The hourly rate of urinary amylase excretion, serum amylase, and serum lipase

SHEILA L. WALLER¹ AND A. J. RALSTON with the technical assistance of G. KAY

From the Clinical Division of Gastroenterology, Manchester Royal Infirmary

SUMMARY The rates of urinary amylase excretion/hour and the levels of serum amylase and lipase were measured in 190 normal subjects and patients with no evidence of renal or gastrointestinal disorder. The hourly rate of urinary amylase excretion/hour was found to have an upper limit of normal of 69 IU. The upper limit of normal for the serum amylase was 251 IU/litre and for the serum lipase 1·6 units/ml.

Raised levels of serum amylase and lipase with a normal rate of urinary amylase excretion/hour were found in chronic renal failure.

Part I In control subjects and patients with renal disease

The diagnosis of acute and relapsing chronic pancreatitis may be difficult if a rise in serum amylase which may be transient is missed. The value of determining urinary amylase in the diagnosis of pancreatic disease is not clear, although it has been suggested that the hourly rate of urinary amylase excretion may remain elevated for up to 10 days after an attack of acute pancreatitis (Saxon, Hinkley, Vogel, and Zieve, 1957: Gambill and Mason, 1963). A moderate rise in serum amylase may accompany other acute abdominal conditions, eg, biliary disease, gallstone colic, perforated duodenal ulcer, intestinal obstruction, and ruptured ectopic pregnancy (Kelley, 1957) and may follow upper abdominal surgery (Keighley, Johnson, and Stevens, 1969). In addition it is important to know the effect of impaired renal function on the output of amylase into the urine since acute pancreatitis may be accompanied by renal insufficiency (Dankner and Heifitz, 1951; Meroney, Lawson, Rubini, and Carbone, 1956; Blainey and Northam, 1967).

For a biochemical measurement to be of value in establishing the presence or absence of organic disease it is important to know the normal range and the effect of other diseases on this range. It is also preferable to obtain the blood or urine under clinical rather than experimental conditions.

¹Address for reprints: S.L.W., MRC Gastroenterology Unit, Central Middlesex Hospital, Acton Lane, London, NW10.

Received for publication 22 July 1971.
and with the AutoAnalyzer respectively. The total two-hour urine volume was recorded and the specimen kept at 4°C until analysed. The amylase concentration of two aliquots was determined by the modified method of Huggins and Russell and the mean of these two results used to calculate the rate of urinary amylase excretion/hour. Replicate analyses of samples kept at 4°C for varying periods of time did not differ significantly.

**ESTIMATION OF AMYLASE**

The method used to estimate amylase concentrations in serum and urine was based on the modification by Varley (1967) of the Huggins and Russell method. However the present method (Varley and Hewitt, unpublished data) differed from that described by Varley in several details. The incubation mixture was prepared from 2·5 ml of phosphate buffer, 2·0 ml of an 0·5% starch substrate, 0·3 ml of 0·9% saline, and 0·2 ml of serum or urine. Aliquots, each of 0·5 ml, were withdrawn from the incubation mixture at 0, 5, 15, and 30 minutes and treated as described previously (Varley, 1967). Amylase concentration in Somogyi units/100 ml was calculated by multiplying the number of milligrams of starch fermented at five minutes by a factor of 3000, at 15 minutes by a factor of 1000, and at 30 minutes by a factor of 500. Thirty minutes' incubation covered the range 0-250 Somogyi units/100 ml, 15 minutes' 250-500 Somogyi units/100 ml, and five minutes' 500-1000 Somogyi units/100 ml. If hydrolysis was almost complete in five minutes, the estimation was repeated using 0·1 ml of serum or urine. In this paper the units of amylase are expressed as IU/l (μmol of substrate fermented/min/l). One Somogyi unit/100 ml is equivalent to 1·9 IU/l, or 1 IU is equivalent to 5·4 Somogyi units.

