Turk J Med Sci
33 (2003) 167-170
© TÜBİTAK

Ersin FADILLIOĞLU
M. Kemal IRMAK
Murat YAĞMURCA
Hasan ERDOĞAN

Hemodynamic Changes After Aortopulmonary Separation

Received: April 09, 2003

[1]Department of Physiology, Faculty of Medicine, İnönü University, Malatya; [2]Department of Histology and Embryology, Gülhane Military Medical Academy, Ankara; [3]Department of Histology and Embryology, Faculty of Medicine, Afyon Kocatepe University, Afyon - Turkey

Abstract: The neural crest origin of the aortopulmonary septum has led us to investigate the septum. We designed the present study to assess the hemodynamic changes following aortopulmonary separation in the rat. We freed the ascending aorta from the pulmonary artery by blunt dissection and placed aluminium foil between them in anesthetized, ventilated, open-chest animals and found that the procedure resulted in a slight but significant increase in systolic and diastolic blood pressure and in an insignificant elevation of the heart rate. The hemodynamic deterioration observed after the separation process might be a result of a possible function of the aortopulmonary septum on blood pressure regulation.

Key Words: Aortopulmonary septum, blood pressure, rat

Introduction

The aortopulmonary septum is a connective tissue between the aorta and pulmonary trunk. It is established that the aorta and pulmonary trunk form from truncus arteriosus following septum formation (1). This septum is a derivative of the neural crest cells and when the cardiac neural crest was ablated surgically, embryos were shown to develop congenital anomalies of the heart, especially persistent truncus arteriosus (2). These neural crest cells are site-specific and carry information for the formation of structures appropriate to their origin rather than being defined at the destination of migration. Since certain derivatives of neural crest cells such as parafollicullar cells of the thyroid gland and adrenomedullary cells represent the neuroendocrine cell phenotype, we thought that a portion of the aortopulmonary septum may also contain similar cell types having neuroendocrine function. The embryonic origin of the aortopulmonary septum has therefore led us to hypothesize that this septum may have a special hemodynamic function (3). To test this hypothesis we investigated the aortopulmonary septum of the rat for the presence of such a function. We used a recorder to determine the alterations in blood pressure after separation and discussed the implications of our findings with regard to the relationship between blood pressure and septum.

Materials and Methods

Experiments were performed on 16 female Wistar Albino rats obtained from İnönü University Animal Laboratory. The rats were housed in quiet rooms with a 12:12-h light-dark cycle and the experiments were performed in accordance with the 'Guide for the Care and Use of Laboratory Animals, DHEW Publication No. (NIH) 85–23, 1985'. On the day of the experiment, the rats were anesthetized with urethane at an intraperitoneal dose of 1.2 g/kg. A single dose of heparin (5000 units) was administered prior to surgery. After the induction of anesthesia, the animals were intubated through a tracheotomy and lung ventilation was achieved using a positive pressure respirator (Harvard Co, UK) throughout the experiments. Body temperature was kept constant using a heating mattress. A catheter was introduced into the right carotid artery for the measurement of arterial pressure and heart rate. After a left thoracotomy was made at the third or fourth intercostal space, the lungs were retracted, and the pericardium was cut open to expose the aorta and pulmonary artery. Segments of approximately 1 cm of the ascending aorta and pulmonary artery were then mobilized. These two arteries were separated with the help of forceps, and a four-folded piece of aluminum foil (2 x 0.5 x 0.1 cm) was inserted between the aorta and pulmonary artery to isolate the arteries from each other (Figures 1a and 1b). Arterial blood pressure (BP) and heart rate were monitored continuously by a Harvard model 50-8952 transducer and displayed on a Harvard universal pen-recorder (UK). Hemodynamic monitoring was performed following the completion of each manipulation and after the recorded variables remained unchanged. Each data set consisted of the average of three taken over approximately 2 min. To eliminate the contact effect of

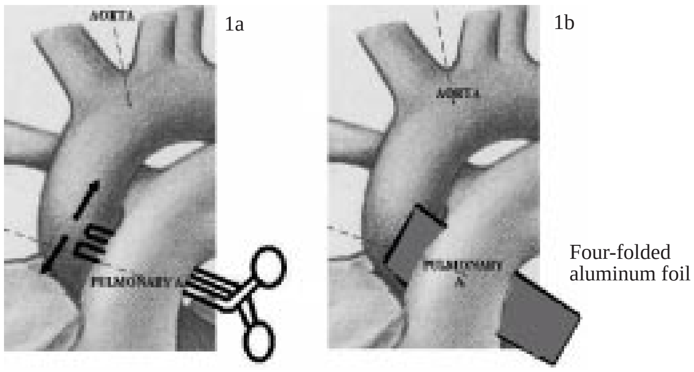

Figure 1. The schematic representation of aortico-pulmonary septum separation. 1a; separation of aorta and pulmonary artery with the help of forceps, 1b; insertion of four-folded aluminum foil between the arteries.

the aluminum foil on the arteries, we also measured the BP and heart rate after putting it on the wall of both arteries at a distance from the septum.

