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VALIDITY OF MATERNAL CALF CIRCUMFERENCE TO IDENTIFY RISK OF INTRAUTERINE GROWTH RETARDATION.

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ABSTRACT

Maternal malnutrition (MM) accounts for most IUGR in developing countries. We examined the validity to screen for risk of IUGR of maternal anthropometries (MA) during pregnancy that are easy to measure, stable throughout pregnancy and related to the timing of MM: **Height (HT), Calf, Arm and Head Circumferences (CC, AC and HC)**. Within 11 Central American hospitals, MA of women with IUGR neonates (total N=687) were compared to similar mothers with non-IUGR neonates (total N=648). In these hospitals incidence of low birth weight was high (up to 15%), and mean MA values in the IUGR groups were low: **HT** 146-158 cm, **HC** 51.6-53.8 cm, **AC** 24.1-26 cm, and **CC** 30.6-33.5 cm. MA rankings across hospitals of sensitivity (Se) at 50% specificity (Sp) were: **CC** > **AC** ($p < 0.001$); **AC** > **HT**, indifference line (IL) and **HC** ($p < 0.03$); and **HT**, IL, **HC** similar; the order of the rankings of Se at 10 and 90% Sp were similar except that at 90% Sp **HT** and **HC** > IL ($p < 0.05$).

The Relative Operating Characteristic method revealed that **CC** discriminated mothers at risk of delivering IUGR significantly better than the indifference line ($p < 0.05$) in 9 out of the 11 hospitals, followed by CB which did so in 6, **HC** in 5 and **HT** in 2. The differences among hospitals are possibly related to the timing, prevalence and degrees of malnutrition across these populations of mothers. Nevertheless **CC** identified overall those mothers at risk of bearing IUGR infants better than **AC**, **HC** and **HT**.

INTRODUCTION

Intrauterine Growth Retardation (IUGR) is a dominant risk factor for perinatal mortality. The more severe the IUGR, the higher the mortality (1). In developing countries where there is a high incidence of IUGR, maternal undernutrition explains a large proportion of this incidence (2). Nutritional supplementation to pregnant women can improve birth weight (3) and thus reduces the incidence of IUGR.

It is necessary to identify women at nutritional risk of delivering IUGR neonates, to include them during pregnancy in locally available nutritional programs. Maternal weight and weight gain are good indicators of this risk but require knowledge of gestational age that is often unknown.

The objective of this study was to select a simple and valid screening anthropometric indicator of nutritional status to identify pregnant women at risk of delivering IUGR neonates.

METHODOLOGY

a) Multicenter study

A Coordinating Team (CT) at INCAP drafted a protocol and defined the hospital profile needed for participation in the study. Twelve large public or social security hospitals in Central America fulfilled the profile defined in the protocol and participated in the study.

The drafted protocol stated that in each hospital two groups of 60 consecutive neonates with normal birth weight (NBW) and with IUGR were to be studied. IUGR and NBW were defined as $<$ and $\geq$ the 10th percentile of birth weight for gestational age. Gestational age was defined as the interval from the date of the last menstrual period to the date of delivery. Exclusion factors included maternal or infant diseases not related to nutritional status but causal of IUGR (example: maternal hypertension, congenital malformations, twin birth). Sample size was chosen to fulfill statistical analysis requirements (please see ahead). Maternal anthropometry data was measured concurrently with delivery.

A one week workshop with the principal investigator (PI) from each hospital was held at INCAP headquarters to discuss, revise and standardize the protocol. PIs also were trained at this workshop in technical and scientific issues related to the project: questionnaire design, anthropometry standardization, data entry and error checking during data entry. The EpiInfo (4) package was used for data processing and statistical analysis.

