Relationships between fat and plasma androstenone and plasma testosterone in fatty and lean young boars following castration

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Abstract. The effect of weight of fatty tissue on fat and plasma androstenone and on plasma testosterone relationships was studied in the young boar following castration. For this purpose, 9 boars were castrated at 175 days of age, plasma steroid levels were determined daily up to 10 days after orchidectomy and fat androstenone concentration was measured 1, 3, 6, 10 and 15 days after castration. The results show that the apparent half-life of stored androstenone is very variable between boars (range: 4 to 14 days) and do not depend on the weight of fatty tissue. The rate of elimination of plasma androstenone is also very variable between boars. The rate of disappearance of fat androstenone following castration does not depend on the rate of androstenone release from fatty tissue to peripheral plasma but is more likely dependent on the intensity of plasma androstenone catabolism and elimination. Therefore, fat androstenone concentration in the intact boar is almost only depending on the equilibrium between the respective rates of testicular production and elimination.

In a previous paper (Bonneau et al. 1982), relationships between fat and plasma androstenone and plasma testosterone in fatty and lean young boars were studied during growth and after hCG stimulation. The lack of effect of weight of fatty tissue on androstenone exchanges between plasma and fat was demonstrated and it was established that there is probably some between-boars-variability in the rates of elimination of androstenone. Claus (1976) showed that, after castration, the apparent half-life of androstenone stored in fatty tissue becomes longer and longer as far as boars become older. However, due to the small number of animals studied, no information is available about the variability of the apparent half-life of stored androstenone in the young boar. Claus (1979) established that, after castration, plasma androstenone level declines slower than testosterone because of androstenone release from fatty tissue. Thus, the evolution of plasma androstenone and testosterone levels following castration reflects androstenone exchanges between plasma and fatty tissue and the respective rates of elimination of the two steroids.

The purpose of this experiment was to study the effect of weight of fatty tissue on the evolution of stored and circulating androstenone and of plasma testosterone following castration of young boars around 180 days (common slaughter age).

Material and Methods

Three groups (Nos. 1, 2 and 3) of 3 littermate Large White boars were reared as described previously (Bonneau et al. 1982) in such a way that fatty and lean young boars may be compared. Insertion of a catheter in the external jugular vein was performed for other experimental purposes (Bonneau et al. 1982) when the animals reached 170 days of age. At 175 days, the boars were castrated under general anaesthesia. Plasma samples
were drawn daily through the catheter until 10 days after castration. Backfat biopsies were taken just before castration and then 1, 3, 6, 10 and 15 days after castration. The boars were slaughtered 15 days after castration and weight of adipose tissue was determined. Radioimmunoassays of plasma androstenone and testosterone and of fat androstenone, calculation of fat androstenone quantity were performed as described previously (Bonneau et al. 1982). Plasma androstenone quantity was estimated as androstenone concentration (ng/ml) × plasma volume (ml), the latter being assumed to be 4% of the body weight (Aulstad 1969).

Results

Plasma androstenone and testosterone levels

Plasma testosterone exhibited a very sharp decrease following castration (Fig. 1) and very low levels (< 0.4 ng/ml) were obtained as soon as the first day after orchidectomy. Plasma testosterone declined more slowly in lean than in fatty boars. Due to previous hCG stimulation and to subsequent slower decrease of plasma androstenone, initial plasma levels were higher for androstenone than for testosterone. Plasma androstenone declined sharply on the first day and then a slow decrease was observed until 10 days after castration. The evolution of plasma androstenone did not differ between fatty and lean boars. Androstenone/testosterone ratio (A/T) was quite stable within boars but very variable between boars: between-boars-variability/within-boars-variability = 41.9 follows Fisher distribution with 7 and 70 degrees of freedom; \( P < 0.001 \). A/T ratio ranged between 2.0 and 21.3, depending on the animal.

![Plasma steroids levels](image)

**Fig. 1.**

Plasma androstenone and testosterone levels following castration. Values are means ± SEM. Significance of differences between fatty and lean boars: + \( P < 0.10 \); * \( P < 0.05 \); ** \( P < 0.01 \).
Fat androstenone levels

Decrease of fat androstenone concentration following castration is reported in Fig. 2. No significant difference was observed between fatty and lean boars. Fat androstenone decrease according to an exponential curve: \( \log C = \alpha t + \beta \) (\( t = +0.93 \) to +0.99 depending on the animal) or \( C = C_0 \exp(-\alpha t) \) where \( C_0 \) and \( C \) are fat androstenone concentrations at times 0 and \( t \), respectively. The apparent half-life (AHL) of stored androstenone, derived from the above equation – AHL = (Log 2)/\( \alpha \) – appeared to be very variable and ranged between 3.8 and 14.0 days depending on the boars.

From determination of the amounts of circulating androstenone (plasma androstenone level \( \times \) plasma volume) and of stored androstenone (fat androstenone concentration \( \times \) weight of fatty tissue \( \times \) percentage ether extract in fatty tissue) it appears that the former is always about thousand times smaller than the latter, and therefore negligible. Consequently, the amount of androstenone eliminated per day (AAE) is approximatively equal to the quantity of this steroid disappearing from fatty tissue within the same time. When dividing AAE by the amount of plasma androstenone (APA), one can obtain a coefficient \( k \) connecting these 2 criteria: \( \text{AAE} (\mu g/d) = k(d^{-1}) \times \text{APA} (\mu g) \). When calculating \( k \) for each boar and for each of the 10 days following castration, one can observe that \( k \) is quite stable within boars and very variable between boars: between-boars-variability/within-boars-variability = 9.9 follows Fisher distribution with 7 and 63 degrees of freedom; \( P < 0.01 \). Therefore, it appears that the amount of androstenone eliminated per day is roughly proportional to the level of circulating androstenone, the coefficient of proportionality (\( k \)) being very variable between boars (range: 173 to 548 d\(^{-1})\). Half-time of elimination of plasma androstenone – HTE = (Log 2)/\( k \) – ranges between 1.8 and 5.8 mn, depending on the boars.

