



COLLATERAL CIRCULATION IN HUMAN HEART

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ABSTRACT

The aim of the investigations was to demonstrate different types of collaterals of coronary arteries using the method of coronary angiography and injection-corrosion method. The investigations were carried out on 30 human cadaveric hearts from the Department of Anatomy, and 30 angiograms of patients from the Cardiology Department of Clinics Centre in Sarajevo. Clinical investigations were retrospective and prospective on patients that were treated in hospital, and on patients that just arrived in hospital (based on findings of coronary angiography). The results show the existence of different types of collaterals: intercoronary and intracoronary. We established collaterals in a case with occlusion of the right coronary artery and left coronary artery in which better development of collaterals was established.

Our patients were classified in two groups:

- 1) Patients with good collaterals and good left ventricular function;
- 2) Patients with good collaterals and impaired left ventricular function.

On the anatomical material we found different types of collaterals as well.

Our results show that coronanary angiography is useful diagnostic method for the demonstration of coronary collaterals.

KEY WORDS: coronary arteries, collaterals, injection-corrosion method, angiography.

INTRODUCTION

The collaterals of human coronary arteries have always attracted the attention of anatomists, pathologists, surgeons, as well as experts in many clinical disciplines. The occurrence of coronary diseases has increased recently so much that it stimulates researchers to become acquainted with collaterals of coronary arteries. Its real significance is expressive in cases with occlusion or stenosis of coronary arteries -angina, myocardial infarction, congenital cardiovascular malformations etc. (1,2,3,4,5). Therefore, the aim of the investigations was to demonstrate different types of collaterals of the coronary arteries in normal condition and the conditions of coronary disease using the method of coronary angiography and injection corrosion method. On the other side, these investigations are important because of contrast opinions that are given in literature concerning coronary arteries collaterals. According to some authors collaterals exist and they are functional (6,7,8,9,10). The others think that collaterals exist, but that they are insufficient for collateral circulation and only develop in pathological conditions (11). Ischemia changes of the heart, variations of coronary arteries and the collaterals have been studied by many authors: Hadžiselimović, Werner, Pohl, Seiler, Kamenica, Šišić, Rockostroh, Rapps, Holmvang, Billinger, Meier and others.

MATERIAL AND METHODS

Our investigations were carried out on 30 human hearts (regardless of sex or age), some of which were without microscopically visible pathological changes, and on 30 angiograms of patients with occlusion or stenosis of coronary arteries. The investigations on the hearts without visible pathological changes were undertaken at the Department of Anatomy of the School of Medicine in Sarajevo, whereas the data regarding the hearts with signs of coronary disease were obtained in cooperation with the Cardiology Department of Clinics Centre in Sarajevo. Clinical investigations were retrospective and prospective on patients that were treated in hospital, and on patients that just arrived to hospital (based on findings of coronary angiography). Their ages ranged from 45-72 years. Diagnoses were different: chronic stable angina and atypical angina, myocardial infarction, arterial hypertension. Various methods were applied in our investigations: injection-corrosion and coronary angiography. In injection-corrosion method, vinilit in two different colours was injected in both of coronary arteries and blue substance in veins. After successful

injection the hearts were placed into 30% HCl solution and then rinsed in a weak jet of water. Soft parts of the hearts decayed and came off, whereas filled blood vessels stayed preserved because they are not subject to corrosion. With this method we examined coronary arteries and veins as well as their collaterals. We also applied coronary angiography method. A catheter was inserted into the femoral artery. We used the catheters by Judkins for both right and left coronary artery. Omnipaque was introduced as a contrast. Both arteries were X-rayed in two radiographic projections: RAO (right anterior oblique) and LAO (left anterior oblique). For all patients we applied left ventriculography for the evaluation of ejective fraction. Using this method we explored the existence of collaterals in occlusion or stenosis of coronary arteries (coronary disease). On the angiograms we analyzed collaterals as "good" and "bad" based on diameter. The investigations were done with respect to ethical standards regulated by Helsinki Declaration.

RESULTS

The results show the existence of different types of collaterals: intracoronary (between the branches of the same coronary artery) and intercoronary (between two coronary arteries). We established collaterals in a case with stenosis or occlusion of the right coronary artery as well as of the left coronary artery and its branches in which better development of collaterals has been established. On the anatomical material we found different types of collaterals using injection-corrosion method (Figure 1,2). Our patients were classified into two groups (based on findings of coronary angiography):

- patients with good collaterals and good left ventricular function (Figure 3, 4, 5, 6)
- patients with good collaterals and impaired left ventricular function (Figure 7, 8, 9, 10).

