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Congenital abnormalities  
newborn  
palmar crease

## Palmar Crease Variants and Their Clinical Significance: A Study of Newborns at Risk

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### Summary

An analysis of palmar crease variants was carried out in a group of "at risk" newborns, without any evident congenital anomalies. This group consisted of 108 prematures, 74 infants who were small for gestational age, 62 newborns with history of gestational complications, and 46 newborns with a history of intrauterine methadone exposure.

A system of classification was developed based on observations of 500 normal newborns as control subjects, 466 normal mothers, and 200 normal children. The palmar crease variants can be divided into four main groups, schematically presented as normal variants, simian crease and its variants, Sydney line and its variants, and another group of unusual variants which do not fit into the other groups. A study of these groups revealed that familial components, race, sex, and age are factors that can

influence the expression of palmar crease patterns. There is an increased frequency of abnormal creases in each of the groups of "at risk" newborns. Moreover, there is an apparent association of interrupted transverse creases and intrauterine methadone exposure.

### Speculation

Our findings suggest that examination of palmar creases and the demonstration of variant patterns may provide a useful, objective indicator of possible abnormal fetal development. Since it is important to utilize a standard scheme in routine newborn examination, both to identify palmar crease variants and to establish a baseline for comparative studies, a system for classification of palmar creases is presented.

The association between unusual palmar creases and various congenital disorders has been reported by many authors. These disorders may be genetic in origin (8, 18), or may be caused by environmental factors such as viruses (1, 19) or a variety of teratogenic agents (9, 13, 14). Although it has been shown that a considerable variability in palmar creases exists in the population (2), most studies have dealt only with the simian crease (5, 6) or with the simian crease and its variants (9, 16). Purvis Smith (16) drew attention to the Sydney line variant which seems to have a clinical significance in certain disorders.

Another previously undescribed palmar crease variant was reported with the congenital alcohol syndrome (11). Johnson and Opitz (10) concluded that "unusual palm creases are associated with unusual children." These and other studies suggest that a variety of palmar crease alterations may be indicative of intrauterine disturbances occurring early in pregnancy (thus providing a tool for definition of high risk groups). To determine the usefulness of this sign, a diagnostic scheme and a system of classification was developed and applied to various groups of normal and "at risk" newborns who did not show gross congenital anomalies.

#### MATERIALS AND METHODS

The study was conducted in the newborn nurseries of the Bronx Municipal Hospital Center, New York, between September 1973 and May 1975, and was carried out as an addition to the routine clinical evaluation during this period. All palmar crease patterns were recorded from direct visual examination by the same observer (Dr. H. Dar).

Additional groups of normal children, aged 3-8 years, were seen at two parochial schools, a nursery school and a well child clinic.

A system of classification was developed initially based on observations of normal subjects, including 500 full term newborns and 200 children. Some of the variants which were found only in the high risk groups and in children with Down's syndrome (4) were added later. This system includes variants described previously (2, 9-11) as well as variants not described before. Only the main transverse creases were classified. The palmar crease patterns can be classified into four main groups: A, patterns that are classified as normal ( $A_1$ ,  $A_2$ ,  $A_3$ ) (Fig. 1a); B, typical simian crease ( $B_0$ ,  $B_1$ ) and variants ( $B_2$ - $B_4$ ) (Fig. 1b); C, Sydney line ( $C_0$ ) and variants ( $C_1$ - $C_3$ ) (Fig. 1c); D, other unusual variants that did not fit into the other groups ( $D_1$ - $D_4$ ) (Fig. 1d). The palms of 990 newborns were examined and the palmar crease patterns categorized according to the scheme in Figure 1. Since the medical records were reviewed after inspection of the crease pattern, the palmar crease evaluation was carried out independently of any clinical assessment.

Although all the newborn infants in the nursery were examined and their palmar crease variants recorded, only singleton newborns who fulfilled the criteria of one of the following groups were included in this study.