**Results**

Two-hour urine collections from 263 subjects were examined, but 24 have been excluded because the values for serum amylase or blood urea are missing. The age and sex distribution, and diagnoses of the 190 controls are shown in Tables I and II and for the 49 patients with renal dysfunction in Table III. A few patients had more than one measurement of the serum amylase, serum lipase, and rate of urinary amylase excretion, but only the initial value obtained for each subject is included in the statistical analysis and scattergrams.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>No. of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart disease</td>
<td>27</td>
</tr>
<tr>
<td>Hypertension</td>
<td>25</td>
</tr>
<tr>
<td>Pernicious anaemia</td>
<td>9</td>
</tr>
<tr>
<td>Bronchitis</td>
<td>16</td>
</tr>
<tr>
<td>Carcinoma bronchus</td>
<td>11</td>
</tr>
<tr>
<td>Asthma</td>
<td>11</td>
</tr>
<tr>
<td>Thyroid disease</td>
<td>10</td>
</tr>
<tr>
<td>Cerebral disease</td>
<td>11</td>
</tr>
<tr>
<td>Arthritis</td>
<td>32</td>
</tr>
<tr>
<td>Neurosis</td>
<td>11</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>10</td>
</tr>
</tbody>
</table>

Table II  Diagnosis in 190 controls

<table>
<thead>
<tr>
<th>Age Groups (Yr)</th>
<th>Total Group</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Patients</td>
<td>Urinary Amylase (IU/l)</td>
<td>Serum Amylase (IU/l)</td>
<td>Urinary Amylase (IU/l)</td>
</tr>
<tr>
<td></td>
<td>Mean ± SD (actual range)</td>
<td>Mean ± SD (actual range)</td>
<td>Mean ± SD (actual range)</td>
</tr>
<tr>
<td>10-19</td>
<td>4</td>
<td>26 (11-99)</td>
<td>1391</td>
</tr>
<tr>
<td>20-29</td>
<td>25</td>
<td>19 (9-60)</td>
<td>135 ± 57 (48-266)</td>
</tr>
<tr>
<td>30-39</td>
<td>23</td>
<td>21 (7-64)</td>
<td>156 ± 46 (57-219)</td>
</tr>
<tr>
<td>40-49</td>
<td>39</td>
<td>21 (4-79)</td>
<td>150 ± 49 (38-247)</td>
</tr>
<tr>
<td>50-59</td>
<td>42</td>
<td>16 (4-55)</td>
<td>156 ± 59 (48-314)</td>
</tr>
<tr>
<td>60-69</td>
<td>62</td>
<td>14 (2-53)</td>
<td>133 ± 46 (48-228)</td>
</tr>
<tr>
<td>70+</td>
<td>15</td>
<td>19 (9-45)</td>
<td>131 ± 57 (67-257)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>190</td>
<td>18 (2-99)</td>
<td>144 ± 53 (38-314)</td>
</tr>
</tbody>
</table>

Table I  Age and sex distribution in 190 controls

1Distribution abnormal or numbers too few.  *Mean ± 2SD
CONTROL PATIENTS
The distribution of the hourly rate of urinary amylase excretion, the serum amylase, and lipase for the 190 control subjects is shown in Figures 1a, 2, and 3. The rate of urinary amylase excretion/hour (Fig. 1a) has a skew distribution, which becomes a normal distribution when the results are translated to a logarithmic scale (Fig. 1b). The mean rate of excretion of urinary amylase/hour was 18 IU/hour with a range of 5 to 69 IU/hour as calculated from the mean ± 2 standard deviations. The mean serum amylase for this group was 144 IU/l with a calculated range of 38 to 251 IU/l. The selected upper limit of normal for the serum lipase (at the 97.5% level, Fig. 3) gave a value of 1.6 units/ml. The hourly rate of urinary amylase excretion was not significantly affected by increasing age (Table I), but the mean values of both the hourly rate of urinary amylase and the serum amylase were significantly lower in women than in men (p < 0.05, Table I).

