were done on the right side whereas the left side was used as the control.

GROUP-I:

Under general anaesthesia (30 mg. per Kg of Nembutal sodium solution, intraperitoneally) and aseptic conditions, the right sternocleidomastoid (SCM) or right trapezius (TRAP) or both were exposed in the neck and either of the two muscles or both were injected 0.05 ml of 30% horseradish peroxidase (HRP; Sigma type VI) solution as per details given in Table-I

Table I. Table showing the amount of HRP solution injected into SCM , TRAP or both.

Group	No. of animals	Muscle(s) injected	Amount of HRP solution
IA	Five (3 males, 2 females)	Right SCM and Right TRAP	0.05 ml of 30% HRP in each muscle
IB	Five (3 males, 2 females)	Right SCM	0.05 ml of 30% HRP
IC	Five (3 males, 2 females)	Right TRAP	0.05 ml of 30% HRP

After 48 hours of survival, the animals were re-anaesthetised and, perfused transcardially (through left ventricle), first with normal saline at room temperature, then with 1.25% gluteraldehyde and 1% paraformaldehyde in O.1 M phosphate buffer at pH 7.4 at room temperature, and finally, with 10% sucrose in the same buffer at 4 degrees C.

After perfusion, the medulla oblongata and the 1st, 2nd, 3rd, 4th, 5th, and 6th cervical segments of spinal cord were removed by dorsal approach, placed in above sucrose buffer solution at 4 degrees C for 24 hours. Thereafter, their serial transverse section were cut in a cryostat at 60 micrometers.

The sections were collected in the above phosphate buffer without sucrose and treated according to tetramethyl benzidine (TMB)-HRP method of Mesulam (1978).

GROUP-II

Included 5 rats (3 males, 2 females). Under general anaesthesia (30 mg per Kg Nembutal sodium, intraperitoneally) and aseptic conditions, the trunk of the right accessory nerve (before it supplies the SCM and TRAP muscles) was exposed in the neck and a portion removed to prevent re-union. After 21 to 28 days of post-operative survival, the animals were killed, their circulation flushed with normal saline and perfused with 10% formal-saline at a pressure of 120 mm Hg.

After perfusion, the medulla oblongata and the 1st, 2nd, 3rd, 4th, 5th and 6th Cervical segments of spinal cord were removed by a dorsal approach, separated from each other, embedded in paraffin wax and their serial transverse sections cut at a thickness of 40 micrometers. The sections were mounted on slides and stained with thionine.

The sections were examined microscopically to identify the chromatolysed neuron somata and to compare the experimental right side with the control left side. From the serial transverse sections, a reconstruction was made of the the longitudinal cell columns of the ventral grey horn of the spinal cord using the method of Elliott (1942) in which a series of sections are summated.

RESULTS

The cell columns found on reconstruction from the serial transverse sections are shown in Figure 1. The results of the present study were as follows (Figures 1-24):

(A) The locations of HRP labeled neuron somata in animals of group IA (in which HRP was injected in both SCM & TRAP muscles) and the chromatolysed neuron somata in animals of group II (in which the trunk of accessory nerve was cut in the neck) were identical and were as follows (Figures 1, 2, 22, 23 and 24):

1. They were located in the caudal part (caudal 0.9 to 1.2 mm) of medulla oblongata, the whole lengths of C-1, C-2, C-3, C-4 and C-5 and the rostral-fourth of C-6.
2. In the medulla oblongata, they were located at a site immediately ventrolateral to the pyramidal fibres (that were passing dorsolaterally after their decussation).
3. In C-1, they were located in the dorsomedial (DM) and central (CEN) columns of the ventral grey horn.
4. In C-2, they were located in three columns, the dorsomedial (DM), central (CEN) and ventrolateral (VL) columns.
5. In C-3, C-4, C-5 and rostral-fourth of C-6, they were located in the ventrolateral (VL) column.

(B) In animals of Group IB (in which HRP was injected into SCM only), the locations of HRP labeled neuron somata were as follows (Figure 2):

1. They were located in the caudal part (caudal 0.9 to 1.2 mm) of Medulla oblongata, the whole lengths of C-1 and C-2 and rostral three-fourths of C-3.
2. In the medulla oblongata, they were located at a site immediately ventrolateral to the pyramidal fibres (that were passing dorsolaterally after their decussation).
3. In C-1, they were located in dorsomedial (DM) and central (CEN) columns.
4. In C-2, they were located in three columns, dorsomedial (DM), central (CEN) and ventrolateral (VL).
5. In the rostral three-fourths of C-3, they were located in the ventrolateral (VL) column.

(C) In animals of Group IC (in which the HRP was injected into TRAP only), the HRP labeled neuron somata were located in the ventrolateral column (VL) only in caudal three-fourths of C-2, the whole lengths of C-3, C-4 and C-5 and the rostral-fourth of C-6 (Figure 2).

The HRP labeled and chromatolysed neuron somata referred above were observed on the right (experimental) side only and were absent on the control left side.

CONCLUSIONS

As a result of this study, the following conclusions were drawn:

1. Longitudinally, the SNA was located in the caudal part (caudal 0.9 to 1.2 mm) of Medulla oblongata, the whole lengths of C-1, C-2, C-3, C-4 and C-5 and the rostral-fourth of C-6.

