A Comparison of the Serum Lipids, Lipoproteins, Glycoproteins, Urinary 17-Ketosteroids, and Gonadotropins in Eunuchs and Control Male Subjects

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The proclivity of men to coronary artery disease has been recognized for almost 2 centuries. The gonadal hormones have understandably come under scrutiny in the search for the explanation of this marked sex difference in susceptibility to disease. Sex hormones are known to alter the physical state of the serum lipids. It has been suggested that eunuchs suffer a less severe form of coronary atherosclerosis than uncastrated subjects. This study compares the serum lipids and lipoproteins, as well as other serum and urinary constituents, in 24 castrated and 20 uncastrated institutionalized men.

The concept of coronary atherosclerosis primarily as a disease of men had its origin almost 2 centuries ago and appears to be one of the few points over which there is relatively little disagreement among students of atherosclerosis. Indirect support of this concept is provided by Wuest, Dry, and Edwards whose studies indicated that castrated women suffer a more severe form of coronary atherosclerosis than uncastrated women. More directly applicable are the suggestions of White, Howard and Gertler, and Hawke that eunuchs manifest less anatomic evidence of coronary atherosclerosis than uncastrated men. These differences may be related, at least in part, to the known influence of gonadal steroids on serum lipids and lipoproteins. Considerations such as these prompted us to study a group of 24 eunuchs and 20 uncastrated men, all institutionalized at a training school for the mentally retarded.

**Selection of Subjects and Methodology**

Only subjects in apparent good health were retained in this study after physical examination, electrocardiogram, chest x-ray, and determinations of the serum total protein and hemoglobin had been made. There were no hypertensive individuals or members of the Hebrew race. There was 1 Negro among the eunuchs, none in the control group.

The age distribution for both groups was between 23 and 79 years and is shown in figure 1. The mean age of the eunuchs was 39, that of the controls 41. Castrated and control subjects were matched with respect to age and weight as closely as the nature of the school population would permit.

The mean body weight of the castrates was 69.5 ± 2.7 Kg., that of the controls 65.5 ± 2.3 Kg. Mean body surface area of the castrates was 1.80 ± .04 M², that of the controls 1.72 ± .03 M².

**Fig. 1.** Distribution of subjects according to age at the time of study.
The mean age at castration was 18 years. The relationship between age at castration and age at the time of this study is depicted in figure 2. It is of interest to note that castration had been accomplished by the sixteenth year in 10 subjects. One subject, age 28, was found on examination...
TABLE 1.—Serum Lipids and Lipoproteins; Mean Values* and Standard Errors

