Changes of the Constituents in Serum and Aortic Tissue by the Differences of the Kinds of Feed —SHR—


It was reported by Youdkin et al.1,2) that the patients with ischemic heart disease had taken much intake of sugar. But Walker3) or Key4) maintain that they have some doubts whether sugar have been the chief player on the genesis of ischemic heart disease.

Kritchevsky et al.5) and Murakami et al.6) reported that clear vessel injury to artery of the aorta and the kidney was produced by sugar administration on rabbits.

There are many explanations7,8) on the mechanism of the vessel injury by sugar but the mechanism is not clarified yet. So, to investigate the mechanism of the vessel injury by sugar administration, three kinds of feed were given to spontaneous hypertensive rats (SHR) and following substances i.e. serum cholesterol, serum ultra-watersoluble (Serum-UWS) lipoprotein, serum non-watersoluble (Serum-Non-WS) lipoprotein, serum total binding hexose (Serum-TBH), serum UWS-TBH, serum non-WS-TBH and lipids or binding hexose in aortic tissue were measured on two points i.e. after 3–8 weeks and 10–12 months of feeding.

**Material and subject**

1) SHR

Ninety SHRs after 2–3 months from birth were used, 52 male and 38 female SHRs. Body weight is 140–200 g in male SHRs and 120–170 g in female SHRs.

Blood pressure increased during 2–3 months from birth up to 170–200 mmHg in systolic blood pressure.

2) Three kinds of feed were administered to SHRs so that they were classified into three groups respectively. First group (Standard Group) of 18 males and 10 females was given the standard feed (oriental solid) and water. Second group (Sugar Group) of 20 males and 13 females was given the standard feed and 10% sucrose solution as drinking water. Third group (Lard Group) of 14 males and 15 females was given the standard feed whose 40% of total calorie was replaced with lard and water.

3) Serum was separated from fasting blood by formal method and aortic tissue was pooled together into freezer with −20°C until this experiment was performed.

4) The extraction from intima and media dissected from aortic tissue was performed by Hoff’s method9) and the modifications method as shown in Table 1. The estimation of AoI, AoII and AoIII fractions were showed in Table 1, too.

5) Total cholesterol was measured by enzymatic method and total binding hexose by Sato’s method10). Serum UWS- and serum Non-WS-fractions were obtained by Kanazawa’s method11).
Table 1 Method of extraction from aortic wall

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<th>Intima-Media of Aorta</th>
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<td>Dialysis against water X 5000rpm for 30min.</td>
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<td>Extraction by triton X-100 X 5000rpm for 30min.</td>
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Fig. 1 Serum cholesterol by three kinds of feed.

(16.6±6.4 mg/dl) < sugar group (26.9±12.7 mg/dl).
After 10-12 months those in sugar group (37.0±1.9 mg/dl) and lard group (34.1±9.4 mg/dl) are higher than these in standard group (27.7±8.8 mg/dl).

c) Serum Non-WS-cholesterol concentrations after 3-8 weeks of feeding are in the order of standard group (50.0±10.3 mg/dl) < sugar group (80.6±21.8 mg/dl) < lard group (76.4±18.1 mg/dl) but after 10-12 months no differences are found among the three groups.

2. Cholesterol in aortic tissue

a) Cholesterol amounts in AoI do not show significant differences among the three groups and these amounts are too little.
But after 10-12 months these are in the order of...
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b) Cholesterol amounts in AoII do not show significant differences among the three groups but after 10–12 months these are in the order of standard group (1.80±0.32 mg/g·wet.)<lard group (1.86±0.46 mg/g·wet.)>sugar group (1.12±0.12 mg/g·wet.).

c) Cholesterol amounts in AoIII do not show significant differences among the three groups and after 10–12 months the same results were obtained. Although the amounts of cholesterol are too little after 3–8 weeks, after 10–12 months those increased until 0.02–0.42 mg/g wet tissue.

