6. Schneyer, L. H., *J. Dental Research,* 1955, v34, 257.

7. Schneyer, L. H., and Levin, L. K., *J. Appl. Physiol.,* 1955, v7, 508.

8. Werner, I., and Odin, L., *Acta Soc. Med. Upsaliensis,* 1952, v57, 230.

9. Myers, V. C., Free, A. H., and Rosinski, E. E., *J. Biol. Chem.,* 1944, v154, 39.

10. Ericsson, Y., and Stjernstrom, L., *Oral Surg., Oral Med., Oral Pathol.,* 1951, v4, 1465.

11. Dewar, M. R., and Parfitt, G. J., *J. Dental Research,* 1954, v33, 596.

12. Robertson, W. V. B., Ropes, M. W., and Bauer, W., *J. Biol. Chem.,* 1940, v133, 261.

13. Knox, K. W., *J. Dental Research,* 1953, v32, 367.

14. Gore, J. T., *Dental Cosmos,* 1935, v77, 942.

15. ———, *J. Dental Research,* 1938, v17, 69.

16. ———, *ibid.,* 1956, v35, 102.

17. Ware, A. G., Guest, M. M., and Seegers, W. H., *Arch. Biochem.,* 1947, v13, 231.

18. Ronkin, R. R., *Arch. Biochem. and Biophys.,* 1955, v56, 76.

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Serum Glutamic Pyruvic Transaminase in Cardiac and Hepatic Disease.* (22330)

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Characteristic alterations of serum glutamic oxaloacetic transaminase (SGO-T) activity have been shown to be useful in assessing the presence and degree of heart muscle cell and hepatocellular damage(1,2). The activities of glutamic oxaloacetic (GO-T) transaminase and of glutamic pyruvic transaminase (GP-T) in different tissue homogenates are compared in Table I. The activity of GP-T was found to be relatively greater in liver than other tissues as compared with GO-T activity. This observation suggested that serum glutamic pyruvic transaminase (SGP-T) might be a more specific index of liver cell damage than SGO-T because of its selective concentration in liver tissue. Furthermore, since the cardiac tissue activity of GP-T is low, myocardial necrosis might not be associated with significant alterations of SGP-T activity, thus providing a more specific serum enzyme indicator of hepatocellular damage.

Method of study. The SGP-T activity was measured spectrophotometrically. The transamination reaction (Reaction 1) is coupled to the reduction of pyruvate to lactate by reduced diphosphopyridinenucleotide (DPNH), in the presence of added excess of purified lactic dehydrogenase (Reaction 2).

$$\alpha\text{-keto glutarate} + \text{l-alanine} \xrightarrow{\text{SGP-T}} \text{glutamate} + \text{pyruvate} \quad \text{(Reaction 1)}$$

$$\text{pyruvate} + \text{DPNH} \xrightarrow[\text{dehydrogenase}]{\text{lactic}} \text{lactate} + \text{DPN} \quad (\text{ " } 2)$$

Oxidation of DPNH, and thereby the transamination reaction, is followed by measuring the decrease in light absorption at wavelength 340 mμ at which reduced diphosphopyridinenucleotide has an absorption peak. The *reagents* include: alanine, α-keto-glutaric acid, reduced diphosphopyridinenucleotide, and purified lactic dehydrogenase which can be obtained commercially. From 0.1 to 1.0 ml of serum, 1.0 ml of 0.1 M phosphate buffer (pH 7.4), 0.5 ml of 0.2 M l-alanine in buffer (pH 7.4), 0.2 ml of DPNH (1 mg/ml) and 0.1 ml of a solution of purified lactic dehydrogenase (8000 units/1.0 ml) were mixed and brought to final volume of 2.8 ml in a cuvette having a 1 cm light path. The blank contained all reactants listed except DPNH. After 15 minutes, 0.2 ml of 0.1 M α-ketoglutarate in buffer, pH 7.4, was added. The optical density at wavelength 340 mμ was

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TABLE I. Comparison of Glutamic Oxaloacetic Transaminase and Glutamic Pyruvic Transaminase in Normal Adult Tissue Homogenates.

Tissue	GO-T	GP-T
	Units/g wet tissue (× 1000)	
Heart	156	7.1
Liver	142	44
Skeletal muscle	99	4.8
Kidney	91	19
Pancreas	28	2
Spleen	14	1.2
Lung	10	.7
Serum	.02	.016

followed for 5 minutes and the rate of decrease in optical density taken as measure of the glutamic pyruvic transaminase activity of the serum. The reaction was followed in a Beckman DU spectrophotometer at room temperature (23°C). Serum activity is expressed in units/ml/minute. One unit equals a decrease in optical density of 0.001 mμ under the conditions described.

Results. Glutamic pyruvic transaminase was measured at 23°C in sera of 260 normal humans and the activities had a mean value of 16 ± 9 units/ml/minute. When the mean value of SGP-T activity is converted to micromoles/ml hour the values fall within the range of 0.23 to 0.82 micromoles/ml/hour found by quantitative paper chromatographic assay previously reported(3).