<table>
<thead>
<tr>
<th>Determination</th>
<th>Age</th>
<th>Castrates</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean values</td>
<td>No. subjects</td>
</tr>
<tr>
<td>Total cholesterol</td>
<td></td>
<td></td>
<td>No.</td>
</tr>
<tr>
<td>mg. %</td>
<td>21–30†</td>
<td>161 ± 6</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>31–50</td>
<td>180 ± 9</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>51 &amp; over</td>
<td>182 ± 2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>All ages</td>
<td>175 ± 6</td>
<td>24</td>
</tr>
<tr>
<td>Phospholipid</td>
<td>21–30</td>
<td>226 ± 8</td>
<td>7</td>
</tr>
<tr>
<td>mg. %</td>
<td>31–50</td>
<td>238 ± 8</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>51 &amp; over</td>
<td>243 ± 3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>All ages</td>
<td>235 ± 5</td>
<td>24</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>21–30</td>
<td>0.70 ± 0.03</td>
<td>7</td>
</tr>
<tr>
<td>mg. %</td>
<td>31–50</td>
<td>0.72 ± 0.02</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>51 &amp; over</td>
<td>0.77 ± 0.03</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>All ages</td>
<td>0.73 ± 0.01</td>
<td>24</td>
</tr>
<tr>
<td>Phospholipid</td>
<td>21–30</td>
<td>207 ± 11</td>
<td>7</td>
</tr>
<tr>
<td>mg. %</td>
<td>31–50</td>
<td>195 ± 10</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>51 &amp; over</td>
<td>217 ± 4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>All ages</td>
<td>202 ± 7</td>
<td>24</td>
</tr>
<tr>
<td>lipoproteins</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>–S₁₂₁ 0–12 mg. %</td>
<td>21–30</td>
<td>173 ± 6</td>
<td>7</td>
</tr>
<tr>
<td>(“alpha”)</td>
<td>31–50</td>
<td>183 ± 14</td>
<td>13</td>
</tr>
<tr>
<td>(“beta”)</td>
<td>51 &amp; over</td>
<td>191 ± 16</td>
<td>4</td>
</tr>
<tr>
<td>lipoproteins</td>
<td>All ages†</td>
<td>182 ± 8</td>
<td>24</td>
</tr>
<tr>
<td>–S₁₂₁ 25–70 mg. %</td>
<td>21–30</td>
<td>203 ± 9</td>
<td>7</td>
</tr>
<tr>
<td>(“alpha”)</td>
<td>31–50</td>
<td>227 ± 13</td>
<td>13</td>
</tr>
<tr>
<td>(“beta”)</td>
<td>51 &amp; over</td>
<td>219 ± 17</td>
<td>4</td>
</tr>
<tr>
<td>lipoproteins</td>
<td>All ages§</td>
<td>219 ± 8</td>
<td>24</td>
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<tr>
<td>Ratio: †</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Cholesterol</td>
<td>21–30</td>
<td>1.21 ± 0.05</td>
<td>7</td>
</tr>
<tr>
<td>0–12</td>
<td>31–50</td>
<td>1.12 ± 0.07</td>
<td>13</td>
</tr>
<tr>
<td>(“alpha”)</td>
<td>51 &amp; over</td>
<td>1.19 ± 0.10</td>
<td>4</td>
</tr>
<tr>
<td>(“beta”)</td>
<td>All ages†</td>
<td>1.18 ± 0.07</td>
<td>24</td>
</tr>
<tr>
<td>Ratio: §</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>–S₁₂₁ 0–12 Phospholipid</td>
<td>21–30</td>
<td>0.91 ± 0.04</td>
<td>7</td>
</tr>
<tr>
<td>0–12</td>
<td>31–50</td>
<td>0.81 ± 0.04</td>
<td>13</td>
</tr>
<tr>
<td>(“alpha”)</td>
<td>51 &amp; over</td>
<td>0.93 ± 0.05</td>
<td>4</td>
</tr>
<tr>
<td>(“beta”)</td>
<td>All ages†</td>
<td>0.86 ± 0.03</td>
<td>24</td>
</tr>
</tbody>
</table>

* Values listed are "true means" where N = number of subjects (rather than number of samples) studied.
† Differences between castrates and controls in this group significant at 0.05 level.
‡ Differences between castrates and controls in this group significant at 0.02 level.
§ Differences between castrates and controls in this group significant at 0.001 level.
during the course of the study to be eunuchoidal but not castrate. There was a history of testicular atrophy early in childhood, the testes were extremely small, and the body build, fat, and hair distribution were definitely eunuchoidal. Because of these findings he was retained in the castrate group only for compilation of the data presented in the tables.

Five blood samples were obtained from each eunuch (total number of samples 124) and 3 from each control subject (total number 70) in most instances. Blood was usually obtained at intervals of several months over a 2-year period. All blood was drawn in the postabsorptive state. Overnight urine specimens were collected whenever possible for determinations of 17-ketosteroid and urinary gonadotropin. Analyses were performed on a total of 49 urine specimens from 19 control subjects and 67 specimens from 24 castrates.

