Histopathological Changes in The Spinal Cord After Unilateral Segmental Vessel Ligation: An Experimental Study

Erhan TAKÇI¹, Murat SILİ¹, Gökşin ŞENGÜL¹, Elif DEMİRÇİ², Bülent DÜZ³

¹Atatürk Üniversitesi, Tip Fakültesi, Nöroşirurji, Erzurum, Türkiye ²Atatürk Üniversitesi, Tip Fakültesi, Patoloji, Erzurum, Türkiye ³Gülhane Askeri Tip Akademisi, Nöroşirurji, Ankara, Türkiye

Summary

Background: Ligation of the segmental vessels is routinely used during the anterior approach to the thoracolumbar spine. There is still an ongoing discussion whether the ligation of the segmental arteries can cause damage to the spinal cord. This study aims to evaluate the alterations in the spinal cord after ligation of the segmental vessels, histopathologically.

Methods: Eight female merino sheep were used. The segmental arteries of the thoracolumbar aorta were clipped, unilaterally, at three levels via left antero-lateral thoracotomy. Animals were sacrificed after 3 days. Spinal cord obtained from thoracolumbar and control cervical segments was examined histopathologically on the basis of ischemic changes and the number of blood vessels.

Results: Slight ischemic changes were observed at the thoracolumbar levels. The number of blood vessels was decreased significantly at the thoracolumbar levels compared to control cervical levels. No animal developed neurological deficit.

Conclusion: Unilateral ligation of segmental vessels at three levels lead pathologic changes in the the spinal cord that do not influence the neurologic function.

Key words: Anterior approach, histopathology, neurologic deficit, segmental vessels, spinal cord

Tek Taraflı Segmental Damar Bağlanmasının Omurilikte Oluşturduğu Histopatolojik Değişiklikler: Deneysel Çalışma

Özet


Sonuç: Segmental damarların üç seviyede tek taraflı bağlanması nörolojik fonksiyonu etkilememeyen omurilik değişiklikleri oluşturmaktadır.

Anahtar Kelimeler: Anterior yaklaşım, histopatoloji, nörolojik defisit, omurilik, segmental damarlar
INTRODUCTION

Anterior approach is a method commonly used to treat the pathologies located in the anterior thoracolumbar spine. It is superior for decompression whenever the lesion anteriorly compresses the spinal cord. Segmental vessels are frequently ligated to expose the vertebrae and discs during anterior spinal surgery\(^{(9)}\). There is still an ongoing discussion whether the ligation of the segmental arteries can cause damage to the spinal cord.

We aimed to examine the histopathological changes in the spinal cord after unilateral ligation of the segmental vessels during anterior spinal surgery, experimentally, in a sheep model.

MATERIAL AND METHODS

The study protocol was approved by the Ataturk University, Ethical Committee. Eight female merino sheep, each weighing between 50-60 kg, were used. All surgical procedures were conducted under general anesthesia, induction with Propofol 2 mg/kg and maintenance with 1.5% endtidal isoflurane in an air/oxygen mixture. A catheter was inserted into the femoral vein for administration of drugs and fluid replacement. All procedures were performed under normothermic conditions (37 °C) measured by continuous rectal temperature. The animals were placed in the right lateral decubitus position. A left antero-lateral thoracotomy was performed between the 7-8th intercostal space. The thoracic aorta was mobilized at the level of the Th12-L1 segmental vessels. The segmental arteries of the thoracolumbar aorta were identified and clipped sequentially (Ligaclip ERCA, Ethicon Endo- Surgery Inc., OH USA) (Figure 1). At the end of the procedure the chest was closed.

All animals were extubated postoperatively. Buprenorphine (0.005 mg/kg, i.m.) was used for post-operative analgesia as needed. Post-operative neurological examination was performed daily by an independent veterinarian in all animals. To assess neurological function, the Tarlov score\(^{(11)}\) was used as follows: 0 = paraplegia, 1= light limb movements, 2= good limb movements, but not able to stand, 3= able to stand, but not able to walk, 4= normal function.

Animals were sacrificed after 3 days, under general anesthesia (Ketamine 10 mg/kg and Xylazine 0.2 mg/kg) by the intravenous injection of T61 (1.0 ml/kg, Intervet GmbH, Unterschleißheim, Germany). Spinal cord was harvested and fixed in 4% paraformaldehyde before staining. Transverse slices of the cord, spaced 5 cm apart, were obtained from thoracolumbar and cervical segments and embedded in paraffin. For every animal, sections from thoracolumbar cord were assessed using an Olympus Bx51 light microscope (Olympus Europe GmbH, Hamburg, Germany). Cervical cord sections served as internal controls. Number of the capillary vessels in the spinal cord were counted. Ischemic damage was examined on haematoxylin and eosin (HE) stained slices. using a modified score described by Meylaerts et al.\(^{(8)}\) 0= no changes, 1= no infarction, but hypoxic changes of neurons (homogenized and/ or swollen or shrunken neurons, eosinophilia in HE), 2= small infarction (1/3 of the gray and white matter), 3= moderate infarction (1/3 to 1/2 of the gray and white matter), 4= large infarction (>1/2 of the gray and white matter), 5= complete infarction of the gray and white area.

Data analysis was performed using SPSS version 15.0 for Windows (SPSS Inc., Chicago, IL, USA). The ordinal rankings of histological damage were analysed using the Mann-Whitney U-test. A p value < 0.05 was considered to be significant.