#### CONTROL GROUP

This was a group which consisted of 500 normal full term newborns with birth weight of 2,500 g or more, born consecutively in the hospital between September 1974 and April 1975. These infants had no evident congenital anomalies and no history of gestational or perinatal complications.

#### MOTHERS

Whenever possible, the palmar crease patterns of the mothers were recorded and categorized in the same way.

#### NEWBORNS AT RISK

The majority were seen in the neonatal intensive care unit. Newborns with evident congenital malformations were excluded. Four groups were studied.

*Group 1: Premature Infants.* This group consisted of 108 premature newborns admitted to the intensive care unit with a gestational age of 36 weeks or less, as determined by dates, physical and neurological examinations.

*Group 2: Small for Gestational Age Infants.* This group consisted of 74 newborns with a birth weight which was less than the 10th percentile for their gestational age (12). The gestational age ranged from 31 to 43 weeks.

*Group 3: Infants with Gestational Complications.* This group consisted of 62 newborns. The complications during pregnancy were mostly hypertension (31 newborns), but also included toxemia, syphilis, hypothyroidism, hepatitis, and others. Newborns of diabetic mothers were excluded from this study.

*Group 4: Newborns with Intrauterine Methadone Exposure.* An additional 46 newborns of mothers who were on methadone maintenance during pregnancy were included in this group. A few of the mothers were known users of other drugs as well, mainly heroin. Five of the infants were premature and six were small for dates, but since the mothers had been on methadone maintenance they were retained in this subgroup.

The characteristics of the study population in regard to sex and race are shown in Tables 1 and 2.

#### RESULTS

##### STUDIES OF NORMAL INFANTS AND CHILDREN

*Sex and Racial Differences.* Since our study population includes white as well as black newborns, an examination was carried out for possible racial as well as sex differences among the normal newborn control group (Table 2). Statistically significant differences between whites and blacks are observed in two instances. A higher incidence of the Sydney line (C) is seen among white females, and the unusual variants which fall into the D group (Fig. 1d) occur with higher incidence among black females, the differences being statistically significant in each case ( $\chi^2 = 10.80$ ,  $P < 0.005$ ;  $\chi^2 = 5.12$ ,  $P < 0.025$ , respectively).

No significant racial or sex differences are found in relation to the simian crease and its variants.

*Age Differences.* Since the incidence of the Sydney line in our newborn population, especially in females, appears to be higher than in previous reports (2, 15, 16), a group of 200 normal children aged 3-8 years with a similar racial composition was studied. Although 9.2% of palms of normal female newborns have variants classified as Sydney lines, only 1.5% of the palms of older girls show this feature (Fig. 1c,  $C_0$ ). The pattern classified as  $A_{2-4}$  (Fig. 1), in which the proximal transverse crease extends beyond the midline of the fifth finger but does not cross the whole palm, occurs in 11% of the palms of older girls, but only in 0.4% of the palms of female newborns. The same trend is seen in the males of the two age groups. Since the frequency of the  $A_{2-4}$  pattern plus that of the Sydney line is about the same in the two age groups, it appears that some of the palms classified as having a Sydney line at birth, develop a palmar crease pattern that resembles the  $A_{2-4}$  pattern later in childhood. Debrunner (7) reported a higher incidence of palmar crease variants which, by description, might be classified as the Sydney line, in a large group of fetuses and newborns as compared with adults. A longitudinal study is needed to clarify the basis for the difference in frequency of the Sydney line in newborns and in older children. Without such data, the use of a control group unmatched for age for the study of frequency of palmar crease variants may lead to erroneous conclusions. No significant differences were found in regard to the frequency of the other variants.