Lipoproteins were determined refractometrically after preparative ultracentrifugation at solvent density 1.21 Gm. per ml., according to the method of Lewis, Green, and Page as employed in this laboratory. The value of the ratio
\[
\frac{\text{high density} - S_{1.21} 0-12}{\text{lower density} - S_{1.21} 25-40}
\]

("alpha") lipoproteins is employed to provide an index of the relative amounts of these 2 major lipoprotein groups. Use is also made of the values of the ratios
\[
\frac{S_{1.21} 0-12 \text{ lipoproteins}}{\text{total cholesterol}}
\]

and
\[
\frac{\text{phospholipid}}{S_{1.21} 0-12 \text{ lipoproteins}}
\]

to relate high density lipoprotein concentrations to the chemically determined native serum total cholesterol and phospholipid levels. Total and unesterified cholesterol were determined by the method of Sperry and Webb and lipid phosphorus by a modification of the method of Youngburg. The factor 25 was used to convert lipid phosphorus to phospholipid.

Urinary gonadotropin was assayed according to the nondialysis method of Klinefelter, Albright, and Griswold, and levels of less than 96 mouse uterine units per 24 hours were considered normal. Urinary neutral 17-ketosteroids were determined by the Zimmerman reaction. Initially, acid hydrolysis, extraction with carbon tetrachloride and a modified Zimmerman reaction were employed according to the technic outlined by Holtorff and Koch. In analyses undertaken after May 1955, the technic proposed by Klendshoj, Feldstein, and Sprague was employed, without change in values considered "normal."

Serum glycoprotein (protein-bound carbohydrate) according to the method of Shetlar, Foster, and Everett, in which the results are expressed in terms of bound hexose, and total serum protein by the method of Weichselbaum were determined in 27 samples of serum from 11 control subjects and in 63 samples from 22 castrates. The ratio
\[
\frac{\text{serum glycoprotein hexose} \times 100}{\text{total protein}}
\]
is utilized to relate the concentration of protein-bound carbohydrate to the total concentration of circulating protein. The mean age of the controls whose sera were studied for glycoproteins was 36 years, that of the castrates 40.

The data for the 2 groups are compared according to the following age classifications: 21-30 ("young"), 31-50 ("middle-aged"), and over 50 years of age ("old"), as well as irrespective of age. The significance of differences was determined by t test.

**RESULTS**

Mean values for the several lipid and lipoprotein fractions studied are presented in table 1.

Mean serum total cholesterol levels were significantly lower in the castrates only in the young or 21 to 30-year age group. The mean values for the 2 groups in the other age classifications were not significantly different. The degree of esterification was similar in all of the subjects.

Differences in serum phospholipid concentrations between eunuchs and controls were not significant at any age level, nor did cholesterol/phospholipid ratios differ significantly.

Higher concentrations of high density (S1.21 0-12 or "alpha") lipoproteins characterized the castrate group at each age level as well as irrespective of age, although these differences were not statistically significant.

Lower concentrations of lower density (S1.21 25-40 or "beta") lipoproteins characterized the castrate group at every age level, but statistically these differences were significant only when the castrate and control groups were considered in their entirety. The more inclusive S1.21 25-70 lower density lipoprotein concentrations were also consistently lower in the castrates but, as was the case for the S1.21 25-40 fraction, the difference was statistically significant only when the 2 groups were considered in their entirety.
Low density lipoproteins with flotation rate characteristics above \(-S_{1.21}\) 70 were inconstantly present in small amounts and did not differ significantly in the 2 groups. Concentrations of \(-S_{1.21}\) 20-25 ("alpha-2") lipoproteins likewise did not differ in the 2 groups.

The values for high density: lower density \(\left(-S_{1.21}\right) 0\text{-}12 \frac{mg.}{24\text{ hours}}\) lipoprotein ratios were consistently higher in the castrates for all age groups, and the difference between castrates and controls was statistically highly significant in the middle and old age groups, and for the groups considered in their entirety.

