The Effects of Bilateral Thoracic Sympathectomy on Cardiovascular System (An Experimental Study)

Bilateral Torakal Sempatektominin Kardiyovasküler Sistem Üzerine Etkileri (Deneysel Çalışma)

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ABSTRACT Objective: Sympathectomy for palmar hyperhidrosis has been performed with long-term favorable results. The most common side effects of sympathectomy are compensatory sweating, gustatory sweating and cardiac changes including decreasing heart rate, systolic-diastolic and mean arterial pressure. The mechanism of bradycardia and other cardiac complications that develop after thoracic sympathectomy are still unclear. The aim of this study was to explain the effects of thoracic sympathectomy on cardiopulmonary functions and hemodynamics. **Material and Methods:** The rats (Ratus norvecus) were divided into two groups as the control group and the sympathectomy group. Prior to the operation, an indwelling arterial catheter was placed to monitor instant arterial blood pressure, heart rate, pulse oximeter and electrocardiogram (ECG). Bilateral thoracotomy was performed in both groups. Positive pressure ventilation was carried on via a nasal mask while the chest cavity was opened. Thoracic sympathectomy was performed only in the sympathectomy group. All rats were monitored and the results were recorded 60 minutes before and after the operation. **Results:** Heart rate and systolic blood pressure decreased significantly after T2 T3 ganglionectomy. A prolonged QT interval was also recorded ($p< 0.05$). The decrease in systolic and diastolic blood pressure was insignificant in group I ($p> 0.05$). SpO_2 values were relatively decreased in all animals at the beginning of the operation ($p< 0.05$). No mortality was recorded. **Conclusion:** Surgeons should be aware of adverse effects such as bradycardia during thoracic sympathectomy. This study suggested that careful monitoring was required during thoracic sympathectomy and early postoperative period.

Key Words: Sympathectomy; bradycardia; stellate ganglion

ÖZET Amaç: Palmar hiperhidrozis tedavisinde torakal sempatektomi yıllardır başarıyla uygulanmaktadır. Sempatektominin en sık görülen yan etkileri kompensatuar terleme, yemek sonrası baş bölgesinde terleme ve kalp hızında, sistolik-diyastolik ve ortalama arteriyel basınçta düşmeyi içeren kardiyak komplikasyonlardır. Torakal sempatektomi sonrası gelişen bradikardi ve diğer kardiyak komplikasyonların oluşma mekanizması tam olarak bilinmemektedir. Çalışmadaki amaç, torakal sempatektominin kardiyopulmoner fonksiyonlar ve hemodinami üzerine olan etkilerini açıklamaktır. **Gereç ve Yöntemler:** Sıçanlardan (Ratus norvecus) iki ayrı grup oluşturuldu. Birinci grup kontrol grubu, ikinci grup ise sempatektomi grubu olarak adlandırıldı. Her iki gruptaki deneklere bilateral torakotomi ameliyatı uygulandı. Torakal sempatektomi sadece ikinci gruba uygulandı. Çalışma genel anestezi altında yapıldı. Operasyondan önce deneğe damar içi arteryel kateter yerleştirildi. Bu yolla anlık arteriyel kan basıncı, nabız hızı, kandaki oksijen miktarı ve elektrokardiyogramı izlendi ve kaydedildi. **Bulgular:** T2 ve T3 ganglionektomi kalp atım hızını ve sistolik kan basıncını ciddi anlamda düşürdü ve QT aralığını uzattı ($p< 0.05$). Grup I'deki sistolik ve diyastolik kan basıncı düşüşü önemsizdi ($p> 0.05$). Operasyonun başlangıcında SpO_2 değerleri bütün hayvanlarda göreceli olarak düştü. Mortalite görülmedi. **Sonuç:** Sempatektomi sırasında bradikardi gibi yan etkilerin oluşabileceği konusunda cerrahların dikkatli olması önemlidir. Bu çalışma, torakal sempatektomi sırasında ve erken postoperatif dönemde dikkatli bir izlem gerektiğini göstermiştir.