##### COMPARISON OF PALMAR CREASE VARIANTS OF MOTHERS AND THEIR INFANTS

In an attempt to obtain some information concerning intra-familial similarities in palmar crease patterns, studies were carried out on 466 mothers of newborns examined. In the majority

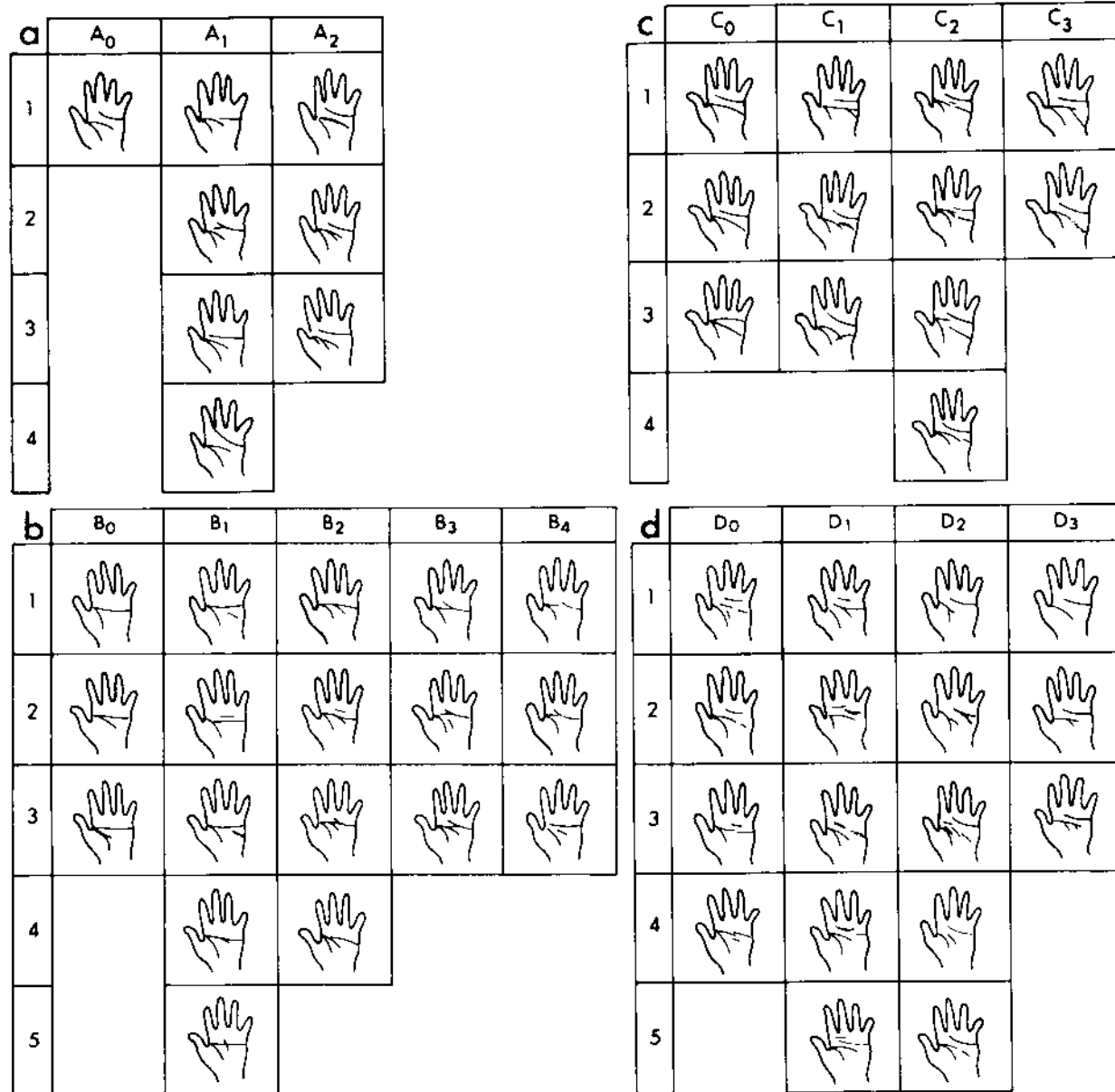


Fig. 1. Palmar crease variants based on 200 normal children (100 males and 100 females) and 500 normal newborns (260 males and 240 females). *a*: "normal" palmar creases and variants (A). A<sub>0</sub>, typical normal palmar creases—the most prevalent type, found in 94% of the normal individuals studied. A<sub>1</sub>, variants of the distal transverse crease. A<sub>2</sub>, variants of the proximal transverse crease. *b*: simian crease (B—B<sub>0</sub>, B<sub>1</sub>) and its variants (B<sub>2</sub>–B<sub>4</sub>, B<sub>3</sub>, B<sub>4</sub>). B<sub>0</sub>, typical simian crease. Uninterrupted single line crosses the palm. (Variant B<sub>0-2</sub> was not found among the normal individuals studied, although it was found in 3% of palms of 100 children with Down's syndrome (4).) B<sub>1</sub>, typical simian crease with rudimentary second transverse crease. (Variant B<sub>1-1</sub> was found in 4% of patients with Down's syndrome but not in normal individuals.) B<sub>2</sub>, uninterrupted line crosses the palm; the proximal transverse crease is present. B<sub>3</sub>, continuous horizontal line formed by a connection between the proximal and distal transverse lines. (Variant B<sub>3-1</sub> was not found in normal individuals; however, it was found in 4% of the palms of 100 children with Down's syndrome.) B<sub>4</sub>, slightly interrupted horizontal line crosses the palm. Sometimes a rudimentary proximal transverse crease is found. *c*: Sydney line (C) and its variants (C<sub>0</sub>–C<sub>3</sub>, C<sub>2</sub>, C<sub>3</sub>). C<sub>0</sub>, uninterrupted proximal transverse line extends to the ulnar border of the palm. It is wider than two epidermal ridges in the typical form (C<sub>0-1</sub>) or it becomes thinner toward the ulnar border line of the palm (C<sub>0-2</sub>). (Variant C<sub>0-3</sub> was not found in normal