RENAL AND URINARY TRACT DISEASE
There were 49 patients in this group (Table III, Fig. 4), five with urinary tract disease, 38 with a blood urea level between 45 (the upper limit of normal in our laboratory) and 100 mg/100 ml and six with a blood urea greater than 100 mg/100 ml. In the last group two patients had a normal rate of urinary amylase excretion/hour in the presence of raised levels of blood urea, serum amylase, and lipase; one had a blood urea value of 400 mg/100 ml, an hourly rate of urinary amylase excretion from 21 to 41 IU/hour,

Table III  Diagnoses, sex, and age in 49 patients with renal dysfunction

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>No. of Patients</th>
<th>Age Range in Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renal disease</td>
<td>5</td>
<td>49</td>
</tr>
<tr>
<td>Urinary tract disease</td>
<td>38 Male</td>
<td>18-85</td>
</tr>
<tr>
<td>Blood urea &gt; 45 &lt; 100 mg/100 ml</td>
<td>6 Female</td>
<td></td>
</tr>
<tr>
<td>Blood urea &gt; 100 mg/100 ml</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 1  Hourly rate of urinary amylase excretion in 190 control subjects.

Fig. 1a  Plotted on an arithmetic scale.

Fig. 1b  Plotted on a logarithmic scale.  
Horizontal dotted lines = mean ± 2SD.
The hourly rate of urinary amylase excretion, serum amylase and serum lipase

Fig. 2
Serum amylase levels in 190 control subjects (horizontal dotted lines = mean ± 2SD).

Fig. 3
Serum lipase levels in 190 control subjects (horizontal dotted lines = upper limit of normal).

Fig. 4
Hourly rates of urinary amylase excretion in 49 patients with renal disorders (logarithmic scale)

Fig. 4a Urinary tract infection

Fig. 4b Blood urea less than 100 mg/100 ml

Fig. 4c Blood urea greater than 100 mg/100 ml (horizontal dotted lines = limits of normal for the control group).
whilst the serum amylase was 1,292 to 1,957 IU/l and
the serum lipase 5 to 6 units/ml. The other patient had
a urinary amylase excretion of 39 IU/hour with a
blood urea level of 270 mg/100 ml, serum amylase of
447 IU/l, and a serum lipase of 3·1 units/ml. Both
patients died and there was no evidence of pan-
creatic disease at necropsy. In contrast a patient with
a blood urea level of 110 mg/100 ml following a
gastrointestinal haemorrhage had a urinary amylase
excretion rate of 113 IU/hour, which fell to 49 IU/
hour when the blood urea returned to normal but at
no time was the serum amylase or lipase raised.
Three patients with blood urea levels between 59 and
98 mg/100 ml had serum amylase levels just above
the upper limit of normal for this study (295 to 361
IU/litre), but normal serum lipase values and rates of
urinary amylase excretion/hour. On the other hand
a patient with a hypernephroma excreted 119 IU/
hour with a blood urea level of 50 mg/100 ml and a
normal serum amylase; the serum lipase was not
recorded in this case.

Discussion

The value of measurements of urinary amylase in the
diagnosis of pancreatic disease has long been dis-
puted (von Benczur, 1910; Dozzi, 1940; Sachar, 1952;
Saxon, Hinkley, Vogel, and Zieve, 1957; Budd, Walter,
Harris, and Knight, 1959; Gambill and Mason, 1963). Interpretation and comparison of published
results is difficult since there are so many methods
of estimation and a variety of ways in which the results
can be expressed. Also may authors do not publish
the data on which their conclusions are based.
Recently it has been suggested that the hourly rate
of amylase excretion into the urine is a more sensitive
index of pancreatic disease than is the serum amylase
(Saxon et al, 1957; Gambill and Mason, 1963).
However, in two published series, histograms of
rates of urinary amylase excretion for control sub-
jects showed a distribution with a skew to the right
(Sachar, 1952; Gambill and Mason, 1964). Similar
distributions have been seen when the urinary amylase
is expressed as a concentration (van Riet and Hoeke,
1967) and as total 24-hour outputs (Aw, Hobbs, and
Wootton, 1967). Comparison of Figs. 1a and 1b clearly shows the log normal distribution of our data: the upper limit of normal for the 190
control subjects was 69 IU/hour. This confirms our
impression that the hourly rate of urinary amylase
excretion was somewhat higher than the 300 Smith
Roe units/hour (63 IU/hour) previously suggested by
Gambill and Mason (1964). However, the present
results do not take into account any effect on the
upper limit of normal that may accompany non-
pancreatic gastrointestinal diseases, a point dis-
cussed in part II of this paper. Whilst the apparent
tendency for the rate of urinary amylase excretion
to decrease with age was not maintained, women had
a significantly lower rate of excretion than men, in all
age groups.