Anahtar Kelimeler: Sempatektomi; bradikardi; stellat ganglion

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Thoracic sympathectomy has become a standard method for the treatment of primary hyperhidrosis.[1] The most common side effects of sympathectomy are compensatory sweating, gustatory sweating and cardiac changes including decreasing heart rate, systolic-diastolic and mean arterial pressure.[2,3] Cardiac complications such as bradycardia, after thoracic sympathectomy are associated with the anatomic relations between the ganglia and chains.[4]

A small animal model for sympathectomy does not exist in the literature.

In this experimental study, we aimed to establish a small animal model to evaluate the side effects of thoracic sympathectomy on cardiopulmonary physiology and hemodynamics.

MATERIAL AND METHODS

The study was approved by the Ethics Committee for Experimental Animal Studies of the Gülhane Military Medical School (GMMA). This experimental study was carried out at the GMMA Animal Research Center between June and July 2007.

ANIMALS

The rats were divided into two groups with six rats in each group (Ratus norvecus, cracdawley, 60 days old, body weight: 150 gm +/- 15 gm). Group I was the control group and group II was the sympathectomy group. In the control group, rats were subject to the same experimental protocol, but they did not undergo thoracic sympathectomy. Thoracic sympathectomy was performed in group II. All the animals were submitted in the same homogeneous experimental conditions. Animals had free access to water and food before and after thoracic sympathectomy. The food included standard rat food with 24% protein. A day-night cycle of 12 h was applied. Mean room temperature was 21-24 ^{o}C and the mean humidity was 55-60%.

OPERATION PROCESS

The study was performed under general anesthesia by intraperitoneal 10 mg/kg Xylazine and 90 mg/kg Ketamine. Oxygen was administered continuously with a flow rate of 0.5 L per minute over a nasal mask during the operation process. This kind of general anesthesia is known not to cause severe respiratory depression. Tracheal intubation of rats was not used because it was a long procedure for a small animal and caused some degree of laryngeal edema and hemoptysis. Prior to the operation, an indwelling arterial catheter was placed. Carotid artery was explored and 26-G (Purple colored) IV catheter was placed. A portable monitor (Welch Allyn propaq 246) (Figure 1) was used to monitor the invasive arterial blood pressure and an extremity pulse oximetry probe and a 5-channel ECG cable of the same monitor were used to monitor SpO2 and ECG respectively. Thus, the monitoring process included instant arterial blood pressure, heart rate, pulse oxymeter and ECG. From the starting point of Q wave to end point of T wave was accepted as QT interval as millisecond (msec).[5] All rats were monitored and the results were recorded 60 minutes before and after the operation.

After stabilizing the hemodynamic conditions, the rats were restrained in the left lateral decubitis position. The arm was abducted 90 degrees on a rest. The antecubital fossa over the armrest was padded with care. Skin incision was made at the third intercostal space on the anterior axilla line. The latissimus dorsi muscle was retracted posteriorly to expose the serratus anterior muscle. The serratus was spread with care, being careful to avoid any injury to the long thoracic nerve of the serratus anterior muscle. The anterior portion of the serratus was divided with the cutting current to expose the intercostal muscles. Two ribs were separated to facilitate the exposure. The intercostal muscles were divided near their inferior attachment to the rib.

Positive pressure ventilation was performed via nasal mask to prevent respiratory insufficiency when the thorax was opened. At the mediastinum, the sympathetic nerves and ganglia lied across the junction of the vertebras and ribs in all rats (Figure 2). The second and third thoracic sympathetic ganglia and rami communicantes were resected only in the second group. The resected thoracic ganglia specimens were sent for histopathologic examination.

FIGURE 1: Monitoring of the arterial blood presure.

Then the lung was reinflated under direct vision and thoracic cavity was closed with a nonabsorbable single suture. The serratus and latissimus dorsi were closed with a running absorbable suture. Skin and subcutaneous tissue were closed with a running absorbable suture. The residual air in pleural space was aspirated by an 18 GA 1.3 x 45 mm IV catheter just after the closure of thoracic cavity. After that, catheter was withdrawn by aspiration. The same procedure was performed for the opposite side in both groups.

Statistical Analysis

Statistical analysis was performed by using Mann-Whitney U and Wilcoxon tests. All the results were assessed as the median (min-max) and $p< 0.05$ was considered statistically significant.

