# Diametric Rule Technique to Measure Liver Size

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***We compare a new simple method to reliably estimate liver size, using a dermatologist's diametric rule, to conventional nuclear scintigraphic measurements. The diametric rule was positioned on the anterior view of 50 liver scans. All edges of the liver within a concentric circle of the rule were included. The diameters were recorded and correlated with the results obtained by more widely known techniques.***

Accurate establishment of liver size and shape is useful in assessing hepatic disease. The liver is complex and its anatomical configuration depends upon several variables. Furthermore, there are many diagnostic techniques available for its measurement including physical examination, ultrasound, radiography, and nuclear scintigraphy.

Liver weight increases with body weight; with increasing height the liver is heavier in men but not in women (*1*). It has also been shown that from infancy to puberty the ratio of liver weight to body surface area is constant—leading to the conclusion that body surface area is the best index to correlate with liver size (*1*). In children, age and sex are more important factors than height and weight in predicting liver size (*2*). Other investigators, using ultrasound, have shown that height versus liver size has the best correlation (*3*).

Our technique uses nuclear scintigraphy. Historically a number of scintigraphic approaches have been applied to quantify liver size. One attempted to superimpose ellipses and parabolas upon different scan views (*4*). Yagan used background subtraction and compared it to autopsy findings (*5*). Finally, Rosenfield established criteria based upon four parameters and concluded that a vertical measurement halfway between the xyphoid and right liver margin was the single best dimension to use in scintigraphic analysis (*6*). Hereafter, we designate Rosenfield's measurement as the midclavicular line (MCL). The arguments for using this measurement alone to estimate liver size were based upon Rosenfield's implied criteria of accuracy, reliability, speed, and ease in measurement. We believe we have found a method that meets these criteria and in fact is superior. It combines the predictive value of all four of Rosenfield's parameters.

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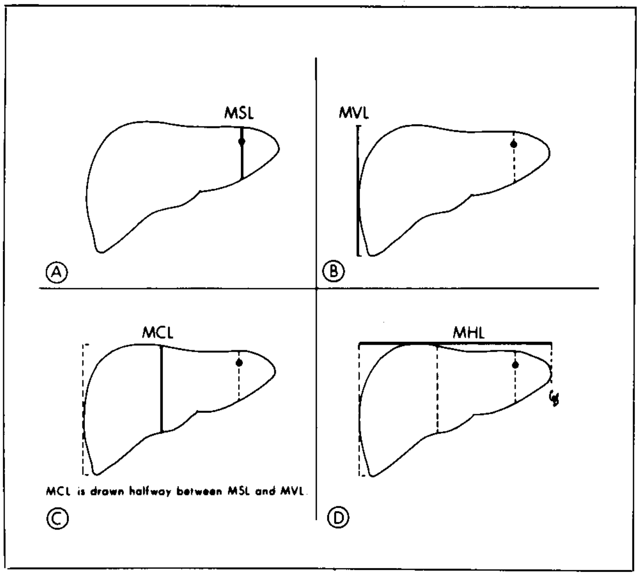


**Fig. 1.** (A) Midsternal line; (B) Maximum vertical length; (C) Midclavicular line; and (D) Maximum horizontal length.

## Materials and Methods

Fifty liver scans were performed after random selection of patients referred to the nuclear medicine division. The patients were adult men (28) and women (22) with age ranges of 17 to 85. Clinical history suggested that we rule out such diseases as liver abscesses, cirrhosis, metastases, and nonspecific hepatomegaly. Both body height and weight were recorded as well as clinical history to aid us in scan interpretation.

An intravenous injection of 2 to 4 mCi of Tc-99m sulfur colloid was given and 15 min later the patients were imaged in the supine position. A Pho/Con tomographic scanner with 10-mm resolving power was used. The spectrometer range was 140 keV with a 20% window and a minimum information density of 1,000 counts/cm$^2$. The scan speed ranged from 700 to 1,000 cm/min. The tomographic separation value was based on the patient's abdominal thickness in centimeters with reference to a tomographic factor chart included in the owner's operation manual.