Most subjects in the present study were patients
admitted to the wards or attending as outpatients
and provided a more suitable comparative group
than normal subjects. Patients with treated pernicious
anaemia were included in the control group unless
they complained of gastrointestinal symptoms. These
patients are usually well and although they have
achlorhydria it is likely that many patients of a
comparable age are hypochlorhydric (Levin, Kirsner,
and Palmer, 1951; Baron, 1963).

Since ill patients may not have been able to tolerate
fluids before admission, the two-hour collections
from control subjects were not made during an
established diuresis. Urine collections are liable to
error, but it has been demonstrated by Saxon et al
(1957) that two-hour collections are as satisfactory as
six- or 24-hour collections when hourly rates of
urinary amylase excretion are determined and are
more convenient unless the patient is dehydrated
when a longer collection period may be necessary.
Although it has been said that fluctuations in the
rate of urinary amylase excretion per hour are less
likely to occur than of amylase concentrations, the
present authors have found wide variations in the
former from day to day (Waller and Ralston,
unpublished observations) and even between two-
hour collections on the same day in acute pancreatitis
(Fig. 6, Table V, Part II). Moreover since blood
samples are more easily and rapidly obtained than
urine, a value for serum amylase is likely to be more
useful than a urinary estimation in the diagnosis of
acute pancreatitis.

The present study also provided control ranges for
the serum amylase and lipase. Whilst the upper level
of 251 IU/l (132 Somogyi units/100 ml) agreed well
with the laboratory level of 266 IU/l (140 Somogyi
units/100 ml) the serum lipase at 1·6 units/ml was
somewhat above the value of 1·15 units/ml for
healthy adults obtained in our laboratory.

Alpha-amylase has a molecular weight of about
45,000 (Danielsson, 1947; Blainey and Northam,
1967) and is cleared from the blood by glomerular
filtration. Urinary amylase levels are dependent on
renal function since the clearance of amylase is
directly related to creatinine clearance (Blainey and
Northam, 1967). Acute and chronic renal failure are
accompanied by retention of both amylase and
lipase (Meroney et al, 1956; Burton, Hammond,
Harper, Howat, Scott, and Varley, 1960). When
recovery from acute renal failure takes place hyper-
amylasuria occurs during the diuretic phase (Howat,
The hourly rate of urinary amylase excretion, serum amylase and serum lipase

personal communication). In the present series blood urea levels above 250 mg/100 ml were definitely associated with elevations in serum amylase and lipase, but the rates of urinary amylase excretion remained within the normal range. Blood urea levels above 45 mg/100 ml were sometimes accompanied by a slight rise in the serum amylase with normal rates of urinary amylase excretion. In one case, after gastrointestinal bleeding, in which the blood urea was elevated, the serum amylase was normal but the rate of urinary amylase excretion was raised. Therefore, an hourly rate of urinary amylase excretion alone could be misleadingly normal in pancreatitis associated with a transient or chronic renal failure.

On the other hand renal disease associated with excretion of large amounts of protein into the urine, such as nephrosis (Corbett, 1913) and toxaemia of pregnancy (Wallis, 1920), is accompanied by elevated rates of urinary amylase excretion.

The elevated rate of urinary amylase excretion in a patient with a hypernephroma and a normal serum amylase level was interesting. One possible explanation was that the tumour produced amylase.

References


The hourly rate of urinary amylase excretion, serum amylase, and serum lipase: Part I In control subjects and patients with renal disease
Sheila L. Waller and A. J. Ralston

*Gut* 1971 12: 878-883
doi: 10.1136/gut.12.11.878

Updated information and services can be found at:
http://gut.bmj.com/content/12/11/878

These include:

**Email alerting service**
Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

**Notes**

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/