2. In the caudal part of the Medulla oblongata, the SNA was represented by one group of neuron somata lying immediately ventrolateral to the pyramidal fibres that were passing dorsolaterally after their decussation.

3. In the spinal cord, the neuron somata of SNA were located in two longitudinal cell columns (DM & CEN) at C-1, three longitudinal cell columns (DM, CEN & VL) at C-2 and in only one longitudinal cell columns (VL) at C-3, C-4, C-5 and rostral-fourth of C-6.

4. The motor neuron somata supplying the SCM were located in the caudal part (caudal 0.9 to 1.2 mm) of medulla oblongata immediately ventrolateral to the pyramidal fibres that were passing dorsolaterally after their decussation. They were also located in two longitudinal cell columns (DM & CEN) at C-1, three longitudinal cell columns (DM, CEN & VL) at C-2 and in only one longitudinal cell columns (VL) at rostral three-fourths of C-3 of spinal cord.

5. The motor neuron somata of TRAP were located in the ventrolateral column only in the caudal three-fourths of C-2, the whole lengths of C-3, C-4, C-5 and the rostral fourth of C-6.

DISCUSSION

LONGITUDINAL EXTENT OF SNA

There is disagreement regarding the longitudinal extent of the SNA in various species of mammals.

It has been located in the caudal part of medulla oblongata and upper cervical segments by Flieger (1964) in sheep, (1966) in horse, (1967) in cow, Matesz and Szekely (1983) in rat, Ullah and Salman (1986) in rabbit, Augustine and White (1986) in Savanna baboon, Ueyama et al. (1990) in Japanese monkey and by Routal and Pal (2000) in human cadaver. The results of the present study are in agreement with the above investigators because in the present study also the SNA was found to be located in the caudal part of medulla oblongata and upper cervical segments of spinal cord.

Pearson (1938) in human embryo, Romanes (1941) in rabbit, Holomanova et al. (1972) in cat, Ruminska-Kowalska et al. (1976) in dog, Kitamura and Sakai (1982) in rat, Satomi et al. (1985) in cat, Jenny et al. (1988) in monkey, Clavenzani et al. (1994) in sheep, Liinamaa et al. (1997) in feline located the SNA only in the cervical segments of spinal cord and the results of present study are in disagreement with them because in the present study the SNA was located in both the upper cervical segments of spinal cord and medulla oblongata.

TOPOGRAPHY OF SNA

Dubois and Foley (1936) in cat, Pearson (1938) in human embryo, Romanes (1941) in rabbit, Holomanova et al. (1972) in cat, Ruminska-Kowalska et al. (1976) in dog, Ullah and Salman (1986) in rabbit, Augustine and White (1986) in baboon, and Routal and Pal (2000) in human cadavers, reported only one group of neuron somata representing the SNA. The results of the present study are not in agreement with them in

this respect because in the present study three longitudinal groups of neuron somata were found to represent the SNA.

The Results of the present study are also in disagreement with Flieger (1964), Flieger (1966), Flieger (1967, Flieger (1970), Clavenzani et al. (1994) who found two groups of neuron somata representing SNA.

Kitamura and Sakai (1982) in rat, Matesz and Szekely (1983) in rat and Liinamaa et al. (1997) in feline found three longitudinal cell columns representing the SNA. Kitamura and Sakai (1982) located the motor neuron somata of SCM and TRAP muscles by retrograde axonal transport of HRP method in rat. Their cell columns G1 correspond to VM column, G2 correspond to CEN column and G4, G5, G6 correspond to VL column of the present study. They located HRP labeled neuron somata of SNA in G1 (VM) at C-1, in G2 (CEN) and G6 (VL) at C-2, in G6 (VL) at C-3, in G5 (VL) at C-4, in G4 (VL) at C-5, and in C4 (VL) at rostral half of C-6. The results of the present study in spinal cord are nearly in agreement with Kitamura and Sakai except that in the present study the central column (CEN) containing SNA motor neuron somata was also found in the caudal three-fourths of C-1. The major disagreement with Kitamura and Sakai is the fact that in the present study the SNA was located in the caudal part of medulla oblongata also but they did not find the SNA there.

From the above description, it is evident that Kitamura and Sakai (1982) found in rat that the rostral part of SNA is located in the medial part of ventral grey horn (in their columns G1 and G2) whereas its caudal part was located in the lateral part of this horn (in ventrolateral column). A more or less similar findings were also reported in rat by Matesz and Szekely (1983) and in cat (Tsuruyama, 1939; Holomanova et al. , 1972), sheep (Romanes, 1940; Flieger, 1964), rabbit (Romanes, 1941; Ullah and Salman, 1986), horse and cow (Flieger, 1966, 1967) though there is a little difference among these species as to the degree and level at which the positional shift occurs. In general the present study is also in agreement with these investigators because in the present study also a more or less similar positional shift of neuron somata was observed. In the present study it was observed that in the rostral-fourth of C-1, the SNA was located in the ventromedial column, in caudal three-fourths of C-1, it was in ventromedial and central columns, in C-2 it was in ventromedial, central and ventrolateral columns and in C-3 to C-6, it was in ventrolateral column only.