Statistical Analysis

Continuous data were presented as the mean ± SE for all positions on each hemodynamic variable. All statistical analyses were carried out using SPSS statistical software (SPSS for Windows; Chicago, IL, USA). A paired Student's t-test (Wilcoxon test) was used for the analysis. P values less than 0.05 were considered statistically significant.

Results and Discussion

The hemodynamic changes after each position are summarized in Figure 2. Overall, the comparison between the hemodynamic status at baseline and other positions showed significant differences for the investigated variables. Dissecting the septum and separating the great vessels induced an increase in both systolic and diastolic BPs ($P < 0.05$) when compared with the previous base values; following the release of the foil, BP decreased with systolic and diastolic pressures falling to 93.75 ± 19.96 and 57.50 ± 18.32 mmHg respectively. Heart rate did not change significantly after separation but it increased significantly when the foil was pulled out. We did not observe significant changes after putting the aluminum foil on the outer wall of the arteries.

In the study presented herein, we investigated the hemodynamic changes after dissection of the aortopulmonary septum. The results indicate that separation of the aortopulmonary septum significantly increased blood pressure and affected the heart rate. Healthy Wistar rats served for the animal model used in the current study. Although it is difficult to extrapolate effects from rodents to humans, the neural crest origin of the aortopulmonary septum in all mammals has led us to think that this septum may also be important for human cardiovascular dynamics. Hemodynamic deterioration observed during the procedures may have clinical value. Exposing great vessels by displacing the beating heart has been reported to produce hemodynamic compromise both in animals (4,5) and humans (6) due to changes in ventricular geometry and valve competence (5). It was also reported that surgically induced hypertension developed in 16 of 50 patients during aortic surgery and desflurane was found to be effective in controling this intraoperative hypertension (7). On the other hand, when the aorta was exposed via the transabdominal approach, some patients were noted to have manifest reduced blood pressure (8). In a method for prosthetic valve replacement in three mongrel dogs, it was shown that incising the aortopulmonary septum at the middle point of both coronary ostia made no significant difference in the pressure gradient between the right ventricle and the main pulmonary artery before or after surgery (9). The hemodynamic changes found in the present study seem to result from the separation of the aortopulmonary septum, since we excluded the contact effect of the aluminum foil by measuring the variables when it was on the outer walls of the arteries.

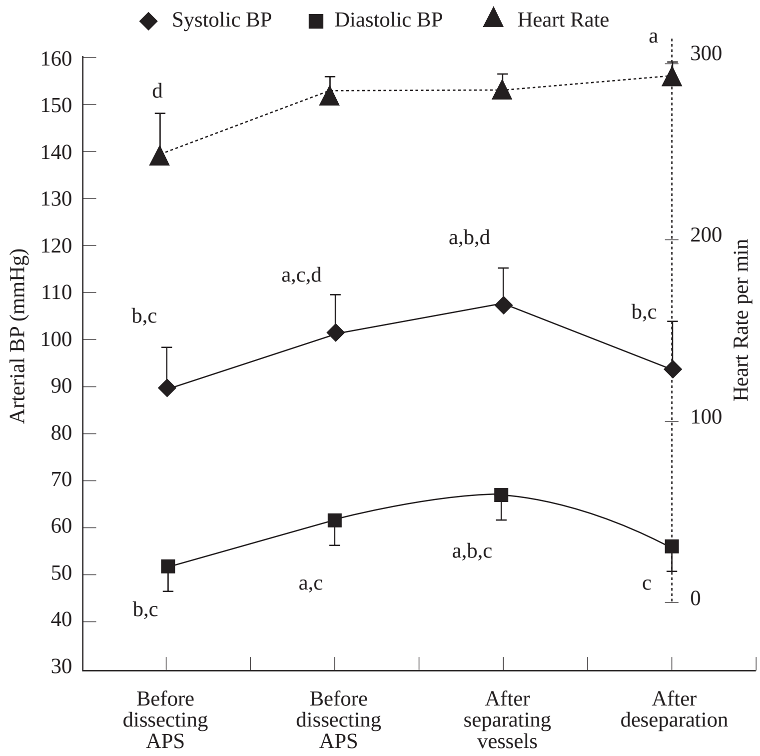

Figure 2. The hemodynamic changes after each position. BP: arterial blood pressure, APS: aortopulmonary septum.
a: P < 0.05 denotes significantly different from "Before dissecting APS' period value"
b: P < 0.05 denotes significantly different from "After dissecting APS' period value"
c: P < 0.05 denotes significantly different from "After separating vessels' period value"
d: P < 0.05 denotes significantly different from "After deseparation's period value"

This study represents the first evaluation of the relation between BP and aortopulmonary septum. The specific cause of the higher pressure levels after aortopulmonary separation cannot be directly ascertained from our present study. This phenomenon might be reflexogenic in origin and due to the stretching of the vessels, but humoral substances possibly released from the septal connective tissue might also be the underlying mechanism that led to hemodynamic deterioration. One can explain the alterations we found in the present study also by differences in modifiable factors induced by surgery. We believe that it must be established whether this change could be attributable to the operation, or if there was an intrinsic alteration in septum properties.