The liver scans were independently measured to rule out enlarged livers by three observers using three conventional parameters: midsternal line (MSL), maximal vertical length (MVL), maximal horizontal length

(MHL), and the MCL as previously defined (Fig. 1).

The anterior image in sharpest focus was used and horizontal and vertical lines were pencilled along the borders of the liver. An electronic mark placed over the sternal edge of the liver on the film served as a reference point for the MSL measurement. A vertical line drawn through this mark and the distance along it between the superior and inferior borders of the liver was used for the MSL measurement. The MCL measurement was obtained by drawing a vertical halfway between the MSL and the right border of the liver and then measuring along that line again between upper and lower liver borders. To obtain the MVL another vertical line was drawn along the liver's right border and a similar measurement was performed.

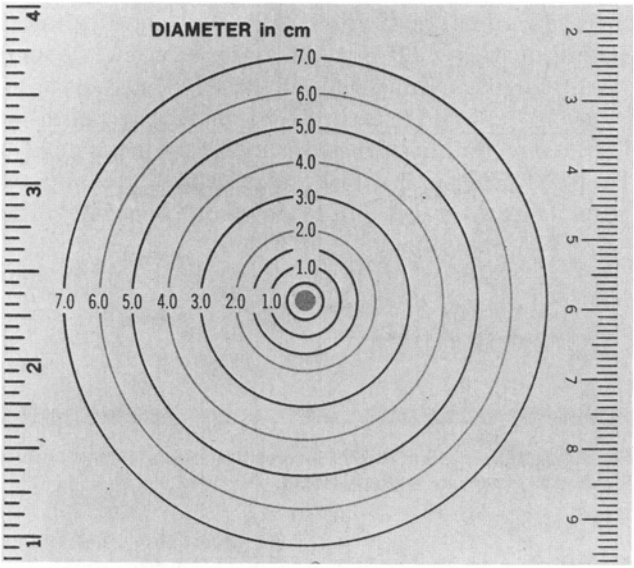


**Fig. 2.** Clear plastic rule with diametric circles.

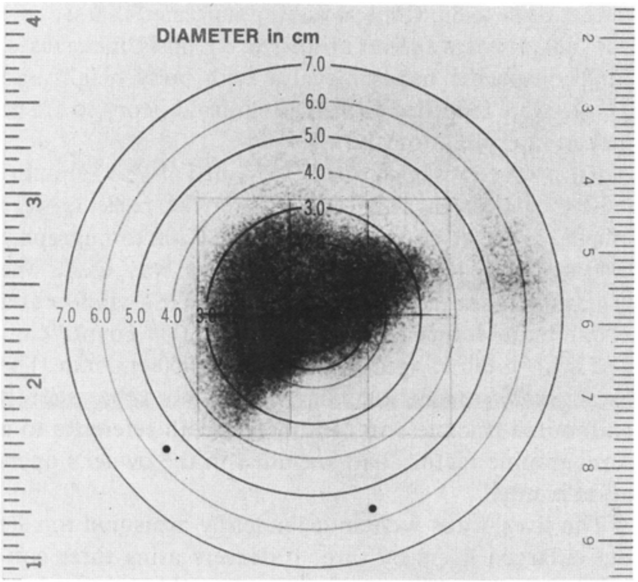


**Fig. 3.** Superimposed clear plastic rule on normal liver scan.

The MHL was the maximum horizontal line between the MVL and a second parallel vertical line; this is done so that both verticals just touched the liver periphery.

The diametric measurement was based on modeling the liver as triangular in shape; a clear plastic rule (Fig. 2) with concentric 1-cm interval diameters up to 10-cm was placed over three prominent liver "apical" edges.