Matesz and Szekely (1983) located the SNA in rat by cobalt labeling (using cobaltic lysine complex solution) and found three longitudinal cell columns containing cobalt labeled neuron somata. They were (1) medial, (2) lateral, and (3) ventral. Their Medial column began at the level of pyramidal decussation in medulla oblongata and terminated at C-2, their lateral column was found in the ventrolateral part of ventral horn and extended from C-2 to C-6, and according to them, their ventral column was not easilydistinguished from the ventral column and was made of thin thread of neurons lying ventral to lateral column. It also extended from C-2 to C-6. Their medial column correspond to the VM column in C-1 and C-2 and their lateral and ventral columns combine together correspond to the neuron somata of SNA observed in VL column of the

present study. However, no continuity was observed between the ventromedial column and the group of neuron somata of SNA observed in the medulla oblongata in the present study. Matesz and Szekely (1983) also observed a few intersposed labeled neuron somata between their medial and lateral columns. These interposed somata correspond to Neuron somata observed in the the central (CEN) column of the present study.

LOCATION OF STERNOCLEIDOMASTOID AND TRAPEZIUS MOTOR NEURON SOMATA WITHIN THE SNA

There are only a few reports regarding the locations of sternocleidomastoid (SCM) and trapezius (TRAP) motor neurons within the SNA.

In rat, Kitamura and Sakai (1982), found that the location of SCM motor neuron somata in C-1, C-2 and C-3, and TRAP motor neuron somata in C-2 (caudal half), C-3, C-4, C-5 and C-6 (rostral half). They did not find SCM motor neuron somata in the medulla oblongata. Regarding the longitudinal extents of motor neuron somata of SCM and TRAP, the findings of the present study are in disagreement with them because in the present study the SCM motor neuron somata were found to be located in the caudal part of medulla oblongata, in whole lengths of C-1 and C-2 and rostral three-fourths of C-3 and TRAP motor neuron somata in caudal three-fourths of C-2, whole lengths of C-3, C-4, C-5 and rostral-fourth of C-6. Kitamura and Sakai (1982) found that the SCM motor neuron somata were located in their column-M (corresponding to ventromedial and central columns of present study) and in columns L and 5 (corresponding to ventrolateral column of present study) and that the TRAP motor neuron somata were located in their columns L and 5 (corresponding to ventrolateral column of present study). Regarding the sites of locations of motor neuron somata of SCM and TRAP in the spinal cord, the results of the present study are in agreement with the above observations of Kitamura and Sakai (1982).

It is known that sternocleidomastoid (SCM) has two parts, sternomastoid (SM) and cleidomastoid (CM) and trapezius has three parts, cleidotrapezius (CT), acromiotrapezius (AT) and spinotrapezius (ST). All parts of sternocleidomastoid and trapezius are innervated by motor neuron somata of spinal nucleus of accessory nerve (SNA) which has been located in rat in the present study. However, there is some controversy as to whether all fibres arising from neuron somata of SNA pass through accessory nerve or some of them also pass through cervical spinal nerves. There are many conflicting reports on the presence or absence of motor innervation of SCM and TRAP through the cervical spinal nerves. Kitamura and Sakai (1982) reported that the CM part of SCM and all three parts of TRAP receive double motor innervation, that is, through the accessory nerve and through ventral rami of cervical spinal nerves. According to them, the motor fibres of the cervical part of accessory nerve arise from their columns M and L and of the cervical spinal nerves arise from their column-5. Russel (1897) and Sherrington (1898) in monkey and Straus and Howell (1936) in chimpanzee and dog reported that the cervical spinal nerves contributed motor innervation to SCM and TRAP but Corbin and Harrison (1938) and Rapoport (1978) denied it in the cat. Motor innervation of TRAP through cervical spinal nerves was reported by Sternberg

(1898) in monkey and by Brodal (1969) in human. Yashizaki (1961) in human and rabbit, Lesbre and Maignon (1908) in dog and Kumaki (1970) in rat reported that the cervical spinal nerves contribute motor innervation to SCM whereas it was denied by Chauveau (1891) in horse, Sternberg (1898) in monkey and Lesbre and Maignon (1908) in cow and horse. However, in the present study the SNA was fully localized but it was not investigated as to whether the SNA sends fibres to SCM and TRAP through the accessory nerve only or through both accessory nerve and cervical ventral rami.

Matesz and Szekely (1983) investigated the SNA in rat but did not locate the SCM and TRAP motor neurons somata within the SNA.

In monkey, rabbit and rat, Karim and Nah (1981) found that the SCM motor neuron somata chiefly occupied a medial position in the ventral grey horn of the upper cervical segments of spinal cord and TRAP motor neuron somata were located at the lateral part of this horn at a more caudal level of cervical spinal cord. They did not find any SCM motor neuron somata in the medulla oblongata. Regarding the location of SCM motor neuron somata, the findings of the present study do not agree with Karim et al. (1981) because in the present study the motor neuron somata of SCM were found to be located in medulla oblongata and the VM, CEN and VL columns of spinal cord. The findings of the present study are in agreement with them regarding the location of motor neuron somata of TRAP because in the present study, the TRAP motor neuron somata were located in the ventrolateral column (VL) situated in the lateral part of ventral grey horn.