The \(\frac{-S_{1.21}}{\text{total cholesterol}} \frac{0.12}{25-40} \) and \(\frac{-S_{1.21}}{\text{phospholipid}} 0.12 \frac{mg.}{L}\) ratios had consistently higher values for all ages in the castrate group, but the differences were statistically significant only when the groups were considered in their entirety.

Mean values of glycoprotein and total protein are listed in table 2. Serum glycoprotein concentrations were significantly higher in the castrate group as was the value for the glycoprotein hexose \(\times 100\). Serum glycoprotein levels in the control subjects were generally within "normal limits," as determined on a larger group of apparently healthy subjects by Shetlar, Foster, Kelly, and Everett. No significant differences were noted with respect to total serum protein concentrations.

### Table 2.—Glycoproteins; Mean Values* and Standard Errors, All Ages

<table>
<thead>
<tr>
<th>Determination</th>
<th>Castrates</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean values</td>
<td>Subjects</td>
</tr>
<tr>
<td>Serum glycoprotein hexose† mg. %</td>
<td>146±3</td>
<td>22</td>
</tr>
<tr>
<td>Serum total protein, Gm. %</td>
<td>7.27±.12</td>
<td>22</td>
</tr>
<tr>
<td>Glycoprotein hexose×100†</td>
<td>2.00±.05</td>
<td>22</td>
</tr>
</tbody>
</table>

* Values listed are "true means" where N = number of subjects (rather than number of samples) studied.

† Differences between castrates and controls significant at 0.05 level.

### Table 3.—Ketosteroid Excretion; Mean Values* and Standard Errors

<table>
<thead>
<tr>
<th>Determination</th>
<th>Age</th>
<th>Castrates</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean values</td>
<td>Subjects</td>
<td>Samples</td>
</tr>
<tr>
<td>17-ketosteroid excretion, mg./24 hours</td>
<td>21–30</td>
<td>9.4±1.7</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>31–50</td>
<td>9.7±0.7</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>51 &amp; over</td>
<td>5.3±1.0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>All ages</td>
<td>8.9±0.7</td>
<td>24</td>
</tr>
<tr>
<td>17-ketosteroid excretion, mg./L</td>
<td>21–30</td>
<td>6.4±1.7</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>31–50</td>
<td>5.2±0.7</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>51 &amp; over</td>
<td>3.9±0.4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>All ages†</td>
<td>5.3±0.6</td>
<td>24</td>
</tr>
</tbody>
</table>

* Values listed are "true means" where N = number of subjects (rather than number of samples) studied.

† Difference between castrates and controls significant at 0.05 level.
TABLE 4.—Gonadotropin Excretion, All Ages

<table>
<thead>
<tr>
<th>Mouse uterine units</th>
<th>Castrates</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>subjects</td>
<td></td>
</tr>
<tr>
<td>&gt; 384</td>
<td>16</td>
<td>67</td>
</tr>
<tr>
<td>&gt; 192</td>
<td>22</td>
<td>92</td>
</tr>
<tr>
<td>&gt; 96</td>
<td>23</td>
<td>96</td>
</tr>
<tr>
<td>&lt; 96</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>100</td>
</tr>
</tbody>
</table>

Urinary 17-ketosteroid and gonadotropin values are presented in tables 3 and 4. The 17-ketosteroid excretion per 24 hours did not differ significantly between the 2 groups for any age category. When the urinary 17-ketosteroid concentration was determined, a significantly higher level was noted in the total control group. Urinary gonadotropin excretion was as expected, with the majority of eunuchs (22 out of 24) excreting more than 192 mouse uterine units per day while only 3 of 19 control subjects excreted more than 192 units.