individuals, but was found in 2% of the palms of children with Down's syndrome.) C<sub>1</sub>, a branched proximal transverse line extends to the ulnar border of the palm. C<sub>2</sub>, an interrupted proximal transverse crease extends to the ulnar border of the palm. C<sub>3</sub>, a broken proximal transverse crease extends to the ulnar border of the palm. *d*: other unusual palmar creases (D). D<sub>0</sub>, interrupted and partially developed distal and proximal transverse creases. (Variant D<sub>0-3</sub> was not found in normal individuals but was found in 4% of newborns exposed to methadone during fetal life.) D<sub>1</sub>, interrupted distal palmar creases. D<sub>2</sub>, unusual proximal transverse crease. D<sub>3</sub>, undeveloped thenar crease. (Variant D<sub>3-1</sub> was not found among normal individuals but was found in 1% of children with Down's syndrome.)

of cases, the mothers had normal newborn babies (control group). A small group of twins and prematures and their mothers was included as well. The results are summarized in Table 3. The overall incidence of newborns with simian creases and their variants (B and B<sub>v</sub>) was 7.9%. However, 5 of 21 (23.8%) babies born to mothers with simian creases or variants showed this feature. This difference is statistically significant ( $\chi^2 = 6.12$ ;  $P$

$< 0.025$ ). A familial component is similarly seen for each of the groups of palmar crease variants.

"AT RISK" NEWBORNS (TABLE 4)

*Group 1: Premature Infants.* This group shows a significantly higher incidence of simian crease variants (B<sub>v</sub>), although the

Table 1. *Composition of study population according to sex and race*

Sex	Race	Full term newborns	Normal children	Prematures	Small for gestational age	Intrauterine methadone exposure	Gestational complications
Male	White	160	78	29	16	10	19
	Black	100	22	20	13	18	7
	Subtotal	260	100	49	29	28	26
Female	White	140	65	34	26	9	21
	Black	100	35	25	19	9	15
	Subtotal	240	100	59	45	18	36
Total		500	200	108	74	46	62

Table 2. *Distribution (percentage) of palmar crease patterns in palms of 500 normal newborns according to sex and race<sup>1</sup>*