The findings of the present study are in disagreement with Satomi et al. (1985) who found in cat that the SCM motor neuron somata were located in C-1 to C-3 only whereas in the present study, they were located in medulla oblongata also. Regarding the location of TRAP motor neuron somata, the present study is nearly in agreement with Satomi et al. who found them located chiefly more caudally as compared to SCM motor neuron somata.

The results of present study are in agreement with Ueyama et al (1990) who found in monkey that the SCM motor neuron somata were located in the medulla oblongata and upper three cervical segments and TRAP motor neuron somata were located in C-2 to C-6.

In feline, Liinamaa et al. (1997) found three motor nuclei laminated mediolaterally representing sternomastoid (SM), cliedomastoid (CM) and trapezius (TRAP) respectively. They found SM and CM in upper cervical segments and TRAP in C-1 to C-6. The results of the present study in rat are in disagreement with Liinamaa et al.

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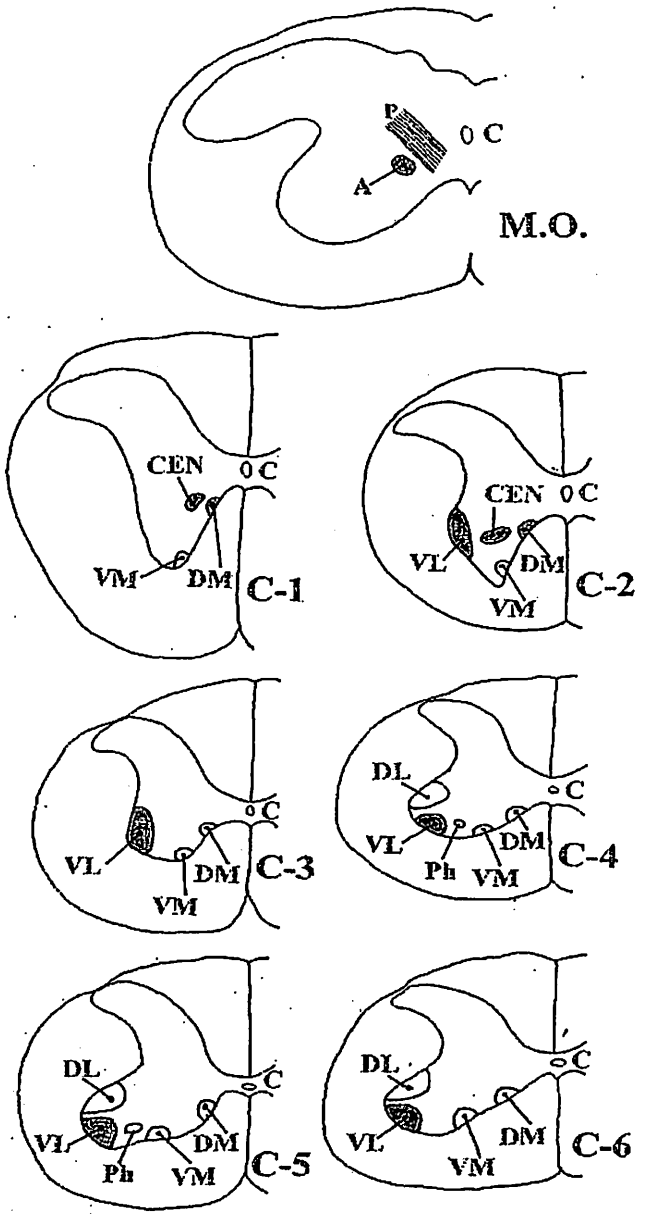

Figure 1.

Diagram showing the transverse sections of the caudal end of medulla oblongata (M.O.), middle of 1st (C-1), 2nd (C-2), 3rd (C-3), 4th (C-4) and 5th (C-5) cervical segments and rostral part of 6th (C-6) cervical segment of spinal cord. (C=central canal; P=pyramidal fibres; A=location of motor neuron somata of SNA in medulla oblongata; DM=dorsomedial column; VM=ventromedial column; VL=ventrolateral column; DL=dorsolateral column; CEN=central column. Solid BLACK areas indicate the locations of neuron somata of SNA found in the present study.