The paraganglia are clusters of chromaffin cells intimately associated with the autonomic nervous system and cardiovascular system (10). The aortopulmonary paraganglia, which also form from neural crest cells, were reported to influence the adaptation of the cardiovascular system (11). It is possible that by releasing catecholamines and peptides, these paraganglia may participate in the mechanisms involved in BP regulation, and changes in the structure and physiology of septal cardiac ganglia due to the operation may play a role in BP alterations. We previously reported that there are a number of mast cells and numerous multilocular adipocytes in the aortopulmonary septum of the adult rat and we suggested that these cells might play a physiological role in functions of the cardiovascular system (12).

It is primarily the vessel elasticity of the large arteries that determines the pressure within a vessel when the ventricles contract. The elasticity results from the resilient nature of the arterial wall. If a vessel becomes less elastic, as often happens with aging (arteriosclerosis), BP rises, and the recoil is lost. BP within the large systemic arteries must be maintained precisely to ensure adequate blood flow to the tissues. The major factors that regulate arterial BP are those that regulate cardiac output and total peripheral resistance. The main pathomechanism of higher BP after the dissection of aortopulmonary septum might be vasoconstriction. It may result from activation of the sympathetic nervous system, or of endothelium-derived vasoconstrictors (e.g., endothelin-1), which lead to an elevation of systemic vascular resistance. Other possible mechanisms include reduced production of vasodilators (e.g., nitric oxide), and vascular rigidity by solid metal leading to reduced compliance of both elastic arteries (13). Histological studies on the aorto pulmonary septum are necessary to estimate the degree of mechanical injury caused by the surgical separation technique, and histochemical and/or biochemical investigations are required to prove the existence and deliberation of the regulatory agents in the BP and heart rate alterations observed.

In conclusion, we observed hemodynamic deterioration after aortopulmonary separation and although it is difficult to interpret the clinical significance of the hemodynamic changes observed in the present study, we concluded that the aortopulmonary septum may be important in hemodynamic functions, and this study might be a useful tool to investigate BP regulation.

Corresponding author:
Ersin FADILLIOĞLU
Department of Physiology
Faculty of Medicine
İnönü University
44069, Malatya - TURKEY
E-mail: efadillioglu@yahoo.com

References

1. Beall AC, Rosenquist TH. Smooth muscle cells of neural crest origin from the aortopulmonary septum in the avian embryo. Anat Rec 226: 360-366, 1990.
2. Kirby ML, Gale TF, Stewart DE. Neural crest cells contribute to normal aortopulmonary septation. Science 220: 1059-1061, 1983.
3. Irmak MK, Ozcan O. Human diversity, environmental adaptation, and neural crest. Medical Hypotheses 48: 407-410, 1997.
4. Grundeman PF, Borst C, van Herwaarden JA, et al. Hemodynamic changes during displacement of the beating heart by the Utrecht Octopus method. Ann Thorac Surg 63: S88-S92, 1997.
5. Grundeman PF, Borst C, Verlaan CWJ, et al. Exposure of circumflex branches in the tilted, beating porcine heart: echocardiographic evidence of right ventricular deformation and the effect of right or left bypass. J Thorac Cardiovasc Surg 118: 316-323, 1999.
6. Jansen EWL, Borst C, Lahpor JR, et al. Coronary artery bypass grafting without cardiopulmonary bypass using the Octopus method: results in the first 100 patients. J Thorac Cardiovasc Surg 116: 60-67, 1998.
7. Eyraud D, Benmalek F, Teugels K, et al. Does desflurane alter left ventricular function when used to control surgical stimulation during aortic surgery? Acta Anaesthesiol Scand 43: 737-743, 1999.
8. Hudson JC, Wurm WH, O'Donnell TF Jr, et al. Hemodynamics and prostacyclin release in the early phases of aortic surgery: comparison of transabdominal and retroperitoneal approaches. J Vasc Surg 7: 190-198, 1988.
9. Katsumata T, Kurosawa H, Koyanagi H. Intra-arterial aortoinfundibuloplasty: hemodynamic and anatomical study of a new method for the enlargement of a small aortic annulus. J Card Surg 8: 125-129, 1993.
10. Gobbi H, Barbosa AJA, Nogueira JC, et al. Enkephalin- and serotonin-like immunoreactivity in the aortopulmonary paraganglia of the white-belly opossum *Didelphis albiventris* (Marsupialia). Histochem J 24: 110-114, 1992.
11. Boyd JD. The inferior aortopulmonary glomus. Brit Med Bull 17: 127-131, 1981.
12. Irmak MK, Dalcik H, Ozcan O. Histology of rat aortopulmonary septum. Turk J Med Res 13: 131-135, 1995.
13. Scharer K, Schmidt KG, Soergel M. Cardiac function and structure in patients with chronic renal failure. Pediatr Nephrol 13: 951-65, 1999.