Palmar crease pattern <sup>1</sup>	Males			Females			Both sexes		
	White (n = 160)	Black (n = 100)	Total (n = 260)	White (n = 140)	Black (n = 100)	Total (n = 240)	White (n = 300)	Black (n = 200)	Total (n = 500)
A	80.5	87.5	83.4	73.2	75.0	74.0	77.0	81.2	78.8
B	2.8	0.5	1.9	0.7	1.5	1.0	1.8	1.0	1.5
B <sub>v</sub>	2.8	2.0	2.5	3.2	2.5	2.9	3.0	2.3	2.7
C	4.9	3.0	4.3	12.5 <sup>2</sup>	4.5	9.2	8.5 <sup>2</sup>	3.8	6.6
C <sub>v</sub>	7.8	4.5	6.5	8.2	10.5	8.9	8.0	7.5	7.7
D	1.2	2.5	1.5	2.2	6.0 <sup>3</sup>	4.0	1.7	4.2	2.7

<sup>1</sup> For description of patterns, see Figure 1, a-d.

<sup>2</sup> Racial differences are statistically significant ( $\chi^2 = 0.5\%$ ).

<sup>3</sup> Racial differences are statistically significant ( $\chi^2 = 2.5\%$ ).

Table 3. *Palmar crease variants in 466 newborns and their mothers<sup>1</sup>*

Crease patterns	Crease patterns in newborns							Total (mothers)
	A	B	B <sub>v</sub>	C	C <sub>v</sub>	D	Bilateral forms <sup>2</sup>	
Mothers								
A	253	10	15	36	40	9	11	374
B	3		1					4
B <sub>v</sub>	8	1	3	2	3			17
C				3	1			4
C <sub>v</sub>	8		1	1	6		1	17
D	23	4	2	3	4	9	2	47
Bilateral forms <sup>2</sup>	2						1	3
Total (newborns)	297	15	22	45	55	18	14	466

<sup>1</sup> For description of patterns, see Figure 1, a-d.

<sup>2</sup> Number of subjects who showed lack of concordance of the palmar crease pattern in the two palms.

overall incidence of abnormal creases is not significantly different compared with control subjects.

**Group 2: Small for Gestational Age Infants.** There is a significantly increased incidence of simian crease variants (B<sub>v</sub>) as well as variants of Sydney lines (C<sub>v</sub>) among infants who are small for gestational age. However, the increased incidence of Sydney lines appears to reflect the excess number of white females who, in the control group, demonstrate a higher frequency of this pattern.

**Group 3: Newborns with a History of Gestational Complications.** This group shows an increased frequency of abnormal creases, but the difference from control subjects is not statistically significant.

**Group 4: Newborns of Mothers on Methadone Maintenance.** A significantly higher frequency of abnormal creases is found

among newborns of mothers on methadone maintenance. The differences are significant for variants of the Sydney line (C<sub>v</sub>) in female newborns and most striking for variants classified in the D group in male newborns (Fig. 1d).

Further analysis utilizing our detailed diagnostic scheme revealed that 11 out of 12 palms with D variants have interrupted transverse creases. The most striking variants are D<sub>1-2</sub> and D<sub>1-4</sub>, which occur bilaterally in four males (three whites and one black). Among the 500 normal newborns, only one palm shows the D<sub>1-4</sub> variant. The palmar crease variant D<sub>1-4</sub> in a newborn of a mother on methadone is shown in Figure 2. Of eight palms with Sydney line variants (C<sub>v</sub>) in this group, five have an interrupted proximal transverse line. (Variants C<sub>1-3</sub>, C<sub>2-3</sub>, C<sub>2-4</sub> in Fig. 1c). Thus, 16 palms of 11 newborns of mothers on methadone maintenance out of 46 newborns in this group (23.9%) show interrupted transverse creases as compared with 6.6% of the control group. This difference is highly significant ( $\chi^2 = 17.05$ ;  $P < 0.005$ ). Following this finding, 13 newborns of heroin-addicted mothers who were not on methadone were examined. None of these infants show this feature.