RESULTS

No animal developed neurological deficit during the experiment. No ischemic
damage was observed in five specimens obtained from thoracolumbar level. Hypoxic changes were observed in two and small infarction was observed in one specimen, respectively (Figure 2). The mean number of blood vessels was

77.87±19.3 at thoracolumbar levels and 110.37±21.6 at control cervical levels (Figure 3). Significant decrease was found in the number of vessels of the thoracolumbar level (p=0.021). The results of our study are shown in Figure 4.

Figure 1: Intraoperative photograph showing the exposure of the aorta and clipping of left segmental vessels.

Figure 2: Photomicrograph of the sheep spinal cord showing hypoxic ischemic changes at the thoracolumbar level (Haematoxylin & Eosin, x100).
DISCUSSION

To explore whether or not the ligation of spinal segmental arteries would lead to ischemia of the spinal cord, unilateral segmental arteries at three levels, one target vertebra and two adjacent vertebrae, were ligated to simulate the anterior spinal approach for trauma and tumor surgery. Our experiment was applied to sheeps. As there are close similarities to the human spine, the sheep spine has been found to be a reliable model for experiments related to structure and biomechanics of the thoracic and the lumbar spine in many aspects(5,14).

The segmental arteries of the thoracic and upper lumbar spinal column occur from the aorta and pass lateral to each vertebrae. They divide into several branches at the intervertebral foramen to form anastomotic network between adjacent levels. Ligation of the segmental vessels is often used in the anterior approach for performing the

Figure 3: Photomicrograph of the sheep spinal cord 3 days after ligation. A: thoracolumbar level B: cervical level. The number of the vessels are lesser at the thoracolumbar level (Haematoxylin & Eosin, x40).

Figure 4: Average number of blood vessels at the thoracolumbar and control cervical levels.
procedure. However, whether or not segmental vessel ligation reduces the spinal cord blood supply, thus leading to neurological injury, still remains controversial.

The studies in the literature regarding the risks of neurovascular deficit during anterior exposure to the thoracolumbar spine report different results. The largest series report that there exists no risk with unilateral ligation of the segmental arteries. But some studies have reported on isolated cases of neurologic deficit after anterior spinal surgery. During our large number of anterior procedures over the last 10 years, neurologic injury after unilateral segmental vessel ligation have never been observed. Rich anastomoses between ipsilateral and contralateral arteries are likely to preserve the spinal cord circulation after ligation of segmental arteries. In addition, the spinal cord does not receive an afferent blood supply at each segmental level, there being a variability of 2-17 anterior radicular arteries occurring from the segmental arteries. Even when segmental arteries with radicular branch to the spinal cord were occluded, no somatosensory evoked potentials changes could be found. Nevertheless, temporary segmental arterial occlusion with somatosensory evoked potentials has been recommended before definitive ligation, and reports of neurologic injury exist. However, whether reports of neurologic injury exist were purely vascular is still subject to discussion.

In our study, histopathologic changes in spinal cord and changes in the number of spinal blood vessels were investigated after the unilateral ligation of segmental arteries. Our results indicated that unilateral ligation of 3 segmental arteries has some negative effects on histologic structure of the spinal cord that do not lead to functional damage. Hempfing A et al. assessed the influence of unilateral and bilateral segmental vessel ligation on vertebral blood flow by laser Doppler flowmetry intraoperatively. They showed that the blood flow decreased slightly after unilateral ligation of the segmental vessels.

A quantitative histomorphological study was done by Yuan L and coworkers on fresh cadavers to examine the effect of segmental vessel ligation on the blood supply of the thoracic spinal cord. They ligated 5 segmental vessels to simulate the anterior spinal surgery for scoliosis correction and observed the decrease in the number of blood vessels at different levels compared to the corresponding levels of controls. They concluded that unilateral segmental ligation could lead to a significant decrease in the number and density of blood vessels in the spinal cord. As this is a cadaver study they were not able to get functional outcomes.

Ueda Y et al. examined the influence on spinal cord blood flow and function by interruption of bilateral segmental arteries at up to three levels in dogs. They found significant decrease in the spinal cord blood flow that did not damage the spinal cord function.

In a study by Fujimaki Y et al. was done to determine how many ligations of bilateral segmental arteries cause ischemic spinal cord dysfunction using a dog model, they concluded that interruption of bilateral segmental arteries at ≥5 consecutive levels risks producing a spinal cord ischemia capable of injuring the spinal cord.

According to our results and data obtained from literature review, we concluded that unilateral ligation of three segmental arteries can cause histopathologic changes in the spinal cord that do not lead to functional damage. It can safely be performed in the anterior approach for spinal traumas and tumors.

Acknowledgment
The authors thank Mehmet Comez and Yunus Yılmaz for their contribution to this work.
Correspondence to:
Gökşin Şengül
E-mail: goksinsengul@gmail.com

Received by: 22 November 2009
Revised by: 01 April 2011
Accepted: 05 April 2011

The Online Journal of Neurological Sciences (Turkish) 1984-2011
This e-journal is run by Ege University Faculty of Medicine,
Dept. of Neurological Surgery, Bornova,
Izmir-35100TR
as part of the Ege Neurological Surgery World Wide Web service.
Comments and feedback:
E-mail: editor@jns.dergisi.org
URL: http://www.jns.dergisi.org

Journal of Neurological Sciences (Turkish)
Abbr: J. Neurol. Sci.[Turk]
ISSNe 1302-1664

REFERENCES