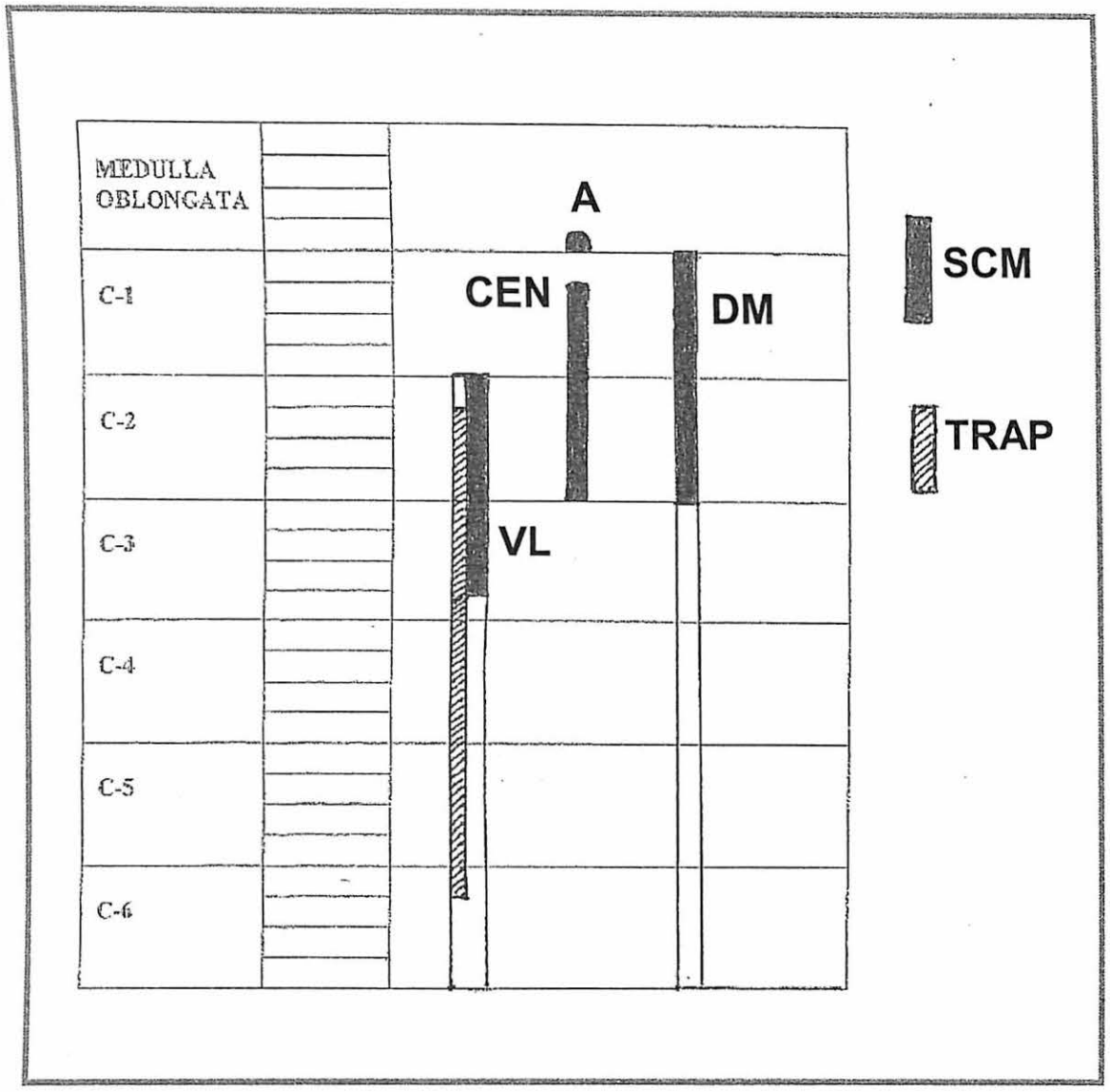

Figure 2. Diagram showing the longitudinal extents of the locations of motor neuron somata of the sternocleidomastoid (SCM) shown as solid black areas and trapezius (TRAP) shown as striped area. (A = location in lower part of medulla oblongata; C-1 to C-6 = First to sixth cervical segments of the spinal cord; DM = Dorsomedial column; VL = Ventrolateral column; CEN = Central column

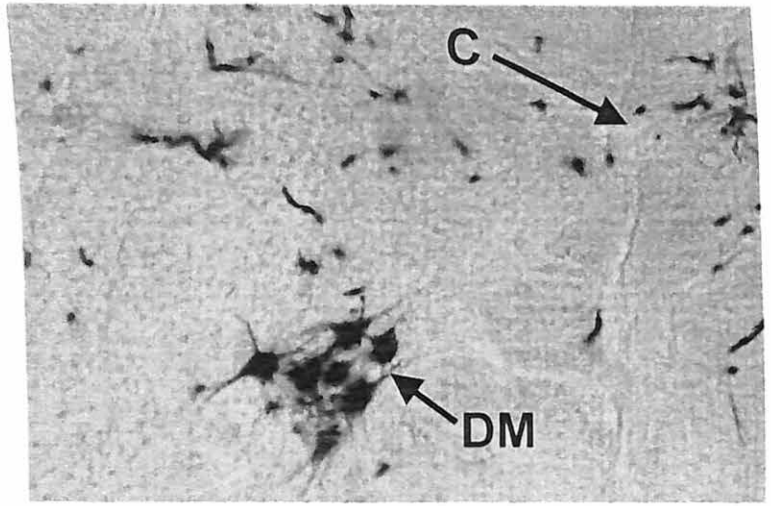

Figure 3. Photomicrograph showing the location of HRP labeled neuron somata of SCM in dorsomedial (DM) column at C-1. (C=central canal)