If all three apices "fit" within a given circular interval, our diametric measurement followed (Fig. 3). Our Pho/Con Tomoscanner, similar to most large field-of-view cameras, has a minification factor of 6. To obtain

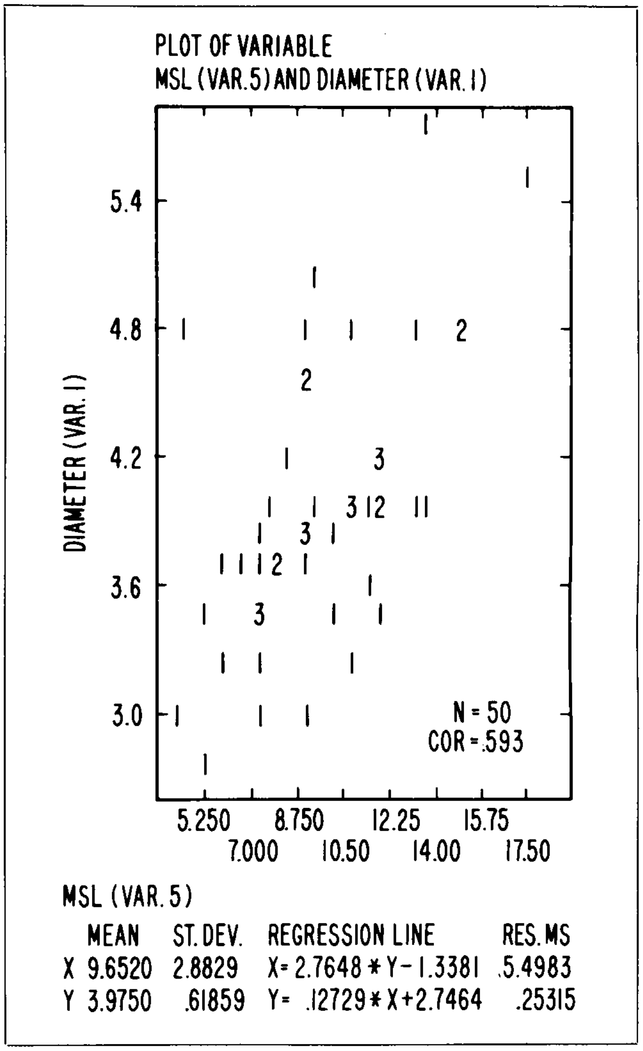


**Fig. 4.** Midsternal line versus diameter.

**TABLE 1. Correlation Matrix (r values) of Diametric Measurements Versus Conventional Measurements**

| | Diametric | MHL | MVL | MCL | MSL |
|---|---|---|---|---|---|
| Diametric | 1.000 | | | | |
| MHL | 0.903 | 1.000 | | | |
| MVL | 0.918 | 0.746 | 1.000 | | |
| MCL | 0.835 | 0.736 | 0.900 | 1.000 | |
| MSL | 0.593 | 0.568 | 0.585 | 0.637 | 1.000 |

