Current Topics in Biophysics 2001, 25(2), 63-65

DOPPLER ULTRASONOGRAPHIC METHOD IN ESTIMATING HEMODYNAMIC PARAMETERS IN SPORTSMEN

ADAM BOGACZ[1], RYSZARD PALUGNIOK[2], ANITA STANJEK[1], ALEKSANDRA BIJAK[1], ALEKSANDRA KOCHAŃSKA-DZIUROWICZ[1]

[1] Department of Radioisotope Diagnostics and Radiopharmaceuticals, Medical University of Silesia, Sosnowiec, Jagiellońska 4
[2] 4th District Specialist Hospital at Bytom

25 junior football players were taken under research. Exercise test was performed on cycloergometer with gradually increasing workload. The test was performed until the player refused to continue. Selected hemodynamic parameters: cardiac output, cardiac output index (CI), and testosterone and cortisol concentrations before the test, 5 minutes after, and 1.5 hours after were monitored. In conclusion authors pointed that the CI increase well correlates with good form of the forwards subgroup.

INTRODUCTION

Hemodynamic parameters of heart function can be monitored by means of invasive and noninvasive methods. Nowadays the most popular and precise invasive method is thermodilution using Swan-Ganz catheter.

Revolutionary progress in computer sciences and electronics enabled us to use noninvasive method of monitoring hemodynamic function of heart. Noninvasive methods of estimating cardiac output include transthoracic bioimpedance, CO_2 rebreathing and ultrasonic Doppler.

Transthoracic bioimpedance is the oldest and simplest method. High frequency current of low amplitude is introduced through skin electrodes to the thorax. Variations in blood volume and velocity in the thorax cause proportional voltage changes in this current during ventricular injection. Absolute accuracy of the cardiac output calculation depends on the validity of the thoracic model. At present the most popular model is RheoCardio, which uses a polynomial fit to weight, height, gender and thorax circumference. Comparing thoracic bioimpedance measurements of cardiac output with thermodilution measurements, the correlation coefficients range from 0.75 to 0.91.

The second method of cardiac output measurement is rebreathing technique. Using the CO_2 Fick equation, cardiac output can be calculated using the partial pressure of end tidal CO_2 to approximate arterial CO_2 and using the lungs as a tonometer to measure venous CO_2. Venous CO_2 concentration is obtained when the patient breathes into a bag and the level of CO_2 rises asymptotically to a plateau level corresponding to the venous level. Because of the need for cooperation, this rebreathing technique has not been used successfully in mechanically ventilated peoples. A variation of the rebreathing technique, which has been adapted for use with ventilated peoples, uses the ratio of the change in the numerator and denominator of the Fick equation to calculate cardiac output. This partial rebreathing technique places dead space (100-200 ml) in the patient breathing circuit for 40 seconds. The ratio of the change in CO_2 production to the change in end-tidal CO_2 is used to solve the differential Fick equation. This technique is more available now than it was in the past because of the availability of on-airway CO_2 monitors. Results with the partial CO_2 rebreathing method report a correlation with thermodilution cardiac output which ranges from $r = 0.84$ to 0.97.

The Doppler technique measures blood velocity and uses estimates or measurements of the blood vessel cross sectional area to calculate flow rate. The technique assumes a known velocity profile across the blood vessel to accurately estimate flow. The accuracy depends on the sensor positioning and orientation relative to blood flow. Precise positioning of the transducer is critical for the technique. In the present report we use suprasternal probe. The probe assesses descending aorta to estimate blood flow.

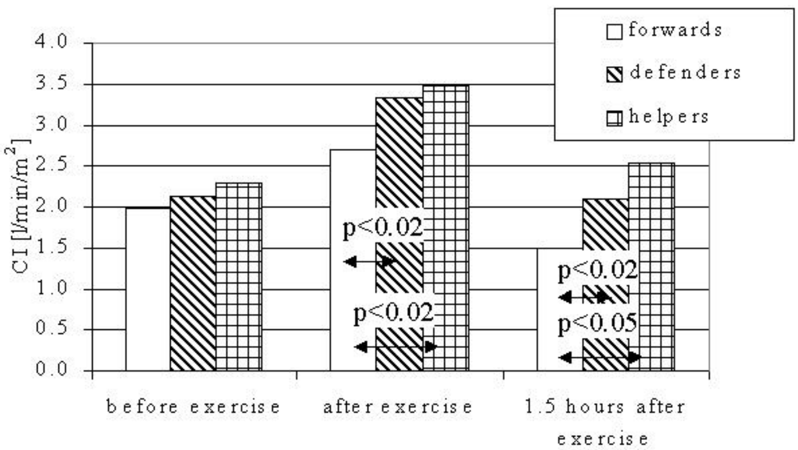

Fig. 1. Changes of CI in the subgroups during the test.

METHODS

25 junior football players from "Gwarek Zabrze" Sports Club (mean age 17.04 ± 0.77) were taken under research. All participants were in good health during the test. The exercise test lasted for about 15 minutes and was performed until the player refused to continue. It was performed on cycloergometer with gradually increasing workload. Maximum power, which was developed by the players was 294 ± 44 W. Total work (TW) was 123 ± 25 kJ. The test which was undertaken by the players included monitoring selected hemodynamic parameters: cardiac output (CO) and cardiac output index (CI), using Cardiac Output Monitor manufactured by Lawrence Medical System as well as testosterone and cortisol concentrations before the test (t_0), 5 minutes after (t), and 1.5 hours after (t_1). Total work of each player after the test was registered. The results were analysed using Statgraphics Package. The mean values (x) and standard deviations (SD) were calculated after checking normal distributions of probes with Chi-Square "Goodness of Fit" test. The differences between normal distributions were checked with Student t test.