DISCUSSION

The relatively small size of the samples of this unique population that were available for study limits the degree of statistical significance that can be assigned to many of the observed differences. Outstanding among the data for the castrates, however, are the consistently higher mean values for high density lipoprotein concentrations and the consistently lower mean concentrations of the lower density lipoproteins. There were no exceptions with respect to these mean values (table 1). The likelihood that such consistency was due to chance alone is extremely small (1.212). The value for the ratio of high density/lower density lipoprotein is, by virtue of its derivation, higher in the castrate group. Further emphasis is lent this consistency of difference in lipoprotein concentrations (and ratios) between the 2 groups by the fact that other than for the significantly lower native serum total cholesterol levels in the young castrates, neither serum cholesterol nor phospholipid values differed significantly or consistently.

The differences between eunuchs and uncastrated men with respect to the high and lower density lipoproteins are characteristic of the changes observed when androgens are withdrawn from, or estrogens administered to, other subjects.7

The significantly lower serum cholesterol levels in the young castrates prompted further scrutiny of the data with reference to what influence the subject’s age at the time of castration might have on his lipids and lipoproteins at the time of study. Figures 2 and 3 are of interest in this regard. It may be noted (fig. 2) that none of the young castrates had a serum cholesterol level in excess of the control mean serum cholesterol level. A young age at castration is of course inherent in the young castrate group. When the middle and old age groups are examined, it is of further interest to note that while none of the eunuchs who was subject to castration before the seventeenth year of age had a serum cholesterol value in excess of the mean serum cholesterol value, each of the 4 prepuberal castrates in the middle age group had individual mean serum cholesterol values (137 ± 6, 149 ± 10, 156 ± 3, and 141 ± 14 mg. per cent) statistically significantly lower (p < 0.01, p < 0.05, p < 0.05, p < 0.05) than the mean cholesterol level (180 ± 9 mg. per cent) for the middle age castrate group as a whole. There are, of course, some eunuchs in the middle age group who underwent castration later than the sixteenth year of age whose serum cholesterol values were also less than the mean control value.

Figure 3 denotes a somewhat different relationship among the 3 variables: age at castration, age at time of study, and the value for the ratio high density/lower density lipoproteins. It is noted that none of the values of this ratio in the castrate group was less than the mean control value, irrespective of age at castration or age at the time of study. It is also of interest to note that only 1 control subject, who happened to fall in the young age group, had a value for the high
density/lower density lipoprotein ratio that exceeded the mean value of this ratio in the eunuchs.

These observations suggest that the influence of the male gonad on the relative amounts of high and lower density serum lipoproteins is at least partially independent of age factors, e.g., the age at which gonadal influence is removed (at least up to the age of 33 years), and probably the age of the subject at the time serum lipoprotein relationships are determined, although the data suggest that alterations in lipoprotein relationships induced by gonadectomy are apt to be more striking in middle-aged male subjects. The influence of castration before the seventeenth year of age on the level of chemically determined serum cholesterol also appears to be somewhat independent of age, since the lower level characteristic of the young eunuchs was noted in the middle age group only in those subjects who were prepuberal eunuchs.

These data, then, are consistent with the hypothesis that the effect of withdrawal of gonadal hormones on the relative amounts of the 2 major serum lipoprotein fractions in men is at least partially independent of age, while the effect on the cholesterol concentration is maintained only when the gonads are removed at or before puberty.

The lack of significant differences in serum phospholipid levels in the 2 groups, previously noted by Hamilton, Bunch, Mestler and Imagawa,18 is undoubtedly related to the fact that the lipid phosphorus content of the high and lower density lipoproteins is similar, namely 26.5 and 23.4 per cent respectively, as reported by Bragdon, Havel, and Boyle.19

The lack of significant differences between the eunuchs and uncastrated men with respect to low density lipoproteins of flotation rates in excess of $-S_{1.21}$ 70 ($S_f$ 20) tends to minimize the etiologic or predictive significance of these low density lipoproteins in atherosclerosis (assuming that eunuchs suffer less atherosclerosis than uncastrated men).