3. Total binding hexose (TBH) in serum

a) Serum TBH concentrations after 3–8 weeks of feeding are in the order of standard group (166.4±23.2 mg/dl)<lard group (190.8±29.0 mg/dl)<sugar group (210.0±9.0 mg/dl). After 10–12 months these are in the order of standard group (261.6±25.2 mg/dl)=lard group (271.3±41.5 mg/dl)<sugar group (300.6±18.2 mg/dl), and sugar group>lard group, and these concentrations after 10–12 months are significantly higher than those after 3–8 weeks.

b) Serum UWS-TBH concentrations after 3–8 weeks of feeding are in the order of standard group (144.5±11.7 mg/dl)<lard group (144.0±17.0 mg/dl)<sugar group (168.1±15.6 mg/dl). After 10–12 months the order was the same but those concentrations after 10–12 months are distinctly higher compared with those after 3–8 weeks.

c) Serum non-WS-TBH concentrations after 3–8 weeks of feeding do not show significant differ-
Fig. 7 Serum total binding hexose by three kinds of feed.

Fig. 8 Ultra-watersoluble total binding hexose in serum by three kinds of feed.

Fig. 9 Non-watersoluble total binding hexose in serum by three kinds of feed.

Fig. 10 Total binding hexose in AoI fraction by three kinds of feeds.

4. TBH in aortic tissue
   a) TBH amounts in AoI do not show significant differences among the three groups. After 10–12 months these are in the order of standard group (26.1±10.5 mg/dl)<sugar group (25.5±27.7 mg/dl)<lard group (69.9±33.3 mg/dl).

References among the three groups but after 10–12 months these are in the order of standard group (26.1±10.5 mg/dl)<sugar group (25.5±27.7 mg/dl)<lard group (69.9±33.3 mg/dl).
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Discussion

It has been often\textsuperscript{12,13} reported that atherosclerotic changes were developed in coronary artery by the administration of cholesterol. Murakami et al.\textsuperscript{14} and Kelsy et al.\textsuperscript{15} published that PAS positive substances and sclerotic changes as well as aneurysma, intimal thickness and calcification etc. appeared in the artery of the kidney, the aorta and the coronary artery by feeding of sugar. According to their papers, there were found clear differences between lipid induced vessel injury and sugar induced vessel injury. In this experiment using SHR, thickness of intima edematous change and alteration of elastic fasern in aortic intima were seen by giving as drinking water 10\% sucrose solution for 10–12 months.

In both groups of sugar and lard, serum cholesterol levels are higher compared with standard group in 3–8 weeks of feeding. When lard was much administered, serum high cholesterol level can be understood well because of including much lipid. But the reason why the sugar increases cholesterol level is unknown. Kritchevsky et al.\textsuperscript{5} reported the increasing level of serum cholesterol with sugar administration but the mechanism was not explained.

But 10–12 months later of feeding, no significant differences were found in serum cholesterol among the three kinds of feed. This fact will elucidate increasing of serum cholesterol in standard group by aging. Goto\textsuperscript{12} annunciated in human, that serum cholesterol increased until fifty–sixty years old.

We reported to be able to separate serum lipoprotein into two fractions\textsuperscript{11}, namely UWS-lipoprotein and non-WS-lipoprotein, and it is useful\textsuperscript{13} for differenciation of cerebral infarction and cerebral haemorrhage from a viewpoint of body fluids.

Therefore in this experiment UWS-lipoprotein and non-WS-lipoprotein were measured in each SHR. UWS-cholesterol levels in sugar group are higher than those in standard and lard group in both periods of 3–8 weeks and 10–12 months. On the other hand, non-WS-cholesterol levels are higher in sugar and lard groups than those in standard group after feeding of 3–8 weeks but after 10–12 months no differences are found among the three groups. As this result may show, high serum cholesterol levels after 3–8 weeks by the adminis-
tration of sugar and lard are due to increasing of non-WS-cholesterol. Muraoka et al.\textsuperscript{14} published almost no differences of non-WS-cholesterol in coronary heart disease. In this experiment, after 10–12 months of feeding non-WS-cholesterol does not show significant differences among the three groups. This result will not contradict their reports because their patients of sclerotic diseases were old (the age being over forty).