Members of the CT traveled to visit and supervise the launching of the data collection at each participant hospital. A final one week workshop with the CT and the PIs was held at INCAP headquarters to clean and analyze the data, discuss and interpret the results and assemble the individual reports by hospital. This workshop also decided on meta-analysis for all the data.

b) Statistical analysis

A Relative Operating Characteristic (ROC) methodology (5) was used. It is based on the analysis of two distributions that overlap of the anthropometric measurements: that of mothers delivering neonates with IUGR (Sensitivity distribution) and that of neonates with NBW (Specificity distribuiton). A good indicator is one which significantly discriminates best between these two distributions. It produces the smallest overlap (see Figure 1) which means the smallest number of false positives and false negatives. A measure of the distance, d_a (X), between the two distributions of an indicator X is:

$$d_a(X) = \frac{\bar{X}_N - \bar{X}_I}{\sqrt{1/2\,[\,S_N^2(X) + S_I^2(X)\,]}}$$

$\bar{X}$ = mean
S^2 = variance
Subscripts N,I = NBW, IUGR

The CT defined X as a valid indicator to identify risk of IUGR if $d_a(X) \geq |1.96|$. Plotting the values of the Sensitivity (Se) and Specificity (Sp) distributions against each other on a double normal probability scaled graph produces the ROC curve (see Figure 2). If $d_a = 0$ the indicator does not discriminate. The indifference line has a $d_a = 0$. The further upwards the indicator is from the indifference line in Figure 2, the better.

If certain conditions are met a statistical test to compare the distances can be applied (5):

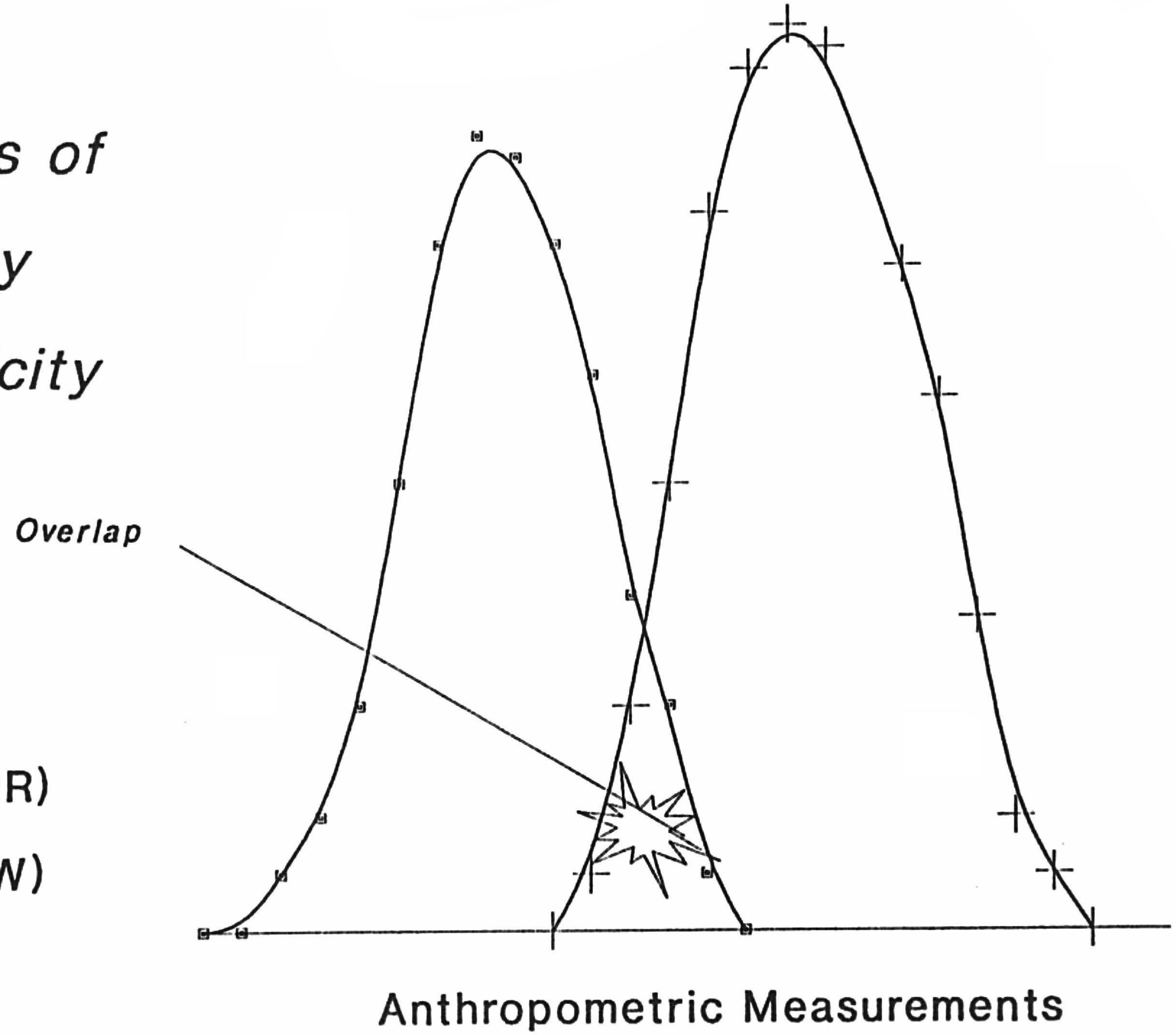
$$Z_{da} = \frac{d_a(X) - d_a(Y)}{\sqrt{\mathrm{var}\, d_a(X) + \mathrm{var}\, d_a(Y) - 2\, \mathrm{cov}\, [\, d_a(X), d_a(Y)\,]}}$$