DISCUSSION

Although many authors (1,6,8,9) wrote about ischemia changes of the heart, variations of coronary artery and their collaterals, even today there are many different and, what is more, contradictory opinions in the literature about the role of collateral circulation in revascularisation in the field with a damaged blood vessels. So, one group of authors (4) consider the role of coronary arteries in that sense minimal, whereas the other authors (2,7,5) find their role important but not examined enough. Our investigations confirmed the existence of the coronary arteries collaterals, both on the hearts with-

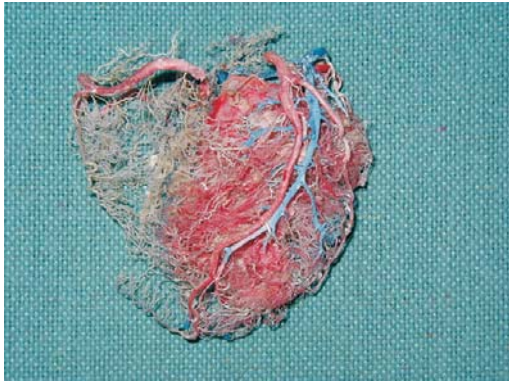


FIGURE 1. Intracoronary collaterals, left coronary artery (injection-corrosion)

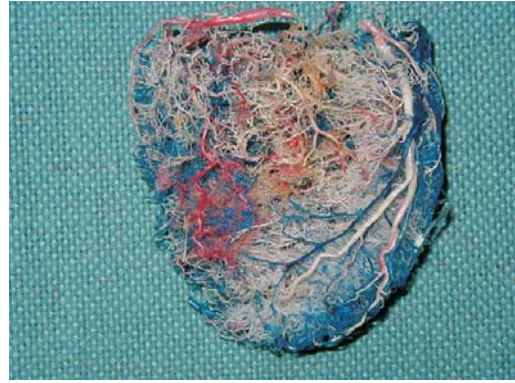


FIGURE 2. Intracoronary collaterals, right coronary artery (injection-corrosion)

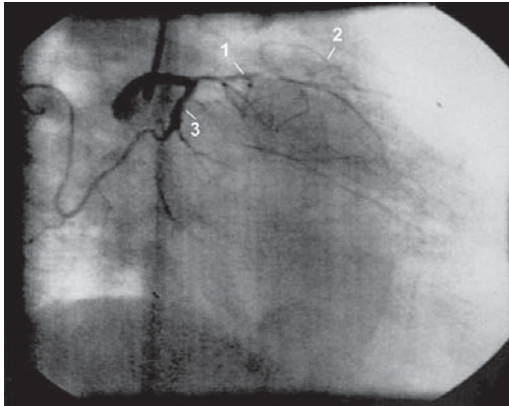


FIGURE 3. RAO: left coronary arteriogram
1. Proximal occlusion of the left anterior descending branch
2. Homocollaterals; 3. Minimal changes on the circumflex branch

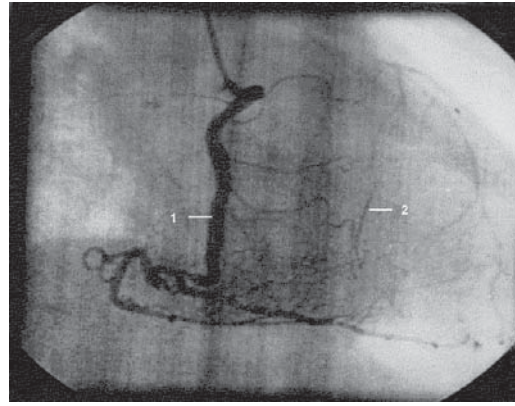


FIGURE 4. RAO: right coronary arteriogram
1. Right coronary artery dominant
2. Distal part LAD has been filling septal branches of the RIP