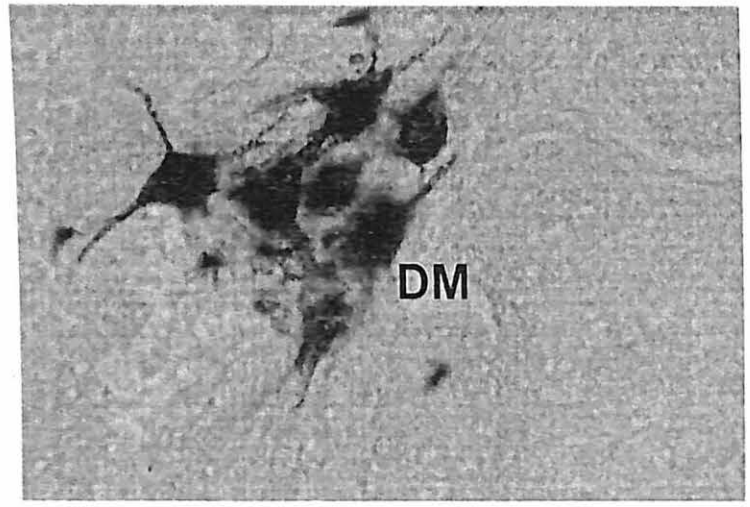

Figure 4. Photomicrograph showing the location of HRP labeled neuron somata of SCM in dorsomedial (DM) column at C-1.

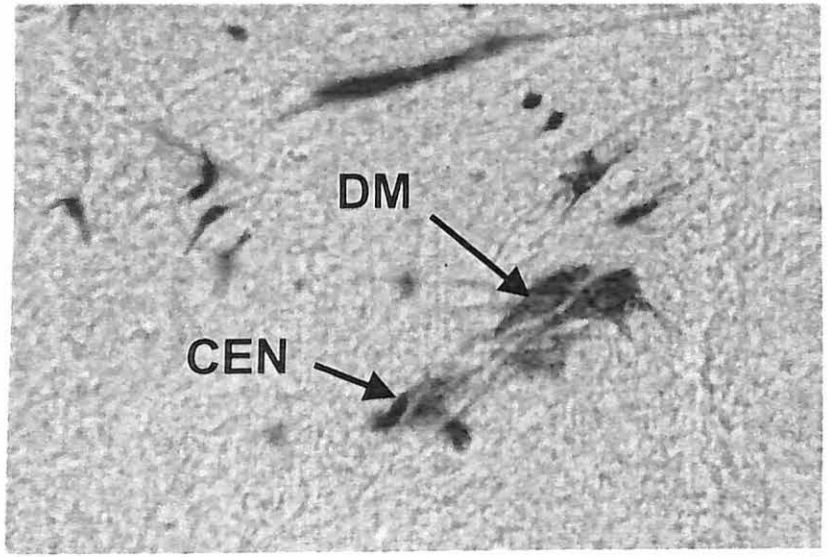

Figure 5. Photomicrograph showing the location of HRP labeled neuron somata of SCM in dorsomedial (DM) and central (CEN) columns at C-1.

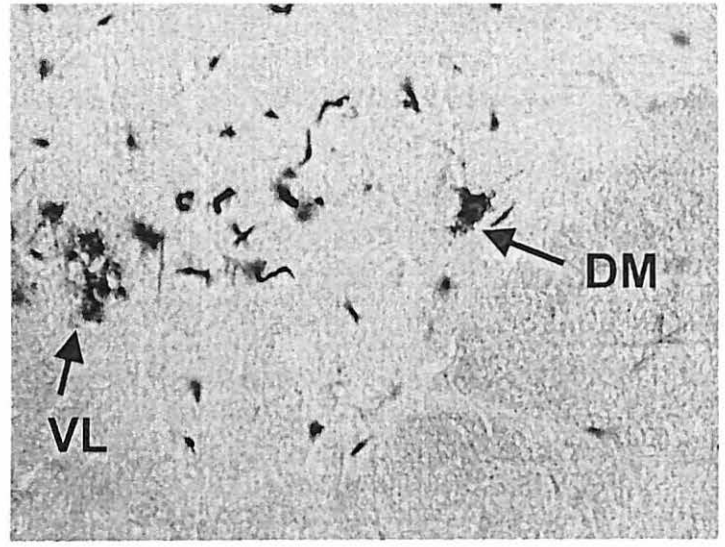

Figure 6. Photomicrograph showing the location of HRP labeled neuron somata of SCM in dorsomedial (DM) and ventrolateral (VL) columns at C-2.

