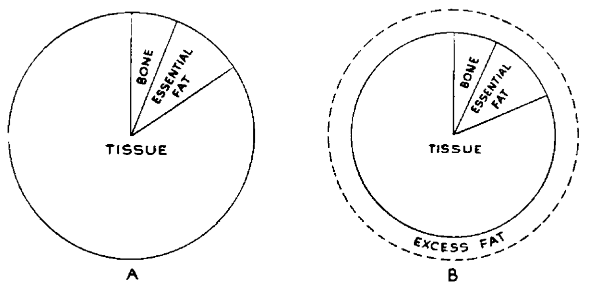
ing 200 pounds (90.9 Kg.), specific gravity 1.082, is divided into its components 1, 2 and 3.

In *B* the inner circle encompasses a mass similar to *A* in specific gravity and composition but differing in weight by 60 pounds (27.3 Kg.). The outer circle circumscribes an accumulation of 60 pounds (27.3 Kg.) of adipose tissue. The specific gravity of this 200 pound mass can be computed as 1.035, in contrast with the value of 1.082 for the mass represented by the inner circle.

The fundamental problem of the amount of variation of constituents 1 and 2 within the lean body mass remains to be determined. For the present the assumption is made that the percentage variation of these constituents based on body weight is small for lean men.

Excess fat therefore is viewed as the prime factor governing the level of specific gravity.

Precise measurements, however, of this excess fat will necessarily await a knowledge of the relative percentage variation of the weight of the skeleton in lean persons.



A represents the volume percentages of the three major specific gravity determinants of the body for a 200 pound, 90.9 Kg., lean man. The calculations were based on the following data: bone 10 per cent of body weight, specific gravity 1.60; essential fat 10 per cent, specific gravity 0.94; tissue 80 per cent, specific gravity 1.06. The volume percentages are therefore bone 6.8 per cent, essential fat 11.5 per cent, tissue volume 81.7 per cent. The specific gravity of this man would be 1.082. The solid inner circle in *B* represents the volume percentages for a 140 pound, 63.6 Kg., lean man. The volume percentages and specific gravity are the same as for the 200 pound (90.9 Kg.) lean man. The dotted outer circle represents the addition of 60 pounds of excess fat to the 140 pound lean man. The bone volume percentage is lowered to 4.5 per cent, the fat volume percentage is increased to 40.8 per cent and the tissue volume is reduced to 54.7 per cent in this man. Thus the specific gravity of the body is reduced to 1.035.

Of the anthropometric measurements, the chest diameters and height are expected to modify the values for specific gravity in persons possessing the same degree of obesity.

CONCLUSIONS

1. The fundamental biologic characteristic of corporeal density can be accurately measured usually within 0.004 unit by the method of hydrostatic weighing, provided a correction is made for the air in the lungs.

2. Values of specific gravity for healthy men ranging in age between 20 and 40 fall between 1.021 and 1.097.

3. Low values for specific gravity indicate obesity and, conversely, high values denote leanness.

4. Individual loss in weight through exercise and a restricted diet is associated with an increase in specific gravity.

5. Difference in the circumferential measurements of chest and abdomen serve as a criterion of obesity and can be correlated with specific gravity.

6. Variation in the percentage of bone in relation to body weight, excluding excess fat, is not expected to produce deviation of more than 0.013 units in comparable values.

THE SPECIFIC GRAVITY OF HEALTHY MEN

BODY WEIGHT ÷ VOLUME AND OTHER PHYSICAL CHARACTERISTICS OF EXCEPTIONAL ATHLETES AND OF NAVAL PERSONNEL

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In the preceding paper Behnke, Feen and Welham [1] have emphasized the value of the specific gravity of the body as a whole as an index of obesity. In their investigations a high value of 1.081 was associated with an average weight of 148.7 pounds (67.6 Kg.), while the corresponding weight for a group having an average low value of 1.056 was 176 pounds (80 Kg.).

If obesity and not weight per se is the chief factor tending to produce low values for specific gravity, then conversely a group of heavy but lean men should possess a high average value for specific gravity.

It was of considerable interest, therefore, to make a study of professional football players, the majority of whom had been selected for "all American" football teams. Essentially it was found that, although the average weight of these men was 200 pounds (90.9 Kg.), the average specific gravity reached the high value of 1.080. For comparison with these data and those recorded in the preceding paper, additional measurements were made on seventy-five naval men.