It may be important for studying vessel injury that non-WS-cholesterol level increases in early period i.e. 3–8 weeks of feeding of sugar and lard. And also, it is characteristic and important that only in sugar group, UWS-cholesterol levels are higher compared with the other two groups, because, although many investigators described the mechanisms of vessel injury by sugar, the originated substances against vessel injury can not be explained clearly.

It has been often reported\textsuperscript{15,16} that serum binding carbohydrate had increased in vessel injury disease. We investigated relationships\textsuperscript{17,18} between TBH and hypertension, aortic arch calcification, diabetes mellitus and cerebrovascular disease, too. Therefore serum TBH was measured in this experiment.

Although serum TBH increased only in sugar group after both periods of 3–8 weeks and 10–12 months of feeding, that did not changed by lard administration.

And serum UWS-TBH increased obviously in sugar group.

Accordingly the increasing of serum TBH is due to increasing of serum UWS-TBH. On the other hand, non-WS-TBH increased only in lard group after 10–12 months. Obvious differences in serum TBH were found between sugar and lard feed.

To investigate whether serum constituents influence aortic tissue constituents, cholesterol in AoI, AoII and AoIII was measured. Although cholesterol in AoI and AoIII is almost not detected after 3–8 weeks, 10–12 months later that could be measured but not much. And after 10–12 months of feeding, cholesterol in AoI in sugar and lard group was higher than that in standard group.

It is very interesting that serum cholesterol is high after 3–8 weeks and that after 10–12 months became almost the same level among the three groups but cholesterol in aortic tissue is almost not measured after 3–8 weeks while after 10–12 months much cholesterol developed in aortic tissue. Namely it might be considered that cholesterol in serum and aortic tissue as well as AoI and AoIII was exchanged during progress of sclerotic change.

Cholesterol in AoII fraction was lower in sugar group than that in the other groups. The meaning of AoII to vessel injury is unknown.

TBH in aortic tissue was investigated among the three feeding groups. Although no differences in TBH in AoI, AoII and AoIII were found among the three groups, those after 3–8 weeks was higher than those after 10–12 months. Cholesterol in aortic tissue was higher after 10–12 months than after 3–8 weeks, but TBH in aortic tissue was the opposite of the results of cholesterol.

This fact will suggest an important role to progressing of vessel injury. And also, it might be considered that lipid and binding hexose may be exchanged in course of vessel injury. In lard group, TBH in AoI and AoIII was higher than that of the other two groups. In aortic tissue, clear differences were found between sugar group and lard group.

Reference

Changes of the Constituents in Serum and Aortic Tissue by the Differences of the Kinds of Feed


Constituents in serum and aortic tissue by the differences of kinds of feed were measured using 90 SHRs after 2–3 months from birth.

Three kinds of feed were given SHRs, namely first of standard feed (oriental solid) and water, second of standard feed and 10% sucrose solution as drinking water, and third of standard feed whose 40% of total calorie was replaced with lard and water.

1) The constituents as well as lipids and binding hexose were changed in serum and aortic vessel wall by the administration of sucrose or lard.

2) The modes of changes of constituents differed among oriental standard feed group, sugar group and lard group. And the changes differed between 3–8 week feeding and 10–12 month feeding, too.

3) Changes of lipids and of binding hexose were not the same in serum or aortic tissue. Namely, both substances must be considered independently as risk factor of vessel injury.

4) Time discrepancy of changes of lipid binding-hexose was found between concentration in serum and amount in aortic tissue.

Key words: Sucrose, vessel injury, lipoprotein, Binding-hexose, ultra-water-soluble fraction, non-water-soluble fraction.