## DISCUSSION

The association of unusual palmar creases, especially the simian crease and its variants, with congenital malformations is well documented (7). Our main interest, however, was to study the prevalence of unusual palmar creases in newborns of mothers with complications of gestation. A higher incidence of abnormal palmar crease patterns in these infants might be the only visible evidence at birth for early intrauterine disturbances. The predictive value of these abnormalities remains to be studied.

Davies (5) found a higher incidence of simian creases in a newborn population as compared with school children. This was not surprising, since cases of stillbirths, neonatal deaths, and newborns with congenital malformations were included in this report. In the same study an increased proportion of low birth weight newborns (including small for gestational age) was found among newborns with simian creases. Similar findings were shown in our preliminary study (3) in which a significantly higher

Table 4. Relative distribution of palmar crease patterns in study population<sup>1</sup>

Palmar crease pattern	Normal newborns		Normal children		Premature		Gestational complications		Small for gestational age		Intrauterine methadone exposure	
	M (520) <sup>2</sup>	F (480)	M (200)	F (200)	M (98)	F (118)	M (52)	F (72)	M (58)	F (90)	M (56)	F (36)
A	83.4 <sup>3</sup>	74.0	89.0	90.5	77.6	76.3	73.2	68.0	81.0	52.3	53.6	72.2
B	1.9	1.0	1.0	1.0	2.0	3.4	1.9	1.4	0	0	5.4	2.8
B <sub>v</sub>	2.5	2.9	3.0	2.0	7.1 <sup>4</sup>	4.2	3.8	6.9	5.8	10.0 <sup>5</sup>	7.1	2.8
C	4.2	9.2	1.5	1.5	8.2	11.0	9.6	15.3	10.3	14.4	7.1	8.3
C <sub>v</sub>	6.5	8.9	2.0	3.5	4.1	3.4	11.5	4.2	3.4	18.9 <sup>5</sup>	5.4	13.9 <sup>4</sup>
D	1.5	4.0	3.5	1.5	1.0	1.7	0	4.2	0	4.4	21.4 <sup>5</sup>	0

<sup>1</sup> M and F refer to male and female, respectively.

<sup>2</sup> Refers to number of palms.

<sup>3</sup> Results are expressed as a percentage of palms in subgroup.

<sup>4</sup> Difference significant at  $P = 0.025$ .

<sup>5</sup> Difference significant at  $P = 0.005$ .

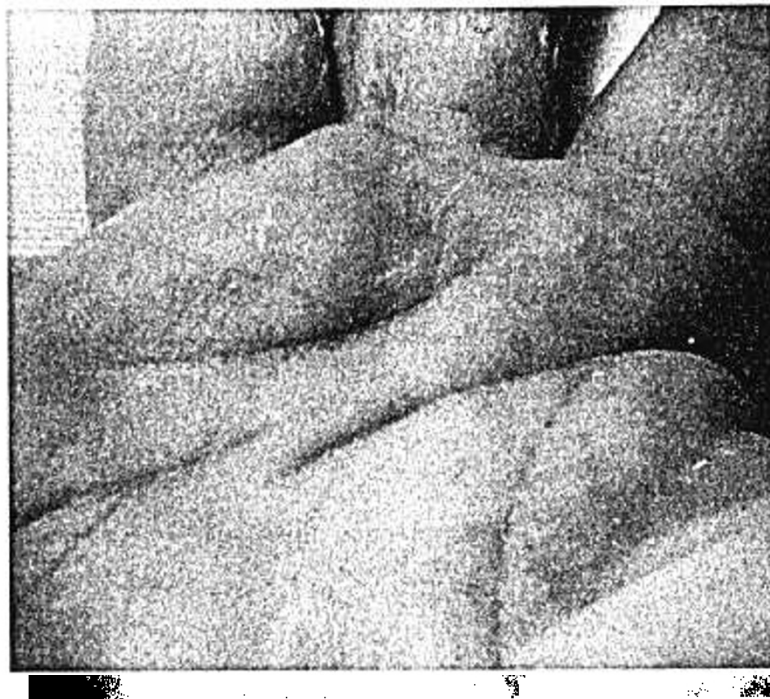


Fig. 2. Right hand of an infant whose mother has a history of methadone intake during pregnancy. Note interrupted transverse creases (D<sub>1d</sub>, Fig. 1d) (23).

frequency of simian creases and variants was found among low birth weight newborns (<2,500 g) without evident congenital malformations, compared with normal weight newborns.