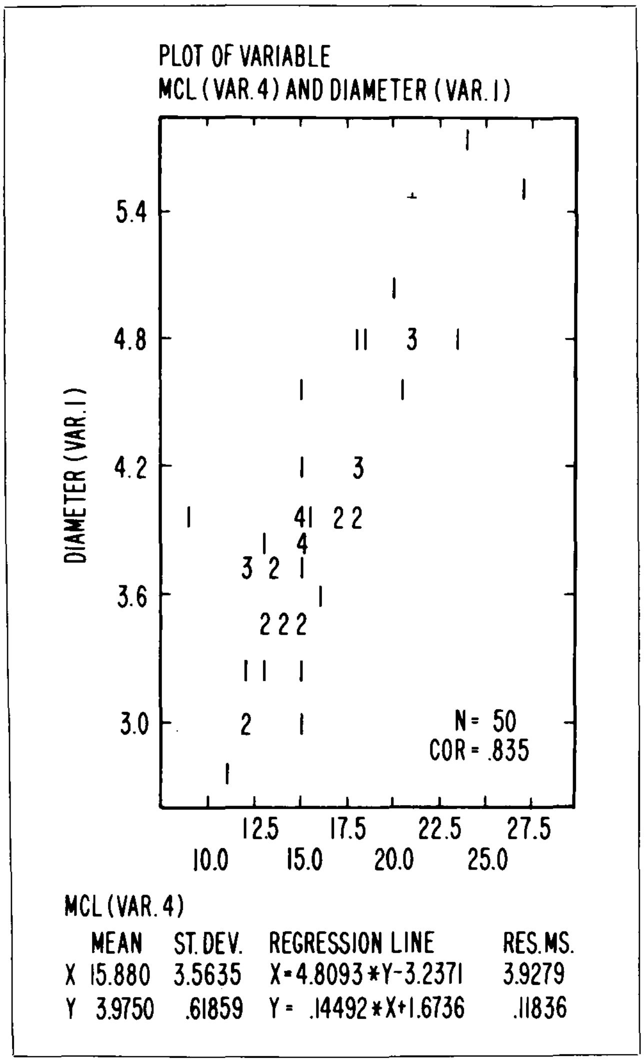


**Fig. 5.** Midclavicular line versus diameter.

the true MSL, MCL, MVL, MHL, and diametric measurements, we multiplied the above rule values by six.

Upon reviewing the literature regarding liver size evaluation by physical exam, ultrasound, or scintigraphy it became clear that each laboratory should determine its own standard ranges for the MCL, MSL, MVL, and MHL measurements. The ranges for MCL, MSL, MHL, and MVL used in our center were established in a cooperative study with the B.F. Goodrich Co. Five hundred of their employees were studied to rule out the presence of liver disease. The study involved liver scintigraphy, ultrasound, laboratory blood enzyme levels, and physical exam. The normal ranges were found to be, MSL = 3–10 cm; MHL = 15–20 cm; MVL = 12–18 cm; and MCL = 9–15 cm. These were taken as the standard to compare to our measured diametric rule values.

## Results and Discussion

The conventional measurements (MSL, MCL, MHL,

**TABLE 2. Squared Multiple Correlations of Each Variable with All Other Variables**

| | |
|---|---|
| 1 Diametric | 0.95371 |
| 2 MHL | 0.87617 |
| 3 MVL | 0.93319 |
| 4 MCL | 0.84304 |
| 5 MSL | 0.42827 |

**TABLE 3. Explained Variance of the Factors**

| Factor | Explained Variance |
|---|---|
| 1 Diametric | 0.960 |
| 3 MVL | 0.938 |
| 4 MCL | 0.925 |
| 2 MHL | 0.890 |
| 5 MSL | 0.739 |

The above factor-loading matrix has been arranged so that the factors appear in decreasing order of variance explained by the factors.