The lower levels of urinary 17-ketosteroids in the eunuchs are obviously a consequence of castration, although the difference in 17-ketosteroid excretion between the 2 groups is quantitatively slight, presumably because of increased adrenal androgen synthesis in the eunuch. Qualitatively these adrenal androgens differ from those of gonadal origin inasmuch as they do not prevent the appearance of eunuchoidal somatic characteristics in the prepubescent castrate. The difference in the lipoprotein relationships of the 2 groups demonstrated in this study is an additional manifestation of this qualitative difference between testicular and adrenal androgens. No correlation was noted between urinary 17-ketosteroid excretion and a subject's age at castration, the concentration of high or low density lipoproteins or their ratio. Aging appeared to be associated with diminishing urinary 17-ketosteroids, a phenomenon previously described by Venning and Kazmin.20

A greater excretion of gonadotropins in castrated than in uncastrated subjects, is of course, expected. The reasons for elevated gonadotropin excretion in 3 of the control subjects are not apparent, since testicular size and consistency were normal in each subject and there were no other stigmata of eunuchoidism or general systemic disease. Two of them were 53 and 79 years old and thus may have been examples of testicular tubular failure occurring with advancing years. When all data from these 3 subjects were excluded, no significant alteration of any of the mean values in the control group resulted.

Scrutiny of the lipid data for intragroup differences related to age reveals a significant ($p < 0.05$) increase in lower density $-S_{1.21}$ 25-70 lipoprotein concentrations in the control subjects on going from the young to the middle age group. This is in keeping with the observation of Jones et al.21 that greater concentrations of $S_f$ 12-20 ($-S_{1.21}$ 25-40) lipoproteins are noted in men beginning with the third decade of life. The failure of serum cholesterol to increase along with the lower density lipoproteins in this respect is attributable to the reduction in high density lipoprotein levels, which reduction, although
not statistically significant, nevertheless was
of sufficient mean magnitude to obviate change in the mean cholesterol concentration
on going from the young to middle age control
group.

The increase in serum cholesterol levels
noted in the eunuchs on going from the young
to the middle age group is significant
\( p < 0.01 \) and resembles the increase re-
ported to occur in women from age 33 through 58.22

The meaning of the glycoprotein and gly-
coprotein/total protein differences must
await further study. At the present time all
that can be said is that castrated subjects
have higher serum glycoprotein concentra-
tions than uncastrated subjects, absolutely
as well as relative to the total serum protein
concentration.

Finally the question of the possible rela-
tionship of these findings to the suggestion
that the castrate enjoys a relative freedom
from coronary atherosclerosis must be con-
considered. It is tempting to suggest that the
relatively greater concentrations of high dens-
ity \(-S_{1.21}\) lipoproteins noted in the ca-
strained group may be importantly related to
this phenomenon. Such thinking gains sup-
port from the studies of Jencks and co-
workers,23 who demonstrated reduced concen-
trations of high density \(\propto\) lipoproteins and
increased concentrations of lower density
\(\beta\) lipoproteins in men with a history of
myocardial infarction. The predictive sig-
ificance (and, therefore, possibly the etio-
logic significance) of the lower density
S, 12-20 and 20-100 lipoprotein concentra-
tions in coronary atherosclerosis is certainly
in doubt at present.24

While the correlation between the lipopro-
tein spectrum (considered in its entirety)
and coronary atherosclerosis is receiving in-
creasing support as a result of studies such as
these, the establishment of such a correla-
tion of course does not provide proof of etio-
logic relationship. Further work along these
lines is clearly necessary.

The only other significant and sustained
alteration in serum constituents reported to
follow castration in the young adult male is
a rise of 1 to 1.5 mg. in serum inorganic phos-
phate.18 The meaning of this rise with re-
spect to atherogenesis remains conjectural at
this point.

The possibility must not be overlooked that
personality changes resulting from castration
are important, as well as the lipid changes.
Increased tractability, stability, diminished
aggressiveness, and, in general, a more tran-
quil existence usually follow castration in the
human subject.6 These characteristics tend
to be associated in the minds of clinicians
with relative freedom from disorders attrib-
utable to "stress," and with longevity and
health.