RESULTS

The heart rate and systolic blood pressure decreased significantly after T_2-T_3 ganglionectomy. A prolonged QT interval was also recorded ($p< 0.05$). A few minutes later after the operation bradycardia occurred in 4 rats in the sympathectomy group. The heart rate distributions were listed in Figure 3.

The decrease in systolic and diastolic blood pressure was insignificant after the operation in the control group ($p> 0.05$). The decrease was significant in the sympathectomy group. The results were shown in Figure 4a, 4b.

SpO_2 values decreased relatively at the beginning of the operation in all animals ($p> 0.05$). SpO_2 values reached normal levels in all groups at postoperative two hours. SpO_2 results were shown in Figure 5. The QT interval was significantly prolonged only in three rats in the sympathectomy group. No mortality and complications were recorded.

DISCUSSION

The thoracic sympathetic trunk is made up of a variable number of ganglia-usually 10-11-that are connected by the sympathetic trunk. The sympathetic innervation lie in the ganglia T2 through T4 of the eccrine glands of the upper extremity.[4] The thoracic sympathetic trunk lies ventral to the heads of the first through tenth ribs, and it passes more ventrally to lie on the bodies of the lower two tho-

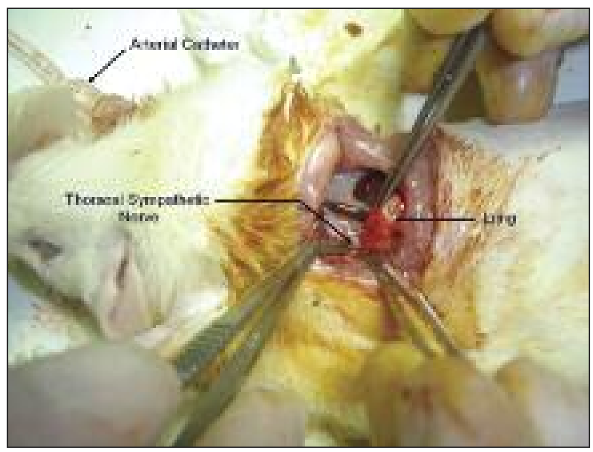

FIGURE 2: The right thoracic sympathetic nerve in rat.

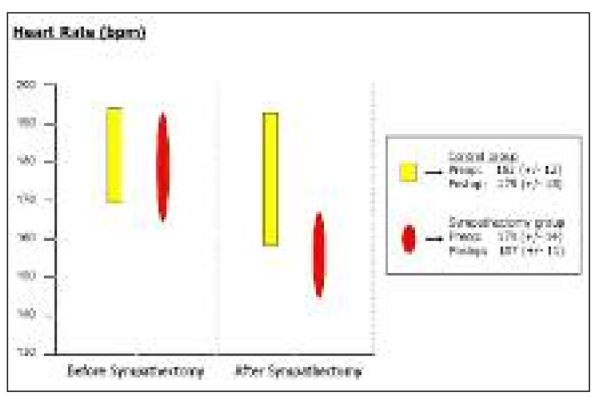

FIGURE 3: Heart rate results in rats.