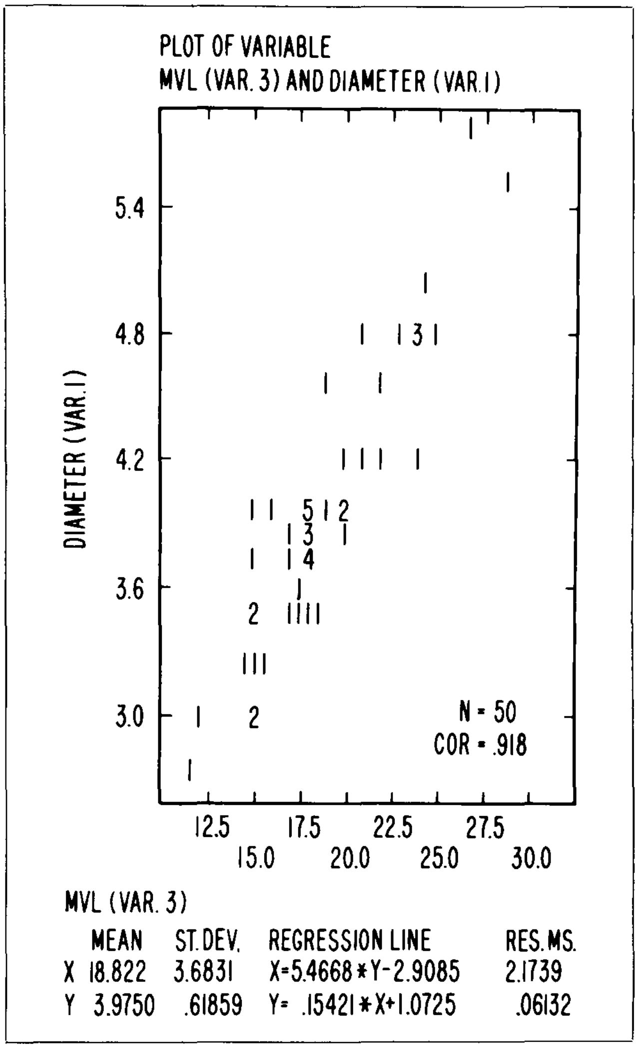


**Fig. 6.** Maximal vertical length versus diameter.

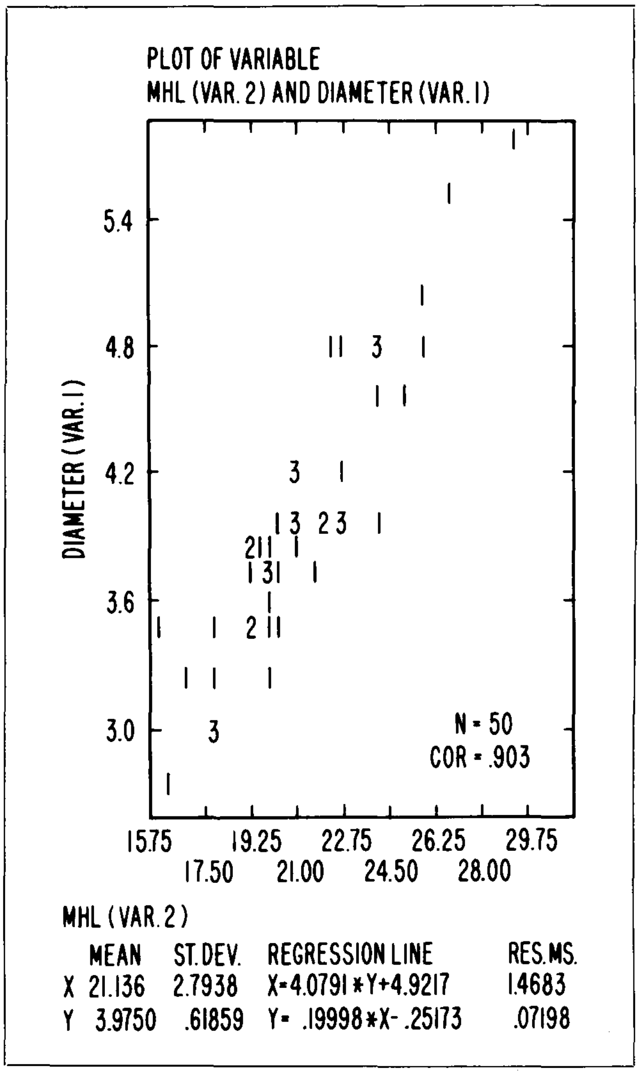


**Fig. 7.** Maximal horizontal length versus diameter.

MVL) and the diametric measurements of liver size were analyzed by computer. Mathematical manipulation was used to determine the relationship between these sets of measurements. The statistical r values obtained are listed in a matrix (Table 1) and the scatter plots, together with their corresponding regression equations, are depicted (Figs. 4–7). Further, the computer generated multiple regression plots as well as a normal probability distribution of the residuals. A correlation matrix (Table 2) depicts a factor analysis of each variable's correlation with all others. Finally, a factor-loading matrix was generated so that columns appear in decreasing order of variance (Table 3).

The correlation matrix (Table 1) of r values reveals a statistically valid relationship between the diametric and conventional measurements as is evident in the scatter plots (Figs. 4–7). The r value matrix demonstrates a sound relationship between variables. However, the data suggest that the MSL has the poorest correlation with the diametric measurement and with conventionally obtained values. For example, in the case of an enlarged left lobe of the liver, the components of the calculated diametric measurement MCL, MHL, and MVL fall easily within the conventional range of values but the MSL portion does not.