According to standard height-weight tables the majority of the football players could be classified as unfit for military service and as not qualified as risks for first class insurance by reason of overweight. The data presented in this paper therefore support the concept that specific gravity or weight of tissue per unit volume gives a true index of proper weight and not the standard tables which interpret weight in relation to height.

These findings together with accurate measurements of thoracic and abdominal circumferences and diameters provide information as to the physical characteristics associated with rugged physique and unusual fitness.

METHODS EMPLOYED

The technic used to measure specific gravity has been described in the preceding paper.[1] The body weight both in air and in water was accurately recorded to within 30 Gm. Measurements were made on the athletes following a morning "workout" and prior to eating. Similar data were recorded on naval personnel usually in the mid morning.

The chest diameters, anteroposterior and lateral, were taken with broad branched calipers at the level of the nipple line and recorded at the mean between inspiration and expiration in accordance with instructions from Dr. Aleš Hrdlička. For these measurements the subjects stood relaxed in the manner indicated in figure *2 A*, elbows held at an angle of 45 degrees from the body, and forearms and hands held in a position of dependent flexion.

The material in this article should be construed only as the personal opinion of the writers and not as representing the opinion of the Navy Department officially.

1. Behnke, A. R., Jr.; Feen, B. G., and Welham, W. C.: The Specific Gravity of Healthy Men, this issue, p. 495.

The body height was recorded with the subject standing erect, his back in contact with a vertical meter stick scale along which a wide sliding prong was used to touch the vertex of the head.

The circumference of the chest and of the abdomen was measured by means of a shellacked length of linen tape graduated in millimeters. For these measurements the subject stood erect and held his arms fully extended upward, the palmar areas of the hands in contact (fig. 2 *B*). This maneuver reduced to a minimum the influence of the pectoral musculature and fat.

The residual volume of the lungs was determined on all subjects by the helium dilution method.[1]

RESULTS OBTAINED

In table 1 are listed the values obtained on the twenty-five exceptional athletes. The averages in whole numbers list specific gravity as 1.080, weight as 200 pounds (90.9 Kg.), height as 72 inches (182.9 cm.), age as 25 years, circumference of the chest as 40 inches (101.6 cm.) and of the abdomen as 33 inches (83.8 cm.). As the weight increases in this group, values for specific gravity tend to decrease.

In table 2 corresponding data are presented from measurements obtained on seventy-five men in the naval service, mainly in the age group of 20 to 35 years. A progressive increase in the difference between thoracic and abdominal girth is associated with an increase in specific gravity. The inverse relationship between weight and specific gravity is also apparent.

In table 3 the averages are given for naval personnel divided into three groups on the basis of high, middle and low values for specific gravity, i. e. above 1.074, 1.060 and 1.074 inclusive and below 1.060 respectively. For comparison, corresponding data are listed for the athletes.

TABLE 1.—*Professional Football Players: Specific Gravity in Relation to Weight, Age, Height and Measurements of Thoracic and Abdominal Circumference, Chest Diameter, Residual Air and Vital Capacity*