RESULTS

The group of 25 football players was divided into 3 subgroups: forwards (6), helpers (11) and defenders (8). Figure 1 shows variations of CI values in the subgroups. Statistically significant differences in CI values during the test between the subgroups were found in measurements 5 min. and 1.5 hours after the exercise. The double increase in CI values in helpers subgroup was found 5 min. after the test. Statistically significant differences in CO variations during the test were not found. Figure 2 shows testosterone values. Statistically significant increase in testosterone was found after the exercise, which significantly decreased below the starting values 1.5 hours after the exercise. Figure 3 shows cortisol concentrations in sportsmen during the test. The changes profile of cortisol concentrations is identical with testosterone.

DISCUSSION

The results show a significant increase in CI as a result of exertion and its remarkable decrease 1.5 hours after the test. Literature data suggest depend-

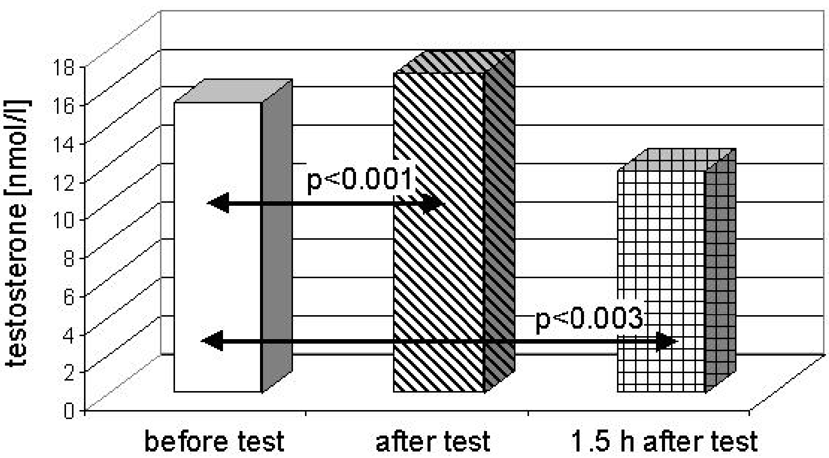

Fig. 2. Changes of testosterone concentrations during the test.

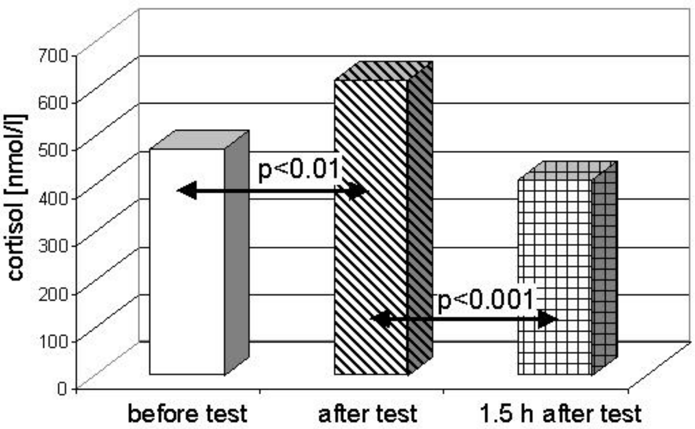

Fig. 3. Changes of cortisol concentrations during the test.

ence between CI variations and the player's form (Liu, Steinacker, Dehnert, Menold, Baur, Lormes & Lehmann, 1998), Jensen-Urstad, Bouvier, Nejat, Saltin & Brodin, 1998). The increase of 200% in CI values during the test suggests player's lack of adequate training preparation (Rowland, Goff, Popowski, DeLuca & Ferrone, 1998). In the whole group under research CI increased 49% and in forwards subgroup the increase was the smallest and was 36% and in defenders subgroup was the highest — 56%. The opinion about the form of the players given by the Sports Club coach was similar to data obtained from the analysis of CI percentage increase during the test. Statistically significant differences were found in CI values between forwards and defenders subgroups after 5 min and 1.5 hours after the test. No dependence between CI and total work was found. The concentrations of testosterone and cortisol increase after the exertion. Similar changes were also observed by other authors (Kochanska-Dziurowicz, Gawel-Szostek, Gabrys & Kmita, 2001; Fahrner & Hackney, 1998).

CONCLUSIONS

1. Exertion significantly increases CI values.
2. Forwards subgroup has the lowest CI increase during the test, which point to best form of the payers.

Acknowledgement

This work was supported by grants from Medical University of Silesian, Katowice NN-4-047/00 & NN-1-047/01.

REFERENCES

Fahrner CL. & Hackney AC. (1998). Effects of endurance exercise on free testosterone concentration and the binding affinity of sex hormone binding globulin (SHBG). *Int. J. Sports. Med.*, **19**, 12-15.

Jensen-Urstad M., Bouvier F., Nejat M., Saltin B. & Brodin L.A. (1998). Left ventricular function in endurance runners during exercise. *Acta Physil. Scan.*, **164**, 167-172.

Kochanska-Dziurowicz A., Gawel-Szostek V., Gabrys T. & Kmita D. (2001). Changes in prolactin and testosterone levels induced by acute physical exertion in young female athletes. *Fiziol. Cheloveka*, **27,** 100-103.

Liu Y., Steinacker J.M., Dehnert C., Menold E., Baur S., Lormes W. & Lehmann M. (1998). Effect of „living high-training low" on cardiac functions at sea level. *Int. J. Sports Med.*, **19**, 380-384.

Rowland T., Goff D., Popowski B., DeLuca P. & Ferrone L. (1998). Cardiac responses to exercise in child distance runners. *Int. J. Sports Med.*, **19**, 385-393.