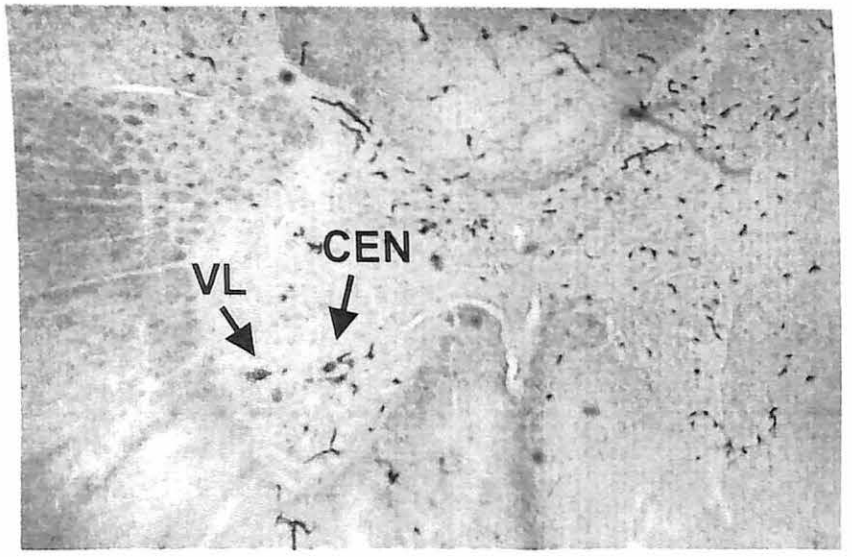

Figure 7.

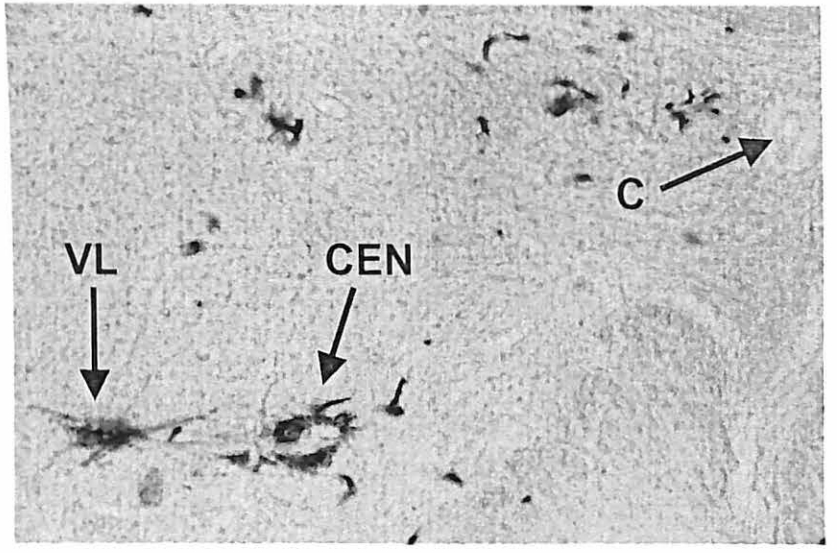

Figure 8.

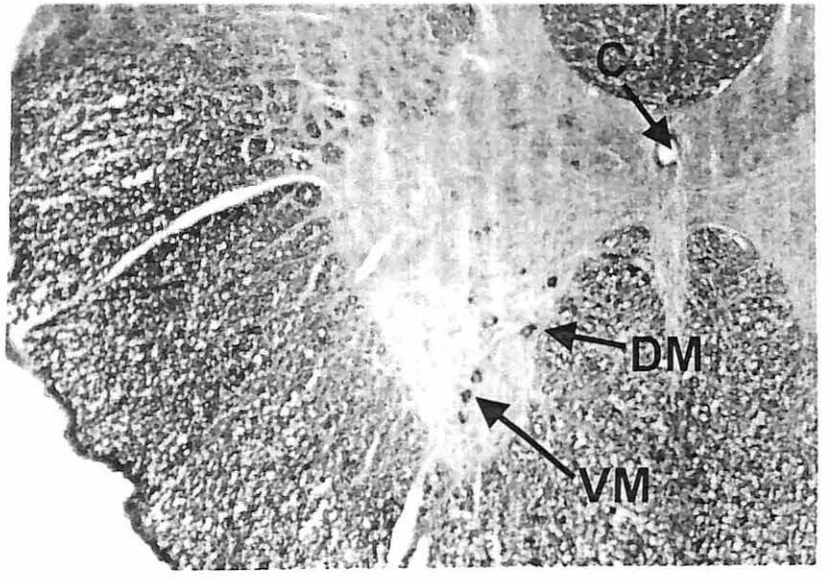

Figure 9.

Figure 7. Photomicrograph of a transverse section of the spinal cord showing the location of HRP labeled neuron somata of SCM in the central (CEN) and ventrolateral (VL) columns at C-2.

Figure 8. Photomicrograph of a transverse section of the spinal cord showing the location of HRP labeled neuron somata of SCM in the central (CEN) and ventrolateral (VL) columns at C-2 (C = Central canal).

Figure 9. Photomicrograph of a transverse section of the spinal cord showing some neuron somata of dorsomedial (DM) and ventromedial (VM) columns at C-1 (Thionine stain; C = Central canal).