		Weight		Height				Circumference				Chest Diameter				
								Chest		Abdomen		A. P.		Lat.		
Subject	Specific Gravity	Lb.	Kg.	In.	Cm.	Age	Vital Capacity, Liters	In.	Cm.	In.	Cm.	In.	Cm.	In.	Cm.	Residual Air, Liters
1	1.097	181.0	82.3	72.1	183.1	22	5.650	37.3	94.8	30.4	77.3	9.5	24.2	12.3	31.3	1.562
2	1.095	185.7	84.4	69.0	175.3	22	6.400	39.1	99.4	31.2	79.3	9.3	23.6	12.2	31.0	1.402
3	1.095	194.7	88.5	72.0	183.9	24	6.600	39.2	99.7	30.7	78.0	9.4	23.8	12.4	31.4	1.500
4	1.094	183.3	83.3	69.2	175.8	24	4.625	38.5	97.9	32.0	81.2	9.2	23.3	12.9	32.9	1.415
5	1.094	190.3	86.5	72.0	182.8	23	6.500	40.2	102.2	30.2	76.7	10.0	25.3	13.1	33.2	1.560
6	1.094	170.2	77.4	69.2	175.7	27	5.600	36.4	92.4	31.2	79.3	8.5	21.5	12.1	30.8	1.438
7	1.091	192.0	87.3	72.7	184.8	24	6.010	39.8	101.0	32.0	81.2	10.0	25.4	12.3	31.2	1.570
8	1.091	183.5	83.4	73.1	185.7	24	6.600	40.1	102.0	30.5	77.5	9.0	23.0	13.9	35.3	1.792
9	1.088	188.2	85.5	72.6	184.4	28	5.320	38.4	97.6	31.4	79.9	9.1	23.2	12.3	31.3	1.339
10	1.088	189.3	86.1	72.3	183.7	31	6.000	38.8	98.5	30.8	78.2	9.2	23.4	12.6	32.1	1.341
11	1.086	205.7	93.5	72.6	184.5	22	6.300	41.3	105.0	34.9	88.8	9.6	24.4	13.7	34.9	1.930
12	1.085	187.7	85.3	73.5	187.6	24	5.310	37.7	95.8	33.0	83.8	9.6	24.5	11.8	30.0	1.301
13	1.084	179.6	81.7	70.5	179.2	25	5.370	39.1	99.4	31.5	80.0	9.2	23.5	13.0	33.0	1.483
14	1.081	220.4	100.2	75.0	190.4	23	6.800	39.4	100.0	33.0	83.9	11.4	29.0	12.4	31.4	1.383
15	1.080	189.9	86.3	68.7	174.4	24	5.700	40.5	102.8	31.5	80.0	10.1	25.7	14.0	35.6	1.330
16	1.080	196.2	89.2	73.2	185.9	25	6.550	40.1	101.8	32.1	81.5	9.5	24.2	13.6	34.5	1.593
17	1.080	209.8	95.4	74.7	189.8	27	6.600	40.9	104.0	34.8	88.5	11.4	29.0	12.3	31.2	1.560
18	1.078	194.4	88.4	69.1	175.6	25	5.600	39.9	101.4	33.3	84.7	10.3	26.3	12.2	31.0	1.187
19	1.071	194.3	88.3	72.1	183.1	29	5.400	40.5	102.9	33.6	85.3	9.6	24.5	13.3	33.9	1 284
20	1.066	217.1	98.7	72.4	183.9	25	5.620	40.1	102.0	36.4	92.5	10.1	25.7	13.2	33.5	1.429
21	1.064	210.6	95.7	72.6	184.5	27	4.500	40.1	101.8	34.7	88.1	10.3	26.3	12.2	31.1	1.388
22	1.064	259.5	117.9	75.3	191.2	25	7.250	45.9	116.5	38 9	98.8	12.1	30.7	15.2	38.6	1.665
23	1.060	217.2	98.7	74.0	188.0	29	4.660	40.9	104.0	34.0	86.3	9.8	24.8	13.4	34.0	1.226
24	1.051	223.0	101.4	73.0	185.5	25	5.940	41.6	105.6	36.0	91.5	10.1	25.6	13.5	34.2	1 488
25	1.051	251.2	114.2	71.8	182.5	27	4.880	44.5	113.0	38.5	97.9	12.3	31.3	14.5	36.9	1.500
Average	1.080	200.6	91.2	72.1	183.1	25.2	5.831	40.0	101.6	33.1	84.1	9.9	25.1	13.0	33.0	1.444

TABLE 2.—*Naval Personnel: Specific Gravity in Relation to Weight, Age, Height and Measurements of Thoracic and Abdominal Circumference, Chest Diameter, Residual Air and Vital Capacity*