Unless hepatic disease is simultaneously present, SGP-T appears not to be significantly altered above the normal range of activity by infectious, neoplastic, reactive, degenerative, congenital or allergic disease states. The SGP-T fails to increase significantly following necrosis resulting from acute myocardial infarction. This is probably accounted for by the fact that GP-T activity is low in heart muscle in contrast to the high activity of GO-T in cardiac tissue. Table II lists the SGO-T and SGP-T activities observed in patients with acute and chronic hepatic and cardiac disease states. From these observations and studies of 40 patients with various acute hepatic diseases it appears that acute hepatitis is associated with a rise in SGP-T activity of from 2 to 1000 times normal. The peak rise during the course of clinical hepatitis is roughly proportional to the severity of the disease process. In acute hepatitis the SGP-T activity was greater than that of SGO-T although the curves are closely parallel. The same similarity of SGP-T and SGO-T concentration was seen in patients with extrahepatic biliary obstruction. Cirrhosis in relapse is associated with increased SGO-T and SGP-T activity but the SGO-T activity is usually greater than the changes in SGP-T. Infiltration of liver by metastatic cancer, leukemic or lymphomatous disease may alter the SGO-T but has not been seen to cause elevation of the SGP-T above the normal range. The SGP-T activity has not been found to increase significantly following acute myocardial infarction in 8 patients, nor in 15 patients with other forms of heart disease. The increase in SGO-T activity in acute hepatic disease has been suggested to result from the release of liver-cell glutamic oxaloacetic transaminase into the blood stream from damaged liver cells(4,5). The presence in hepatic tissue homogenates of considerably less glutamic pyruvic transaminase activity than glutamic oxaloacetic transaminase suggests that the relatively greater increment of SGP-T activity in acute liver disease could not be solely due to release of enzyme from necrotic hepatic tissue. Variations in the release, destruction or excretion of the two enzymes or an unknown metabolic aberration are probably important contributory mechanisms and have yet to be clarified. The increase in SGO-

TABLE II. Comparison of SGO-T and SGP-T in 11 Patients with Hepatic and Cardiac Disease.

Diagnosis		SGO-T	SGP-T
		Units/ml	
Normal individuals	Range	8-40	5-35
	Mean	20	16
Acute infectious hepatitis		330	720
Idem		1380	1800
Acute infectious mononucleosis hepatitis		82	120
Acute extrahepatic obstructive jaundice		108	224
Cirrhosis		134	70
Hodgkins disease of liver		43	16
Acquired hemolytic jaundice		35	24
Acute transmural myocardial infarction		61	18
Idem		228	32
Acute subendocardial infarction		56	15
Angina pectoris		35	20

T following acute myocardial infarction would appear to be primarily due to release of enzyme from necrotic cardiac muscle(6). The failure of significant elevation of SGP-T is probably due to the relatively small and therefore inconsequential amount of glutamic pyruvic transaminase escaping from damaged heart cells which when diluted in the extracellular compartment would fail appreciably to increase the SGP-T.

Summary. The measurement of SGP-T alterations has been found to be a useful tool in the diagnosis and study of acute hepatic disease and appears to be more sensitive than SGO-T in depicting acute hepatocellular damage. SGP-T unlike SGO-T has the added advantage of not being appreciably altered by acute cardiac necrosis. These preliminary conclusions require further study for confirmation.

1. LaDue, J. S., Wróblewski, F., and Karmen, A., *Science*, 1954, v120, 497.

2. Wróblewski, F., and LaDue, J. S., *Ann. Int. Med.*, 1955, v43, 345.

3. Karmen, A., Wróblewski, F., and LaDue, J. S., *J. Clin. Inv.*, 1955, v34, 126.

4. Friend, C., Wróblewski, F., and LaDue, J. S., *J. Exp. Med.*, 1955, v102, 669.

5. Molander, D., Wróblewski, F., and LaDue, J. S., *J. Clin. and Lab. Med.*, 1955, v46, 831.

6. Nydick, I., Wróblewski, F., and LaDue, J. S, *Circulation*, 1955, v12, 161.

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Vitamin A Content of the Livers of Suckling Pigs.* (22331)

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The liver of the normal newly born rat was reported by Guerrant(1) to contain very little vit. A but that the concentration more than doubled during the first week of postnatal life and then remained at a relatively constant level during the remainder of the nursing period. Braude *et al.*(2) reported liver vit. A reserves to be low in the pig at birth with the amount still decreasing during suckling if the sows were fed a vit. A deficient ration.

This paper reports the levels of vit. A found in the livers of pigs which suckled their dams for varying lengths of time.

Methods. This investigation was conducted in the summer. Thirty-five baby pigs from 6 cross-bred litters were used. One pig from each litter was sacrificed at weekly intervals until the litter was exhausted, the first group of 6 being sacrificed before they were 24 hours old. The mothers of the pigs were fed well-fortified rations containing sun-cured alfalfa hay throughout gestation and lactation. The pigs' only feed was the milk of their dam.

TABLE I. Average Vitamin A Content of Livers of Suckling Pigs.

Age at sacrifice, days	No. of pigs	Body wt, lb	Liver wt, g	Liver fat, %	Liver vit. A: Per g (fresh), μg	Liver vit. A: Total, μg
1	6	3.2 ± .5*	38 ± 7.9	3.4 ± .4	15.1 ± 2.6	570 ± 152
7	6	5.5 ± .9	76 ± 7.5	3.3 ± .5	30.6 ± 9.3	2281 ± 456
14	6	8.0 ± 1.9	104 ± 27.7	3.3 ± .5	26.4 ± 5.7	2689 ± 528
21	5	10.2 ± .6	135 ± 19.7	3.6 ± .6	24.4 ± 9.0	3184 ± 640
28	5	13.8 ± 3.9	179 ± 45.5	3.6 ± .4	21.7 ± 5.5	3889 ± 1622
35	5	18.5 ± 2.8	235 ± 49.4	3.3 ± .3	19.3 ± 3.4	4539 ± 975
42	2	16.9 ± 1.2	—	3.8 ± .8	17.4 ± 2.0	—

* Stand. dev. of single observation.

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