Blood and Tissue Distribution of Gamma Glutamyl Transferase in Calves

J. P. BRAUN, A. G. RICO, and P. BENARD
Laboratoire de Biochimie
Ecole Nationale Vétérinaire
31076 Toulouse Cedex, France

J. P. THOUVENOT and M. J. BONNEFIS
Laboratoire de Biochimie II
Hôpital Purpan
31052 Toulouse Cedex, France

ABSTRACT

In five male and five female calves, we studied the tissue distribution of gamma-glutamyl transferase. The enzyme was mainly in kidney, pancreas, and liver; there was no sex-related difference. The relative hepatic and pancreatic specificity of the enzyme indicated that the measure of its activity in serum could be a test of hepatic or pancreatic damage in the calf. Serum activity measured within 159 samples of apparently healthy calves was 15.3 ± 3.7 U/liter, not differing significantly from that of adult cow.

INTRODUCTION

Serum gamma-glutamyl transferase (GGT; 2.3.2.2) was lower in the calf than in the adult cow (4, 5). Both authors gave the same results, 10.7 ± 2.8 U/liter for 14 calves and 15.5 ± 3.0 U/liter for 60 cows. Such differences related to age also have been reported in man whose serum GGT increases with age (13, 15, 18); on the contrary, cord blood GGT activity is about ten times higher than that of adult (3, 8, 12).

Clinical reports established that in the calf serum GGT is increased in liver affections such as acute fasciolosis where it is 3 to 20 times higher than normal (2, 16). Thus, GGT is thought to be the “best marker-enzyme of acute fasciolosis” in this species (2), for it increases early and markedly and remains elevated as long as 300 days (16).

In the aim of establishing the basis of this enzyme test in the calf, we studied the tissue and blood distribution of GGT as we did in the cow (11).

EXPERIMENTAL PROCEDURE

All tissue and blood samples were collected at Toulouse slaughter-house from 169 Francaise Frisonne Pie-Noir, Garonnaise, and Schwitz 4- to 6-mo-old calves of both sexes. From each animal we collected 35 ml of blood into a dry vial. After blood clotting, serum was separated, then centrifuged for 5 min at 3000 x g to remove residual cells.

Within 5 min of slaughter, from five males and five females approximately 10 g of each of the following tissue were collected: kidney (cortex and medulla), pancreas, liver, lung, spleen, jejunum, rumen, omasum, abomasum, heart, muscle and gonads (testicles or ovaries). Each sample was rinsed in normal saline solution (9.0 g NaCl/liter), blotted, packed separately, and stored at -30 C until analyzed within 4 days.

All measurements of GGT activity were on apparently healthy calves as determined by ante- and postmortem examinations and a wide biochemical serum screening including sodium, potassium, chloride, urea, creatinine, proteins, albumin, glucose, calcium, phosphates, alkaline and acid phosphatases, bilirubin, amylase, aspartate and alanine amino-transferases, lactate dehydrogenase, cholesterol, triglycerides, uric acid, and iron. All analytical procedures were as recommended by Autochemist-Sweden.

Serum GGT activity was measured with preceding 22 parameters of serum screening at 25 C by the Autochemist procedure adapted from Szasz (19) and Jacobs (6). Tissues were homogenized in a Potter-Elvejhem device (.5 g of tissue to 4 ml of ice-cold saline solution). The homogenate was then centrifuged for 5 min at 3000 x g, and GGT activity was measured in the supernatant with a commercial kinetic procedure1 at 30 C.

Received October 3, 1977.

1 Boehringer, France.
TABLE 1. Preliminary biochemical screening of the calves.

<table>
<thead>
<tr>
<th>Groupa</th>
<th>Na</th>
<th>K</th>
<th>Cl</th>
<th>P</th>
<th>Ca</th>
<th>Fe</th>
<th>Creatinine</th>
<th>Uric acid</th>
<th>Bilirubine</th>
<th>Urea</th>
<th>Glucose</th>
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<tbody>
<tr>
<td></td>
<td>(mEq/liter)</td>
<td>(mg/liter)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>148</td>
<td>3</td>
<td>5.5</td>
<td>.9</td>
<td>102</td>
<td>14</td>
<td>105</td>
<td>.66</td>
<td>14.7</td>
<td>2.9</td>
<td>11</td>
</tr>
<tr>
<td>R</td>
<td>150</td>
<td>3</td>
<td>5.3</td>
<td>.3</td>
<td>102</td>
<td>7</td>
<td>108</td>
<td>1.14</td>
<td>18.1</td>
<td>3.5</td>
<td>9</td>
</tr>
<tr>
<td>P</td>
<td>&lt;5%</td>
<td>NS</td>
<td>&lt;1%</td>
<td>NS</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>NS</td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>PALb</th>
<th>PACc</th>
<th>TGOd</th>
<th>TGPe</th>
<th>LDHf</th>
<th>Amylaseg</th>
<th>Cholesterol</th>
<th>Triglycerides</th>
<th>Proteins</th>
<th>Albumin</th>
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<tbody>
<tr>
<td></td>
<td>(U/liter)</td>
<td>(g/liter)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>C</td>
<td>211</td>
<td>80</td>
<td>1.7</td>
<td>.4</td>
<td>49</td>
<td>17</td>
<td>13 13</td>
<td>676 208</td>
<td>92 17</td>
<td>15 4</td>
</tr>
<tr>
<td>R</td>
<td>220</td>
<td>126</td>
<td>1.3</td>
<td>.2</td>
<td>46</td>
<td>10</td>
<td>14 2</td>
<td>760 96</td>
<td>87 13</td>
<td>15.3 3.7</td>
</tr>
<tr>
<td>P</td>
<td>NS</td>
<td>NS</td>
<td>&lt;5%</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