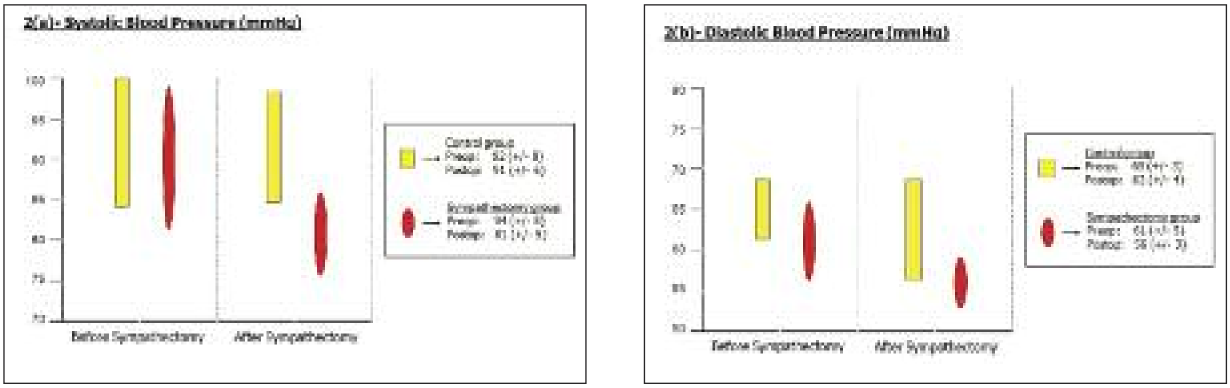

FIGURE 4a, b: (a) Systolic and (b) diastolic blood pressure results in rats.

racic vertebrae. The cardiac sympathetic fibers arise from segments T2-T4 of the spinal cord and are distributed through the middle cervical and cervico-thoracic (or stellate) ganglia and the first four or five ganglia of the thoracic sympathetic chain. The sympathetic fibers pass into the cardiac plexus and from there to the sinoatrial (SA) node and the cardiac muscle. The effect of the sympathetic nerves at the SA node is an increase in heart rate. The sympathetic fibers of the upper extremity lie in the T2-T3 ganglia and according to some authors, T4 ganglia are also included.[4,6] It is well known that sympathetic innervation lay in the ganglia T2 through T4 of the eccrine glands of the palm and axillae. Therefore thoracal sympathectomy is performed for the treatment of hyperhydrosis. Symphathectomy has been performed with favorable long-term results.[3] During sympathectomy, the T2-T4 thoracic sympathetic fibers and ganglia are resected. These resected parts include some cardiac sympathetic fibers and that is why cardiac complications occur after thoracic sympathectomy.

Nakamura et al demonstrated that thoracic sympathectomy significantly decreased heart rate both at rest and on exercise.[7] Moak et al reported that upper thoracic sympathectomy partly decreased cardiac sympathetic innervation density.[8] Similarly, Abraham et al and Hashmonai et al reported that heart rate was significantly decreased after bilateral thoracic sympathectomy.[9,10] Our study also revealed that sympathectomy significantly decreased heart rate ($p > 0.05$).

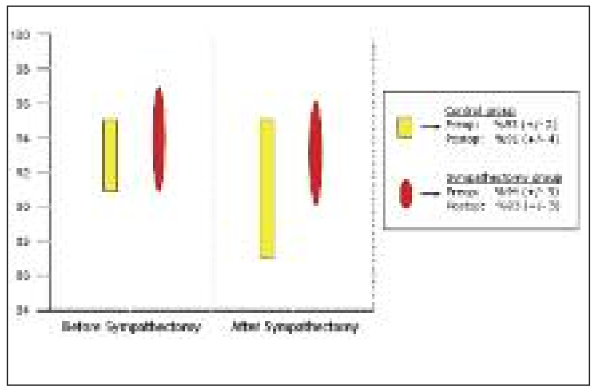

FIGURE 5: SpO_2 values in rats.

Hashmonia et al reported that the T2 and T3 ganglionectomy significantly decreased systolic blood pressure as was the case in our study.[10]

Vigil et al reported that pulmonary function (values spirometrics) was not statistically different after thoracic sympathectomy and the only statistically meaningful change was the decrease in maximal mid-expiratory flow, from 101% to 92%.[2] The clinical relevance of these findings is unknown. In our study, SpO_2 values were relatively decreased at the beginning of the operation in all animals due to thoracotomy. SpO_2 values reached normal levels in both group I and II at postoperative two hours.

Some authors reported that T2 and T3 ganglionectomy prolonged the Q-T interval.[10] Abraham et al also reported that little effect of sympathectomy was found on the QT interval, which tended to decrease after bilateral thoracic sympathectomy.[9] Left thoracic symphatectomy is known to be a treatment method as well as other medical approaches in long QT syndrome.[11] Our study also, it was revealed that sympathectomy significantly prolonged the QT interval.

In this experimental study, no mortality occured related with cardiac complication.

In conclusion, it is important that patients should be carefully evaluated before the operation for a possible cardiac complication such as bradycardia due to sympathectomy. In addition, this study suggested that careful monitoring after thoracic sympathectomy was required.

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