**Summary**

Eunuchs and uncastrated male subjects
are compared with respect to serum lipids,
lipoproteins and glycoproteins, and with re-
spect to the urinary excretion of gonadotropins and 17-ketosteroids.

The mean high density \(-S_{1.21}\) lipoprotein concentrations were con-
sistently higher, and the lower density \(-S_{1.21}\)
25-40 or 25-70 ("\(\beta\)") lipoprotein concen-
trations consistently lower, in eunuchs than
in uncastrated controls, irrespective of age
at the time of study or time of castration. The
ratio of \(\propto\) to \(\beta\) lipoproteins was
also consistently higher in eunuchs. These
differences are characteristic of androgen
withdrawal or estrogen administration.

The mean serum cholesterol level was sig-
ificantly lower in the young eunuchs than
in young controls. Lower individual serum
cholesterol values in the middle aged eunuchs
were noted only in those who had undergone
gonadectomy prior to the seventeenth year
of age. Mean serum cholesterol levels of the
middle and old age castrated subjects and
controls did not differ significantly.

The mean serum glycoprotein concen-
tration was higher in eunuchs than in the
controls. This was also true for the ratio
\[
\frac{\text{glycoprotein}}{\text{total protein}} \times 100
\]

Urinary gonadotropin excretion was in ex-
cess of 192 mouse uterine units per day in 22
of 24 eunuchs, while only 3 of 19 control
subjects excreted more than 192 units per day.

Urinary 17-ketosteroid excretion per day did not differ significantly between the 2 groups. However, the urinary 17-ketosteroid concentration was significantly higher in the controls.

Acknowledgment

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SUMMARIO IN INTERLINGUA

Eunuchos e non-castrate subjectos mascule es comparate con respecto al lipidos, lipoproteinas, e glycoproteinas del sero e al excretion urinari de gonadotropinas e 17-cetosteroides.

Le concentrationes medie del lipoproteinas a alte densitate $S_{1,21}$ 0-12 ("alpha") eseva regularmente plus alte e le concentrationes medie del lipoproteinas a plus basse densitates $S_{1,21}$ 25-50 o 25-70 ("beta") eseva regularmente plus basse in eunuchos que in le non-castrate subjectos de controlo, sin regardso al etate del individuos al tempore del studio o al tempore del castration. Le proportion de lipoproteinas "alpha" a lipoproteinas "beta" eseva etiam regularmente plus alte in eunuchos. Iste differentias es caracteristic effectos del abstention de androgeno o del administration de estrogeno.

Le nivello medie del cholesterol in le sero eseva significativamente plus basse in juvène eunuchos que in juvène subjectos de controlo. Casos individual de reducere valores del cholesterol seral in eunuchos de etates intermediario occurreva solmente quando le gonadectomia habeva esseite effectuate ante le etate de 17 annos. Le nivellos medie del cholesterol seral in castratos de etates intermediari e avantiante non differeva significativemente.

Le concentration medie del glycoproteina seral eseva plus elevate in eunuchos que in le subjectos de controlo. Le mesmo valeva pro

$$\text{glycoproteina} = \frac{\text{hexosa} \times 100}{\text{proteina total}}$$

Le excretion urinari de gonadotropina eseva plus que 192 unitates myo-uterin per die in 22 ex 24 eunuchos e in solmente 3 ex 19 subjectos de controlo.

Le excretion urinari de 17-cetosteroides in 24 horas non differeva significativemente inter le duo gruppis. Tamen le concentration del 17-cetosteroides urinari eseva significativamente plus alte in le subjectos de controlo.

REFERENCES


A Comparison of the Serum Lipids, Lipoproteins, Glycoproteins, Urinary 17-Ketosteroids, and Gonadotropins in Eunuchs and Control Male Subjects
ROBERT H. FURMAN, R. PALMER HOWARD, M. R. SHETLAR, E. CORINNE KEATY and RICHARD IMAGAWA

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