		Average Weight				Average Height		Average Circumference						Chest Diameters						
								Chest		Abdomen				A. P.		Lateral				
Specific Gravity	No. Men	Lb.	Kg.	Range, Lb.	Age	In.	Cm.	In.	Cm.	In.	Cm.	Difference, In.	Difference Range, In.	In.	Cm.	In.	Cm.	Average Residual Air, Liters	Residual Air, Range	Average Vital Capacity, Liters
1.030-1.039	1	183.5	83.4	....	30	71.0	180.3	37.8	96.0	33.0	83.8	4.8	......	9.5	24.2	12.7	32.2	1.260	....	4.910
1.040-1.049	1	159.8	72.6	....	36	67.6	171.7	36.6	93.0	32.4	82.3	4.2	......	9.3	23.6	12.2	31.0	1.047	....	4.640
1.050-1.059	11	172.4	78.4	129-216	31	68.0	172.7	37.7	95.8	33.2	84.3	4.5	0.8- 8.3	9.7	24.6	12.4	31.5	1.375	1.200-1.587	5.415
1.060-1.069	18	165.2	75.1	123-180	30	68.4	173.7	36.3	92.2	31.0	78.7	5.3	2.7- 7.7	8.8	22.3	11.9	30.2	1.437	0.656-6.234	4.592
1.070-1.079	14	158.3	71.9	143-171	24	67.6	171.7	36.5	92.7	30.2	76.7	5.3	5.0- 7.4	8.8	22.3	12.0	30.5	1.496	1.000-2.094	4.963
1.080-1.089	16	156.3	71.0	132-197	25	69.0	175.2	36.5	92.7	30.0	75.9	6.5	3.5- 9.3	8.9	22.6	11.7	29.7	1.603	1.177-2.147	5.132
1.090-1.099	14	154.0	70.0	122-176	23	70.2	178.3	36.0	91.4	28.8	73.1	7.3	4.4-10.0	8.6	21.8	11.9	30.2	1.663	1.340-2.185	4.982

TABLE 3.—*High, Intermediate and Low Specific Gravity Group Values in Relation to Weight and Circumferential Measurements*

			Average Weight		Circumference					Average Height	
					Chest		Abdomen				
No. Men	Average Specific Gravity	Range	Lb.	Kg.	In.	Cm.	In.	Cm.	Difference, In.	In.	Cm.
				Naval Personnel							
13	1.051	1.035-1.057	172.3	78.6	37.6	95.5	33.1	84.1	4.5	68.2	173.2
24	1.066	1.060-1.074	156.9	71.3	36.1	91.7	30.6	77.7	5.5	68.5	174.0
38	1.086	1.075-1.096	156.9	71.3	36.5	92.7	29.7	75.4	6.8	69.4	176.3
			Trained Athletes (Professional Football Players)								
25	1.080	1.051-1.097	200.6	91.2	40.0	101.6	33.1	84.1	6.9	72.1	183.1

The values for residual air showed the greatest range of variation in naval personnel compared with similar values for athletes. An average figure of 1,500 cc. for both groups is in close agreement with previous determinations.[1]

CHEST AND ABDOMINAL MEASUREMENTS

The difference in circumference between chest and abdomen of 6.9 inches (17.5 cm.) for the athlete and of 6.8 inches (17.3 cm.) for the lean naval man is in accord with the conclusions that these types of men possess minimal adipose tissue. For the group having a low specific gravity of 1.051 (table 3) the corresponding difference is 4.5 inches (11.4 cm.).

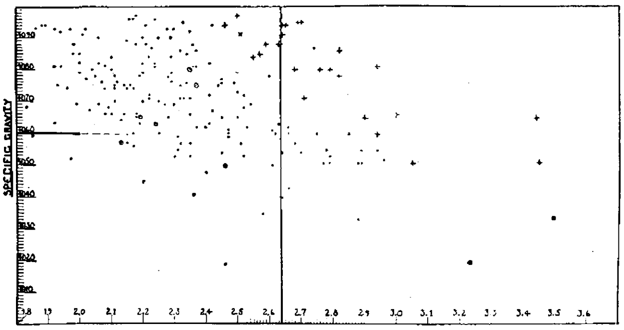

Fig. 1.—The specific gravity of each subject is plotted on the ordinate against the ratio of weight to height for that subject on the abscissas. The dotted points represent values for naval personnel, and the circled dots represent two subjects falling on the same point. The crosses represent values for the athletes studied. The vertical line at a weight to height ratio of 2.65 represents the upper limit of the ratio allowable in selection of men for military duty. For the age group represented by this series, those to the right of the vertical line are considered not qualified as good risks for first class insurance by reason of overweight.

Although individual variation in the circumferential difference is large, the group values correlate closely with specific gravity. Since, these measurements are easy to obtain, their difference may serve as a good index of relative obesity when groups of individuals are compared.

The mean of the thoracic diameters for the athletes is 1 inch (2.54 cm.) greater than the corresponding measurement for the naval group possessing a similar average value for specific gravity.

RESIDUAL AIR AND VITAL CAPACITY

A value of 1,450 cc.[1] can be used as a group average for residual air volume without appreciably altering the results.