In the present study a system of classification of palmar crease pattern was devised. The detailed breakdown of the palmar crease subtypes illustrated in Figure 1 is suggested as a baseline for further investigations of palmar crease patterns. Based on findings in 500 normal newborns, 466 of their mothers, and 200 normal children, correlations were observed between the pattern in the infant or child and maternal pattern, race, sex, and age. All these factors should be taken into consideration in studies of palmar crease variants.

Premature infants were chosen for the study of newborns at risk on the premise that in some of these infants intrauterine disturbances, leading ultimately to the birth of a premature baby, might also cause alterations in the creases. This was confirmed by the significantly increased incidence of simian crease variants found in this group.

Since a higher frequency of congenital malformations was reported among small for gestational age newborns (19), an even higher incidence of palmar crease alterations could be

anticipated in this group. Our results, as shown in Tables 1 and 2, confirm this expectation. A tendency to higher frequency of abnormal creases was also demonstrated in group 3 infants with gestational complications, indicating that some of the complications may result in an insult to the fetus early in fetal life. An interesting finding was the apparent association of interrupted transverse creases and intrauterine exposure to methadone. An association of a characteristic palmar crease variant and a specific teratogen was described in babies with the congenital alcohol syndrome (11).

The findings in this study suggest that examination of palmar crease patterns may provide a useful, objective criterion for fetal developmental abnormalities. It is recommended that a standard scheme be utilized to identify and classify palmar crease variants as part of the routine newborn examination. Such a scheme may serve as a baseline for comparative studies of palmar crease variants.

#### CONCLUSION

Based on a standard scheme for classification of palmar crease patterns, we have found that groups of newborn infants at risk as

a result of a suspected early intrauterine insult show an increased frequency of abnormal creases. There is an association between interrupted transverse creases and intrauterine methadone exposure. Race, sex, age, and intrafamilial concordance are some of the variables that should be considered in evaluating palmar crease patterns.

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22. Informed consent was obtained from the mother before obtaining palm print patterns on newborn infants or older children, in accord with the procedure approved by the Committee on Clinical Investigation of the Bronx Municipal Hospital Center.
23. A signed release was obtained from the mother to permit a photograph to be obtained and published of this infant's hand, in accord with established policy at this institution.
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Appropriate for gestational age (AGA) infants premature infants  
glucagon small for gestational age  
glucose (SGA) infants  
insulin

## Effects of Oral Glucose and Protein Load on Plasma Glucagon and Insulin Concentrations in Small for Gestational Age Infants

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### Summary

This paper reports portal and peripheral blood glucose, insulin, and glucagon levels in small for gestational age (SGA) and appropriate for gestational age (AGA) newborns during the first 48 hr of life. These parameters were studied after an oral glucose and protein load (1 g/kg of each) after a 4-hr fast.

In AGA and SGA infants, mean fasting blood glucose level was significantly higher in the portal vein than in the aorta ( $P < 0.05$ ). After the load, mean blood glucose level rose significantly in both vessels.

The mean fasting plasma insulin level was low and was similar in both vessels. After the load in the AGA group mean plasma insulin level rose significantly at 45 min in both vessels ( $P < 0.05$ ) ( $52.1 \pm 37.2 \mu\text{U/ml}$  in aorta and  $91.8 \pm 75.3 \mu\text{U/ml}$  in portal vein). In the SGA group, the insulin response was minimal in the aorta and in the portal vein; the increase was significant only in the portal vein ( $P < 0.05$ ) at 180 min ( $47.1 \pm 25.3 \mu\text{U/ml}$ ).

The mean fasting plasma glucagon level was higher in the portal vein than in the aorta in both groups ( $P < 0.05$ ). After the load in AGA infants plasma glucagon rose significantly from