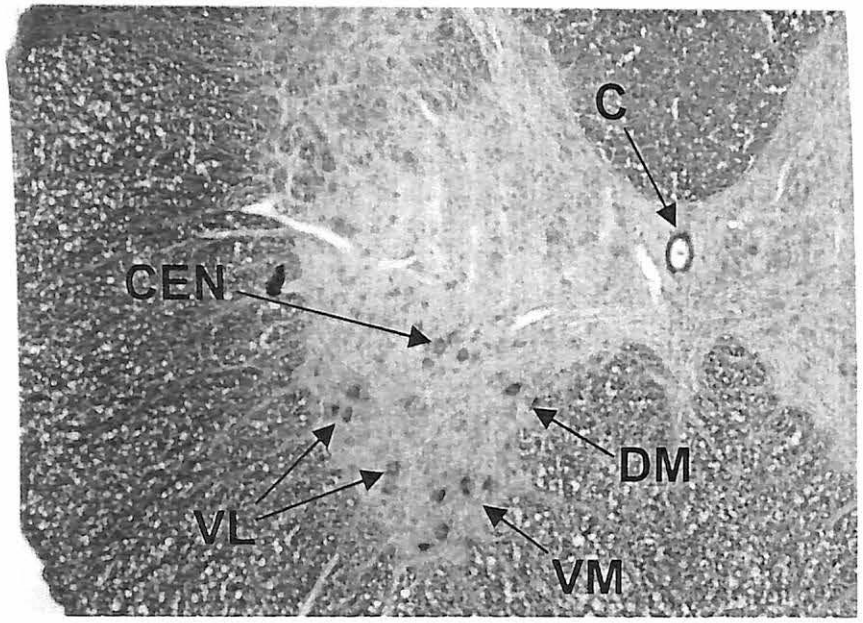

Figure 10

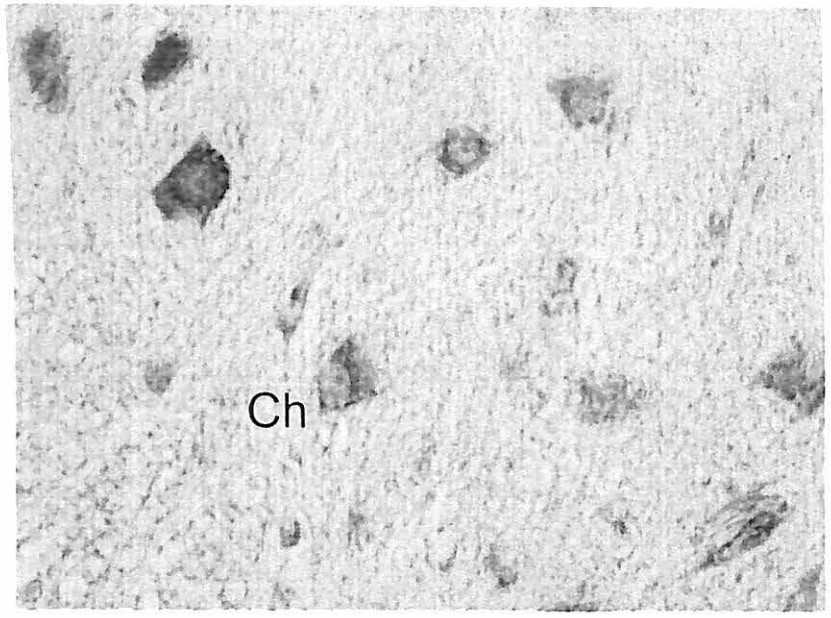

Figure 11

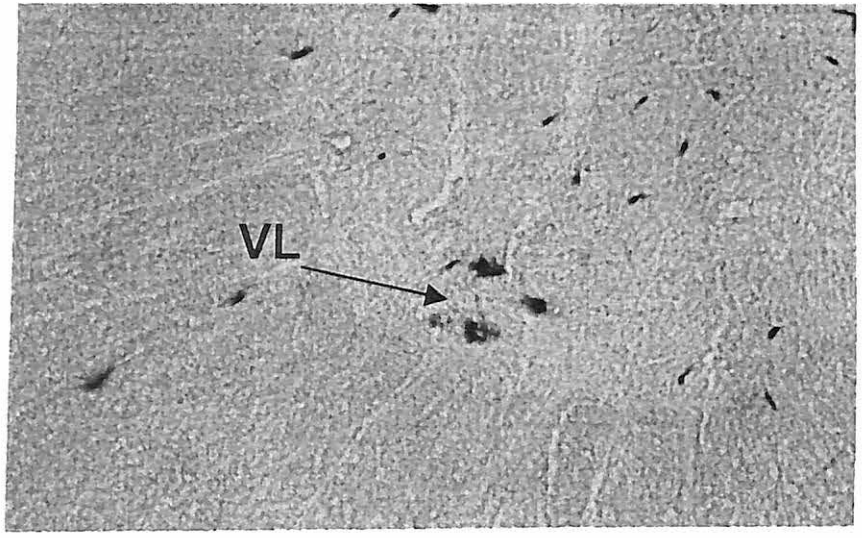

Figure 12

Figure 10. Photomicrograph of a transverse section of the spinal cord showing some neuron somata of the dorsomedial (DM), ventromedial (VM), ventrolateral (VL), and central (CEN) columns at C-2 (Thionine stain; C = Central canal).

Figure 11. Photomicrograph of a transverse section of spinal cord showing a highly chromatolysed neuron soma (Ch) of SNA in the ventrolateral (VL) column at C-2.

Figure 12. Photomicrograph of a transverse section of spinal cord showing HRP labeled neuron somata of trapezius in the ventrolateral column (VL) at C-3.