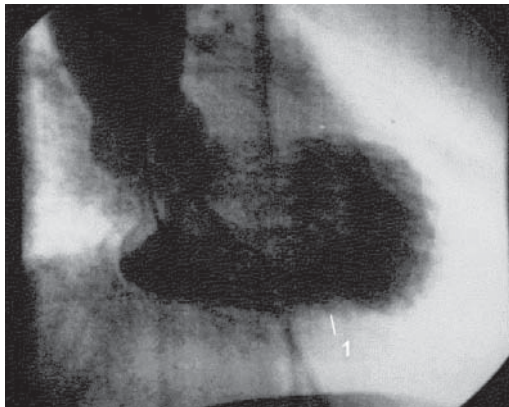


FIGURE 5. RAO: left ventricle (diastole)

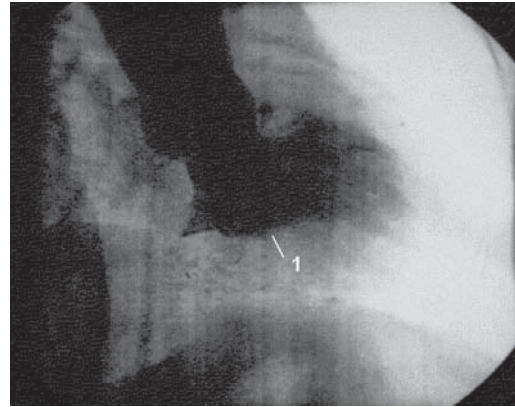


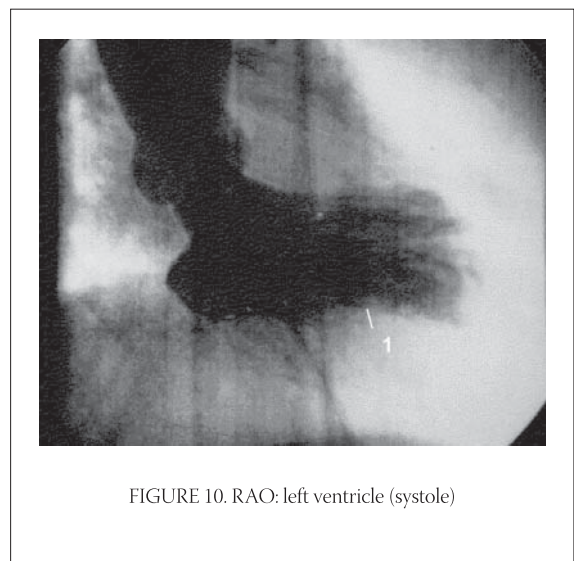
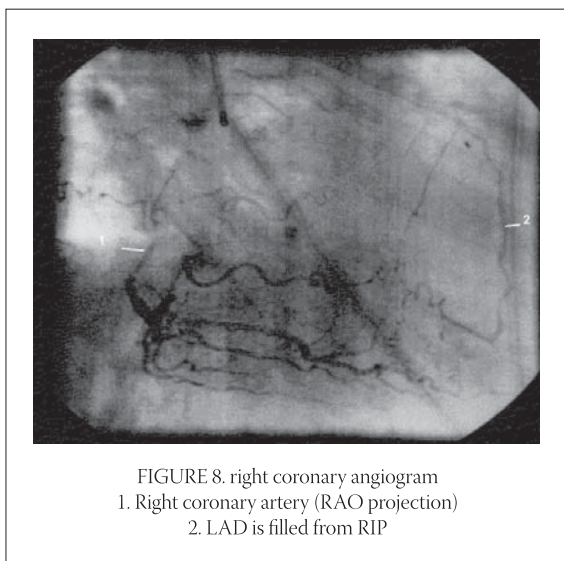
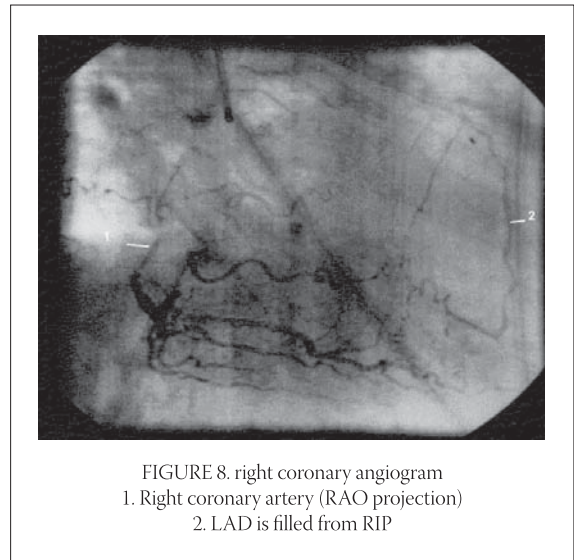
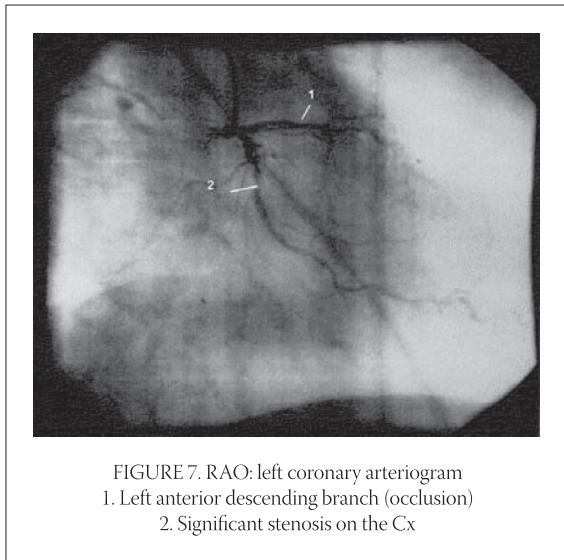
FIGURE 6. RAO: left ventricle (systole)