Y = another indicator

3

FIGURE 1

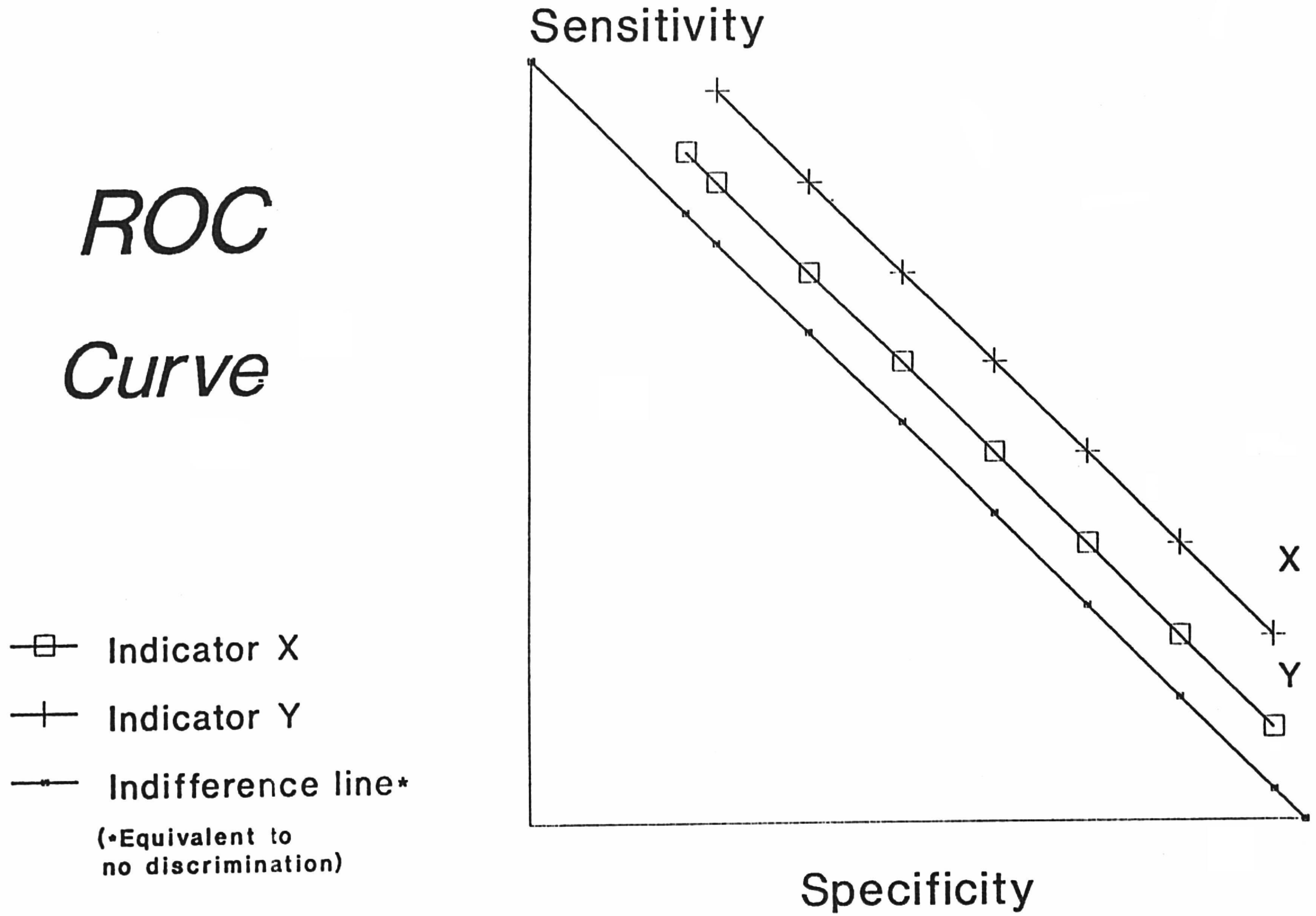
Distributions of Sensitivity and specificity