Table 1.

<table>
<thead>
<tr>
<th>Fat androstenone and plasma steroid criteria after castration. Values are means ± SEM.</th>
<th>A and C boars</th>
<th>B boars</th>
<th>Signification of differences A and C vs B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatty tissue</td>
<td></td>
<td></td>
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<tr>
<td>Weight (kg)</td>
<td>19.33 ± 0.70</td>
<td>12.06 ± 1.14</td>
<td>( P &lt; 0.001 )</td>
</tr>
<tr>
<td>Initial androstenone concentration (( \mu g/g ))</td>
<td>1.15 ± 0.20</td>
<td>1.12 ± 0.28</td>
<td>NS</td>
</tr>
<tr>
<td>Initial androstenone quantity (mg)</td>
<td>19.19 ± 3.84</td>
<td>11.09 ± 2.11</td>
<td>NS</td>
</tr>
<tr>
<td>Apparent half-life of stored androstenone (days)</td>
<td>7.57 ± 1.36</td>
<td>5.95 ± 1.06</td>
<td>NS</td>
</tr>
<tr>
<td>Plasma</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Androstenone level (( ng/ml ))</td>
<td>0.52 ± 0.03</td>
<td>0.43 ± 0.05</td>
<td>NS</td>
</tr>
<tr>
<td>Testosterone level (( ng/ml ))</td>
<td>0.10 ± 0.02</td>
<td>0.21 ± 0.02</td>
<td>( P &lt; 0.01 )</td>
</tr>
<tr>
<td>A/T ratio</td>
<td>8.83 ± 3.44</td>
<td>2.28 ± 0.17</td>
<td>NS</td>
</tr>
<tr>
<td>Half-time of elimination of androstenone (mn)</td>
<td>2.89 ± 0.73</td>
<td>2.35 ± 0.28</td>
<td>NS</td>
</tr>
</tbody>
</table>
There is no significant difference between fatty and lean animals for AHL of stored androstenone and for HTE of circulating androstenone (Table 1). AHL and HTE are highly correlated and both criteria are closely related to plasma A/T ratio (Table 2).

**Discussion**

The curves of evolution of plasma testosterone and of fat and plasma androstenone following castration are similar to those observed by Claus (1976, 1979). In close agreement with the results of Claus (1976), the apparent half-life (AHL) of stored androstenone does not depend on initial fat androstenone concentration. The results of the present experiment show that AHL does not either depend on the initial amount of stored androstenone.

Because of the differences between locations in the concentration of androstenone in fatty tissue, one must not give too much confidence in the absolute figures of fat androstenone quantity and derived variables AAE and HTE (see Bonneau et al. 1982 in Material and Methods part for Discussion). However, the inhomogeneous distribution of androstenone does not impair the relative comparisons within and between boars. The amount of androstenone eliminated per day appears to be roughly proportional to plasma androstenone level, the coefficient of proportionality being very variable between animals. Half-time of elimination (HTE) of plasma androstenone ranges between 2 and 6 min, depending on the boars. These figures do not represent true half-life of circulating androstenone since two mechanisms are responsible for its disappearance from plasma: elimination (accounted for by the former figures) and uptake of steroid by storage compartments (mainly fatty tissue). Previous results obtained in one young boar (Bonneau & Terqui, in press) have shown that metabolic clearance rate of plasma androstenone was around 87 000 litres per day. A volume of plasma equivalent to the total plasma volume (around 4 litres) is completely purified from androstenone in about 0.07 min and true half-time of circulating androstenone is consequently less than 0.1 min. As HTE is in the range 2–6 min, one can observe that uptake of plasma androstenone by storage compartments is quantitatively much more important than elimination.

AHL of stored androstenone is very variable between boars (range: 4 to 14 days). Such a variability may result either from variability in the rate of release of stored androstenone from fat to plasma (first hypothesis) or from variability in the rate of elimination of plasma androstenone (second hypothesis). According to the first hypothesis, AHL of stored androstenone would be negatively correlated with plasma androstenone level, what is contrary to the results of the present experiment. Therefore, the second hypothesis seems to be more
accurate, especially as AHL is highly related to HTE of plasma androstenone. As a conclusion, it appears that the rate of disappearance of fat androstenone following castration does not depend on the rate of androstenone release from fat to plasma but is more likely dependent on the intensity of plasma androstenone catabolism and elimination. Consequently, fat androstenone concentration in the intact boar is almost only dependent on the equilibrium between the respective intensities of androstenone production and elimination. The present work has established that uptake of plasma androstenone by storage compartments is quantitatively much more important than elimination of plasma androstenone. Consequently, a surge in androstenone production is quickly followed by an increase of fat androstenone in all boars (as observed by Claus & Alsing (1976), Malmfors et al. (1976) and Bonneau et al. (1982) after hCG stimulation and by Andresen (1976) and Claus & Alsing (1976) after copulation) whereas fat androstenone decrease after castration is rather slow and variable between boars (Claus 1976 and present results). Plasma A/T ratio reflects the respective rates of production and elimination of the two steroids. In this way, plasma A/T ratio could be a rather good criterion, together with measurement of fat androstenone, for selection of boars against high levels of androstenone in fat. Indeed, through selection for low A/T ratio, boars exhibiting low production and high rate of elimination of androstenone, despite of normal production of testosterone, should be obtained. However, since testicular steroid production is pulsatile (Claus & Gimenez 1977) further research is needed in order to determine the best way of measuring it accurately.

References


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