The values for vital capacity in athletes are considerably higher than the corresponding value obtained on naval personnel. Apparently there is no relationship between specific gravity and vital capacity.

COMMENT

The data obtained on seventy-five naval men in the present investigation are in accord with the previous measurements obtained on a similar group of ninety-nine men [1] as shown in the tabular summaries.

Weight in Relation to Specific Gravity.—With reference to the group of athletes it is observed that an average weight of 200 pounds (90.9 Kg.) is associated with a high value for specific gravity of 1.080, and that in even six of the heaviest men of the group, average weight 230 pounds (104.5 Kg.), the average value for specific gravity was 1.059. This fact supports the concept that adipose tissue and not weight per se is the governing factor determining specific gravity.

Among naval personnel [1] an average value for specific gravity of 1.081, and in the group listed in table 3 of 1.086, was associated with weights of 149 and 157 pounds respectively. The chief physical difference between the exceptional athlete and naval personnel possessing similar tissue densities is approximately 50 pounds (22.7 Kg.) of body mass.

Stature.—Associated with the increase of weight is a taller stature of 2 to 3 inches for the athlete compared with the man in the military service. Whether or not this characteristic means that skeletal size in relation to body mass is an important factor that enables the athlete to maintain a high corporeal density despite the increased weight cannot be determined from the anthropometric data.

Specific Gravity in Relation to Height-Weight Tables.—The criterion as to the proper weight of an individual is based on a relationship between stature and absolute body weight, modified by age. Numerous sturdy persons, however, exceed by 15 per cent the weight values recorded as average for a given height. Rejections for military service, for example, on the basis of overweight might serve to eliminate outstanding athletes.

A more valid basis than standard height-weight tables for an estimate whether or not an individual is obese is not absolute weight but rather specific weight; that is, weight in relation to unit volume of tissue.

The plotted data (fig. 1) show the relationship between specific gravity and weight per unit of height.

If an arbitrary value for specific gravity of 1.060 is taken as the dividing line separating qualified men from those not qualified because of excessive fat, two of the twenty-five athletes would be eliminated.

On the basis of the standard height-weight tables used by insurance companies and in the military service, seventeen of the twenty-five athletes could be considered as not physically qualified for military duty or first class insurance risk, if an allowance of 15 per cent above the average values in the tables is considered as the upper limit.

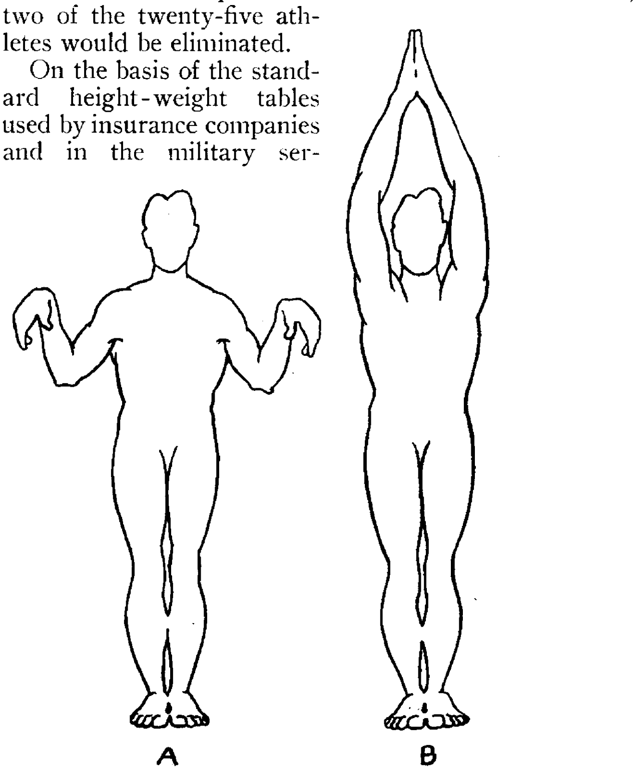

Fig. 2.—*A*, represents the position assumed by the subject for measurements of anteroposterior and lateral chest diameter. The measurements were taken at the level of the nipple line as described in the text. *B*, represents the position assumed for measurements of the circumference of the chest and abdomen. The latter measurements were taken at the level of the umbilicus.