Sensitivity (IUGR)
Specificity (NBW)

FIGURE 2

ROC Curve



RESULTS

Table 1 contains the rankings of maternal anthropometry at 10%, 50% and 90% levels of Se and Sp derived from the ROC curves of individual hospitals. It is shown that at **high Sp, Calf Circumference** was the best indicator in 7 of the 12 hospitals, **Arm Circumference** in 4, and **Head Circumference** and **Height** in 1 each. At **medium levels of Sp and Se, Calf Circumference** was the best in 10 hospitals and **Head Circumference** in 2. At **low levels of Sp, Calf Circumference** was the best indicator in 9, **Height** and **Head Circumference** in 2 and **Arm Circumference** only in 1 hospital.

Maternal and infant anthropometry as well as maternal age and proportion of premature births by birth weight category are presented in **Table 2** for all the 1452 births in the study. The indicators were compared to each other and to the indifference line in **Table 3.** Only **Calf Circumference** was significantly better than the rest of the indicators in its ability to identify risk of IUGR. The remaining 3 indicators were similar among themselves.

The ROC curve (Figure 3) of the merged data confirms the overall superiority of **Calf Circumference** to identify mothers at risk of delivering an IURG newborn: **Calf Circumference** was generally the highest.

Table 1

META-ANALYSIS BEST MATERNAL ANTHROPOMETRIC INDICATORS[1] TO IDENTIFY RISK OF IUGR AT THREE LEVELS OF SPECIFICITY

HOSPITAL	HIGH Sp (Sp = 90 Se = 10)	MEDIUM Sp (Sp = Se = 50)	LOW Sp (Sp = 10 Se = 90)[2]
Guatemala			
Seguro Social	Calf C.	Calf C.	Calf C.
San Juan de Dios	Head C.	Head C.	Head C.
Quetzaltenango	Calf C.	Calf C.	Arm C. and Height
El Salvador			
Seguro Social	Arm. C.	Calf C.	Calf C.
Santa Ana	Calf C.	Calf C.	Head C., Calf C.
Honduras			
Santa Rosa Copán	Arm C.	Calf C.	Calf C.
Juticalpa	Arm C.	Calf C.	Height
Hospital Escuela	Arm C.	Calf C.	Calf C.
Nicaragua			
Carlos Marx	Calf C.	Calf C.	Calf C.
Velez Paiz	Calf C.	Head C.	Calf C.
Granada	Calf C.	Calf C.	Calf C.
Panamá			
Santo Tomás	Calf C. and Height	Calf C.	Calf C.