out visible pathological changes and the ones with visible pathological changes - coronary disease (10,11). Clinical investigations showed two groups of patients: with good collaterals and good left ventricular function and with good collaterals and impaired

left ventricular function. In the first group EF (ejective fraction) was 60%, in the second one EF was 35%. The valuation of collaterals were based on diameter - "good" collaterals with diameter more than 1 mm, and "bad" collaterals with diameter less than 1 mm. (3).

CONCLUSION

Our results show that the injection corrosion method and coronary angiography are useful methods for the demonstration of coronary collaterals in the normal and pathological condition. In patients with coronary artery disease angiographic evaluation of collaterals is a good diagnostic method and has potential clinical value. Collateral function is better in patients with good left ventricular function (ejective fraction 60%) than in those with impaired left ventricular function (ejective fraction 35%). This result would be expected but was not shown clear using angiographic method. The present angiographic study assesses the relation of collateral and regional myocardial function. "Good" collaterals with diameter more than 1mm have important role in protection of left ventricular function (EF-60%) but the situation is not the same for "bad" collaterals" with diameter less than 1mm (EF-35%).



REFERENCES

- (1) Freedman S.B., Isner J. Therapeutic angiogenesis for coronary artery disease. *Ann Intern. Med.* 2002;136(1):54-71.
- (2) Hasanović A. Myocardial perfusion scintigraphy and echocardiography in patients with coronary collaterals. *Med.Jour.* 2002;8(1):32-35.
- (3) Kamenica S. Karakteristike i značaj koronarnog kolateralnog krvotoka u naših bolesnika sa totalnom okluzijom glavnog stabla leve koronarne arterije. *Vojnosanit. Pregl.* 1984; 41:4, 235-239.
- (4) Seiler C., Billinger M., Fleisch M., Meier B. Washout collaterometry: a new method of assessing collaterals using angiographic contrast clearance during coronary occlusion. *Heart* 2001;86:540-546.
- (5) Rockstroh J., Brown G. Coronary collateral size, flow capacity, and growth. *Circulation* 2002;105:168.
- (6) Pohl T., Hochstrasser P., Billinger M., Fleish M., Mailer B., Seiler C. Influence on collateral flow of recanalising chronic total coronary occlusions: a case-control study. *Heart* 2001;86:438-443.
- (7) Werner G.S., Ferrari M., Betge S., Gastman O., Richartz M.B., Figulla H.R. Collateral function in chronic total coronary occlusions is related to regional myocardial function and duration of occlusion. *Circulation* 2001;104:2784.
- (8) Timothy D.H. Therapeutic angiogenesis. *BMJ.* 1999;318:1536-1539.
- (9) Werner S.G., Richartz B.M., Gastman O. Immediate changes of collateral function after successful recanalisation of chronic total coronary occlusions. *Circulation.* 2000;102:2959.
- (10) Seiler C., Fleisch M., Meier B. Direct intracoronary evidence of collateral steal in humans. *Circulation* 1997;96:4261-4267.
- (11) Rapps J.A., Myers P.R., Zhong Q., Parker J.L. Development of endothelium-dependent relaxation in canine coronary collateral arteries. *Circulation* 1998;98:1675-1683.