This is a limitation to the diametric technique but it presents no significant difficulty since the clinician can usually note either an anatomical variant, i.e., Reidel's lobe, or an enlarged left lobe.

Factor analysis (Table 3) reveals excellent explained variance between variables. In fact, the diametric measurement has the highest degree of explained variance while the MSL value has the lowest. This clearly suggests that all four conventional measurements and the diametric measurement are correctly assessing the same variable, that of liver size.

The normal probability plot (Fig. 8) of the residuals demonstrates the predictive ability of the new technique. Its significance can be established by noting the essentially linear relationship between the residuals and expected values.

This new diametric technique has clinically proven itself in interpreting normal versus abnormal sizes. We applied the diametric technique to 50 patients whose liver size ranged from 16.5 ± 0.5 cm to 33.0 ± 0.5 cm in diameter. In 23 out of 25 patients, with liver size equal to or less than 22.5 ± 0.5 cm, at least three of the four

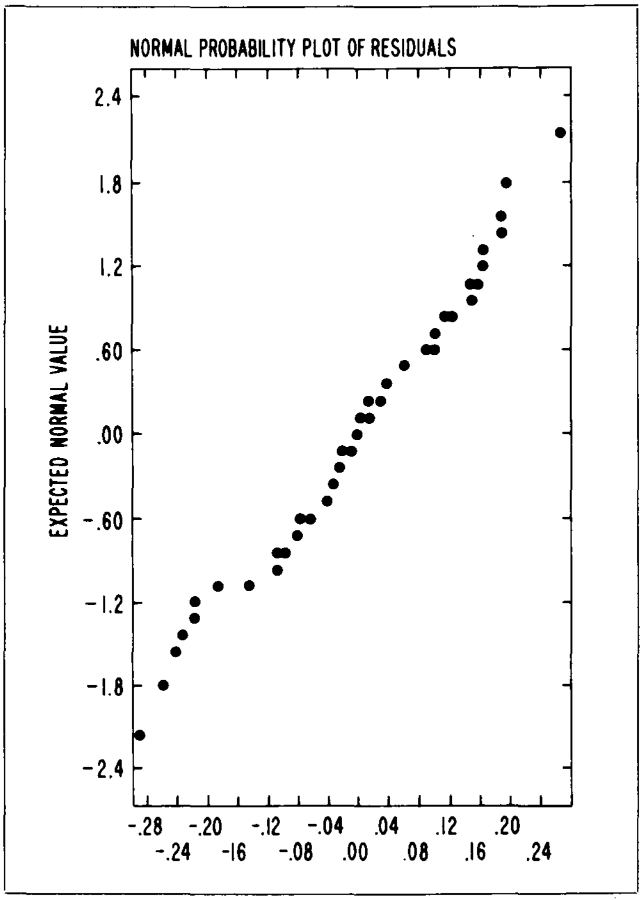


**Fig. 8.** Normal probability plot of residuals.

conventional measurements were within the normal limits (MSL = 3–10 cm; MCL = 9–15 cm; MVL = 12–18 cm; and MHL = 15–20 cm). On the other hand, in 23 out of 25 patients the liver size was equal to or greater than 24 cm in diameter, and either two, three, or four of the conventional measurements were found to be above the normal limits. Consequently, if the liver diametric measurement is found to be equal to or greater than 24.0 ± 0.5 cm in diameter, then hepatomegaly is likely.

## Conclusion

A new method for estimating liver size with scintiscans was used clinically in a speedy and reliable manner. A clear plastic dermatologist's rule marked in centimeters was placed over the anterior liver image and the liver diameter was measured.

The diametric values correlated well with the conventional dimensions (MCL, MVL, MHL). Furthermore, the diametric measurement technique appears to be more reliable in determining abnormal versus normal liver size than any single standard measurement.

For more information concerning the diametric rule (B.W. Co. (R) Measure) contact Burroughs Wellcome Co., Professional Services, 3030 Cornwallis Rd., Research Triangle Park, NC 27709.

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