1 All ranked indicators are above the Indifference Line. (i.e. classify better than chance.

2 10, 50 and 90% are values of Specificity (Sp) and Sensitivity (Se) of the Indifference Line.

Table 2

CHARACTERISTICS OF THE STUDY WOMEN AND INFANTS BY BIRTH WEIGHT GROUP (12 hospitals together)

VARIABLE	NBW n = 710	IUGR n = 742
MOTHER		
Calf circ. (cm)	33.5 ± 2.8[1]	31.9 ± 2.5
Arm circ. (cm)	26.4 ± 2.8	25.4 ± 2.6
Head circ. (cm)	53.2 ± 1.5	52.8 ± 1.5
Height (cm)	153.7 ± 6.2	152.2 ± 6.6
Weight (cm)	55.9 ± 9.5	51.5 ± 7.0
Age (y)	23.0 ± 5.6	25.3 ± 6.3
INFANT		
Birth weight (g)	3231 ± 377	2454 ± 313
Prematurity (% < 37 w)	4.5	7.4

[1] Mean ± S.D.

Table 3

COMPARISON BETWEEN INDICATORS OF MATERNAL NUTRITIONAL STATUS

MATERNAL ANTHROPOMETRIC INDICATOR	COMPARISON EACH INDICATOR VS. IL[1]	COMPARISON BETWEEN INDICATORS	
	Value of Z_{da}[2]	Value of Z_{da}	
Calf Circumference	10.3	Calf Circ. - Height	4.7
Arm Circumference	7.1	Calf Circ. - Arm Circ.	4.3
Head Circumference	5.4	Calf Cir. - Head Circ.	4.2
Height	4.8	Arm Circ. - Head Circ.	N.S.[3]
		Arm Cir. - Height	N.S
		Head Circ. - Height	N.S.