Of the seventeen rejected "all-American" football players, eleven fall into the group possessing high corporeal specific gravity. According to our classification these eleven men are in prime physical condition if the absence of excessive fat is a criterion of fitness. The type of physical exertion, moreover, that these men are called on to make is proof of their sturdy physique, estimated in terms of speed, agility and endurance.

We propose, therefore, the classification of men as overweight on the basis of specific gravity of the body mass, using a tentative dividing line of 1.060 for the elimination of the obese.

This division, following a line parallel to the abscissas (fig. 1), is diametrically opposed to a division based on height-weight tables, which follow a line at right angles to the abscissas (fig. 1).

THE SURGICAL APPROACH TO HYPERTENSION

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Hypertension is a common symptom of several fundamentally different disorders. Its medical treatment in the past has consisted of rest, the use of sedatives, vasodilators and toxic depressants and psychoanalytic sessions.[1] It can be safely stated that none of these measures have ever cured or arrested the progress of hypertension, although their temporary, palliative value, especially in the early stages, cannot be questioned. Recently a depressor substance has been isolated from the normal kidney and used in lowering the blood pressure of animals and of man.[2] It is too early to judge the merits of this extract in combating hypertension. The fact remains that cardiovascular-renal disease, with hypertension as its dominant symptom, stands first in the mortality list today and is responsible for more than half a million deaths annually in the United States. After the age of 45 the death rate from this condition is four times that from cancer and twenty times that from either tuberculosis or diabetes[3] (fig. 1).

With the recognition of entities such as tumor of the chromaffin system[4] and unilateral renal disease producing hypertension,[5] certain surgical indications have been crystallized and have received general acceptance. There remains, however, the overwhelming majority of hypertensive patients about whose classification and treatment there is much disagreement. The early surgical efforts of Italian surgeons, followed in this country by the pioneer work of Adson, Peet, Heuer and other investigators, have given a great impetus to progress in the surgical therapy of hypertension.[6] With increasing experience and frequent exchange of ideas, certain fundamental questions regarding selection of cases and operative technic have become standardized in several clinics. It is our purpose here to describe our classification, preoperative study, indications and technic and the early and late results.

A group study of hypertensive patients is essential, uniting ophthalmologist, pathologist, urologist, internist and surgeon for the common purpose of determining the optimal course of management. Such a cooperative effort, in which all participants speak the same language and in which no group tries to dominate the other or rationalize the other's undertakings, saves many a patient from useless operations and results in an unbiased follow-up study of surgical results.

PATIENTS STUDIED

The number of patients treated is small but the study covers the period from 1932 to 1940, with no patient included who was treated after December 1940, so that the minimal period of follow-up study is six months (table 1). It is obvious that with increasing experience, with the use of routine pyelograms and, if necessary, differential tests of renal function the diagnosis of so-called essential hypertension will yield to a more specific one. Thus, all the patients with this diagnosis were thought primarily to have nonrenal, essential hypertension with no or insignificant urinary abnormal-

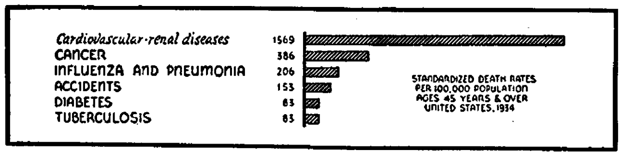

Fig. 1.—Mortality statistics taken from the data of the Metropolitan Life Insurance Company (from Dublin, L. I., and Lotka, A. J.: Twenty-Five Years of Health Progress, New York, Metropolitan Life Insurance Company, 1937).

ities. The history, the renal biopsy specimens taken at operation and the postoperative course led to a recognition of the true nature of the disease. Atrophic pyelonephritis,[5] lupus kidney,[7] congenital hypoplastic kidney[8] and adrenal medullary tumor[4] are becoming recognized causes of chronic diastolic hypertension. We are impressed with the frequency with which toxemia of pregnancy and pyelonephritis of pregnancy also figure in the history of hypertensive women.[9] The pituitary origin of some hypertension is still debatable.[10] The emphasis on renal disease in essential hypertension in human beings does not mean, however, that the con-

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Each of the references cited in this article was chosen for containing an up-to-date review of its subject.

Because of lack of space, a report of illustrtive cases has been omitted. The complete article will appear in the authors' reprints.

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