Values represent mean ± SD for 10 calves used for tissue distribution studies (C) and 159 calves used as reference and for serum GGT study (R). Statistical comparison (P) between two groups was by the t-test with significance or nonsignificance (NS) as indicated.

bPAL = alkaline phosphatase E.C. 3.1.3.2.
cPAC = acid phosphatase E.C. 3.1.3.1.
dTGO = aspartate aminotransferase E.C. 2.6.1.1.
eTGP = alanine aminotransferase E.C. 2.6.1.2.
fLDH = lactate dehydrogenase E.C. 1.1.1.27.
gAmylase E.C. 3.2.1.1.
hGGT = Gamma-glutamyl transferase E.C. 2.3.2.2.
RESULTS

Serum Biochemical Screening

The aim of this screening was to show that the animals tested for tissue GGT were normal and that results applied to typical animals. Table 1 shows the comparison of results for those 10 animals and results of the 159 other analyses with the same equipment. Groups do not differ significantly for 16 of 22 parameters of serum and differences are significant for the 6 other parameters. As these differences are slight, the 10 animals can be considered normal.

Tissue Distribution

Results are in Table 2. As there were no significant differences between males and females, results are the mean of the 10 analyzed animals. Activity of GGT was greatest in kidney cortex followed by kidney medulla, pancreas, and liver. In all other organs, the activity of GGT was less than 2% of that of kidney cortex.

Serum Enzyme

By the Autochemist procedure, average GGT activity in serum of the 159 reference calves was 15.3 ± 3.7 U/liter (Table 1), and no difference was related to sex. The dispersion of calves in serum GGT is in Fig. 1. This distribution is far from gaussian, but it is similar to that in man (15).

DISCUSSION

The preliminary screening results in Table 1 indicated that the animals were apparently healthy. Thus, our results can be discussed from a general point of view.

Tissue distribution of GGT in calf is similar to that in other species: cow (11), horse (10), dog (20). Some differences from adult cows (11) are significant. In the kidney, both medulla and cortex GGT are lower in calves than in adult cows, 44.18 ± 7.58 U/g and 60.50 ± 12.36 U/g (P<.01) for cortex and 32.91 ± 15.78 U/g and 47.52 ± 13.07 U/g (P<.01) for medulla. In the spleen, on the contrary, GGT is more than two times higher in the calf than in the cow, .69 ± .18 U/g and .31 ± .09 U/g (P<.001). Such age-dependent variations of GGT activity in tissues have been reported in other animals, but kidney GGT increases in the last days of gestation or the first days of life, and reaches adult levels soon after birth in rabbit (14), guinea pig (17), and human (1).

Serum GGT activity reported here is higher than that observed by other authors (4, 5) but is similar to that of adult cows. With the same equipment, we observed that in 54 cows serum GGT was 15.0 ± 5.8 U/liter; this difference was

TABLE 2. Distribution of GGT in tissues of the calf.

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Meana</th>
<th>SDa</th>
<th>Relative percentb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kidney cortex</td>
<td>44.18</td>
<td>7.58</td>
<td>100</td>
</tr>
<tr>
<td>Kidney medulla</td>
<td>32.91</td>
<td>15.78</td>
<td>74.49</td>
</tr>
<tr>
<td>Pancreas</td>
<td>20.28</td>
<td>9.78</td>
<td>45.90</td>
</tr>
<tr>
<td>Liver</td>
<td>3.24</td>
<td>1.30</td>
<td>7.33</td>
</tr>
<tr>
<td>Heart</td>
<td>.01</td>
<td>.01</td>
<td>.02</td>
</tr>
<tr>
<td>Muscle</td>
<td>.01</td>
<td>.01</td>
<td>.02</td>
</tr>
<tr>
<td>Omasum</td>
<td>.11</td>
<td>.08</td>
<td>.26</td>
</tr>
<tr>
<td>Abomasum</td>
<td>.04</td>
<td>.03</td>
<td>.09</td>
</tr>
<tr>
<td>Rumen</td>
<td>.14</td>
<td>.04</td>
<td>.32</td>
</tr>
<tr>
<td>Jejunum</td>
<td>.43</td>
<td>.13</td>
<td>.96</td>
</tr>
<tr>
<td>Spleen</td>
<td>.69</td>
<td>.18</td>
<td>1.57</td>
</tr>
<tr>
<td>Lung</td>
<td>.82</td>
<td>.36</td>
<td>1.85</td>
</tr>
<tr>
<td>Ovary</td>
<td>.39</td>
<td>.28</td>
<td>.87</td>
</tr>
<tr>
<td>Testicle</td>
<td>.60</td>
<td>.29</td>
<td>1.35</td>
</tr>
</tbody>
</table>

a Results are U/g of fresh tissue (n = 5 males and 5 females for each tissue except ovary and testicle).

b Each tissue activity is expressed as a percentage of that of kidney cortex.
not significant.

The lack of effect of lower kidney GGT on blood GGT is consistent with the hypothesis of the hepatic and pancreatic origin of blood GGT for in those organs GGT activity is almost the same in young and adult animals. Moreover, kidney lesions are followed by an important flow of enzymes into urine with minimal blood increase of enzyme. So, as reported for man (9), horse (10), and cow (11), serum GGT can be considered relatively specific for liver or for pancreas breakdown in the calf and represents a valuable diagnostic test for hepato-pancreatic disorders in this species.

ACKNOWLEDGMENTS

We wish to thank M. B. Fantini, R. Saez, and J. Ducret for helpful technical assistance.

REFERENCES