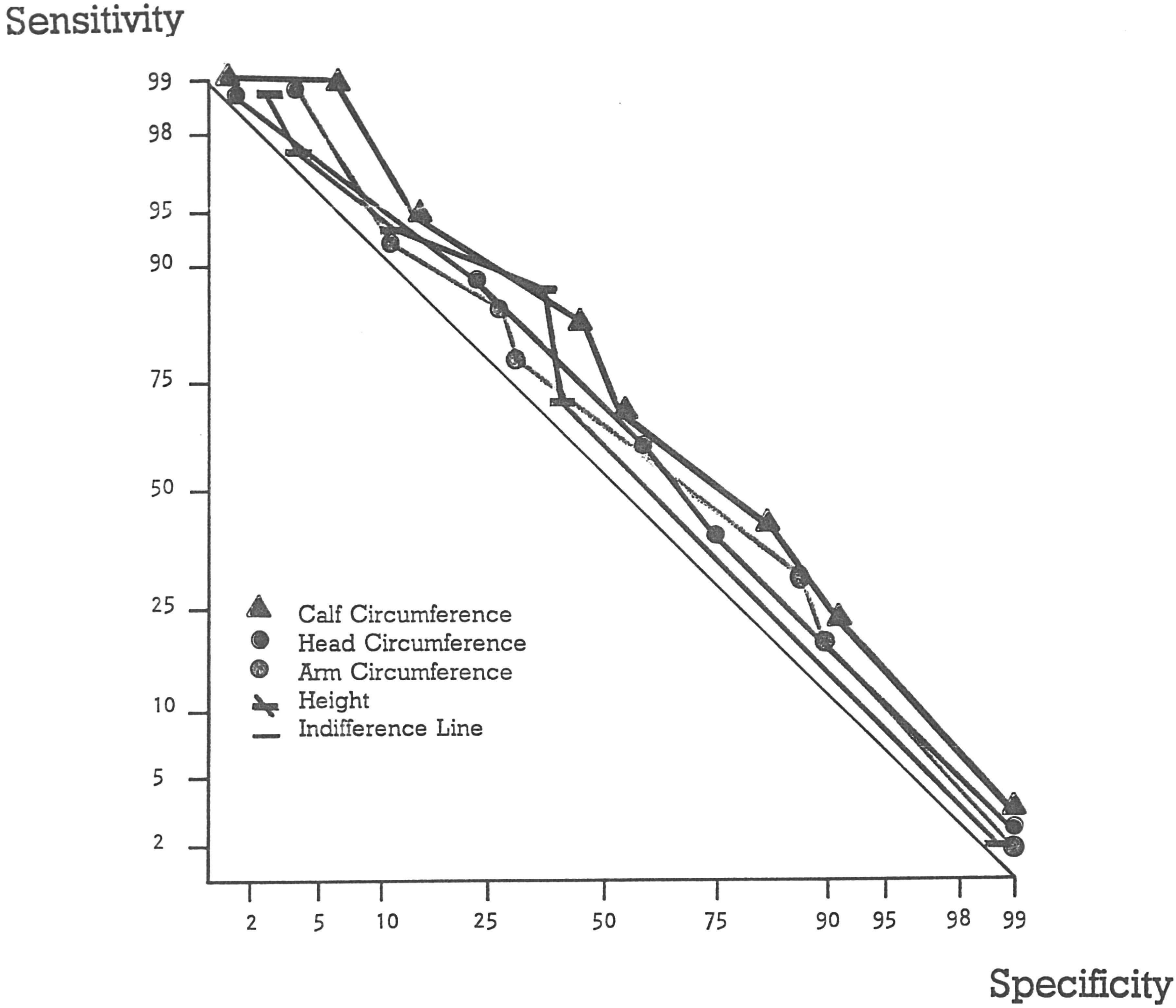
[1] IL = Indifference Line

[2] Z_{da} value: Statistically significant if $\geq |1.96|$.

[3] N.S. = not significant

Figure 3

ROC Curve 12 Hospitals



DISCUSSION

This study examined the validity of anthropometry to screen pregnant women for nutritional risk of delivering a neonate with IUGR.

Calf Circumference was the best indicator in the majority of the 12 hospitals studied, performing better than the rest at high, medium and low levels of Sensitivity and Specificity. This means that **Calf Circumference** allows one to have a better coverage of the truly at risk women at the same level of cost/effectiveness.

Arm Circumference did not perform as well, but had some validity at high Sp. Maternal **Height** performed poorly across hospitals and at different levels of Se and Sp, and so did **Head Circumference.**

It is important to keep in mind that better Se relates to better coverage but sacrifices cost/effectiveness of screening and Sp relates to better cost/effectiveness but sacrifices coverage. Thus, the cut off selection is a trade off which depends on objectives and resources. In this study (results not shown), the cut-off points that minimize the number of false positives and false negatives varied considerably among hospitals, even when the same indicator performed best. This fact is probably less important than decisions about coverage and cost/effectiveness in selecting a single or multiple cut-off points for identifying pregnant women for nutritional interventions.

Calf and **Arm Circumferences** are indicators that reflect current nutritional status. **Height** reflects nutritional status during childhood and adolescence and **Head Circumference** reflects very early (0 - 2 years) nutritional status (6). Differences in the indicators performance between hospitals are possibly due to differences in the type of maternal malnutrition prevalent in Central America.

CONCLUSIONS

The anthropometric indicators explored are easy to measure, related to the type of maternal malnutrition, and relatively stable during pregnancy (7). Their relative stability is ideal for screening, but not for following the progress of pregnancy.

In this study, **Calf Circumference** was the best of these indicators.

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