CLINICAL INVESTIGATION OF NEONATAL DIAPER DERMATOSES*

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Diaper dermatitis was described as early as 1886,[1] and there has been continued interest in this condition since then. However, the etiology, method of prevention, and treatment are still controversial.

The data to be reported here were obtained in order to evaluate the role ammonia and other factors may play in the development of diaper dermatitis in newborn infants, and, in particular, to test the hypothesis proposed by Rapp[2] for older infants that urinary toxins, enzymes and ammonia may be etiologic factors.

Methods and Materials

The studies were conducted at the Episcopal Hospital in Philadelphia. Two hundred and sixty full-term newborn infants, ranging in age from birth to five days, were studied. Standard cloth diapers and commercially prepared formulas were used, and the infants were kept in the supine position.

The babies were examined daily for any evidence of diaper dermatosis, usually manifested as erythema, macules, papules and maceration. Generalized rashes which extended into the diaper area were not classified as diaper dermatitis.

Feces and urine from newborn infants, and the urine of normal adults were used shortly after collection. Diaper fragments were obtained by cutting freshly laundered diapers into one centimeter squares. Putrefied urine was prepared according to the method used

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Supported in part by grants from the Desitin Chemical Company and the Johnson and Johnson Company.

by Rapp, as follows: a fresh sample of urine was incubated at 37 C. for 18 hours, after which time the sample was malodorous. Next, the entire sample was sterilized in an autoclave for 20 minutes at a pressure of 15 pounds per square inch, after which time the sample was still malodorous but non-ammoniacal. This urine was then divided into four portions and the hydrogen ion concentration (pH) was adjusted from five to eight by adding hydrochloric acid.[2]

A majority of the patch tests were made using round, two centimeter band-aids.* In the remaining tests, five centimeter band-aids were used. The band-aids, saturated with the solution to be tested, were applied to the gluteal area for four hours. When multiple patch tests were made on a given infant, a different site was used for each test.

Results

1. *Patch tests with fresh urine:* Tests were performed on nine infants and nine adults. The results of all these tests were negative (Table 1).

TABLE 1
USE OF URINE OBTAINED FROM INFANTS AND ADULTS *

Urine obtained from	pH of urine	Number of cases	Patch test results
Infants	5.5	9	Negative
Adults	5.0	9	Negative

2. *Patch tests with putrefied urine:* Tests were performed on fifteen infants using urine with a pH varying from five to eight. The results of these tests were negative (Table 2).

TABLE 2
RESULTS WITH PUTREFIED URINE OF VARYING pH *

Number of cases	pH of Urine	Results
15	5	Negative
15	6	Negative
15	7	Negative
15	8	Negative

* (Round two cm. patches were applied to the gluteal area for four hours.)

3. *Patch tests with one per cent ammonium hydroxide (NH_4OH) at a pH ranging from five to twelve:* Twenty-two infants were tested and in all cases the results were negative (Table 3).

* Band-aids supplied by Johnson and Johnson Company, New Brunswick, New Jersey.

TABLE 3
RESULTS WITH ONE PER CENT NH_4OH OF VARYING pH *

Number of cases	pH	Results
22	5	Negative
22	6	Negative
22	7	Negative
22	8	Negative
22	9	Negative
22	10	Negative
22	11	Negative
22	12	Negative

4. *Patch tests with one per cent NH_4OH plus neonatal feces, neonatal urine, and diaper fragments:* These tests were performed on 26 infants of whom eight per cent had a positive reaction to the ammonium hydroxide plus neonatal feces. Twelve per cent of the infants had a positive reaction to the ammonium hydroxide plus neonatal urine and diaper fragments (Table 4).

TABLE 4
RESULTS WITH ONE PER CENT NH_4OH, PLUS NEONATAL FECES; AND ONE PER CENT NH_4OH PLUS NEONATAL URINE AND DIAPER FRAGMENT *

Patch Test with	pH	Number of cases	Positive tests
1% NH_4OH plus neonatal feces.	11	26	8 %
1% NH_4OH plus Neonatal urine and diaper fragment.	11	26	12 %

PATCH TEST IN INFANTS AGED ONE TO FIVE DAYS:

5. *Patch tests with five per cent NH_4OH; observations of infants with and without diaper dermatitis:* Five centimeter band-aids saturated with five per cent NH_4OH, with a pH of 14, were applied to 151 babies. Fifty-seven of these infants had naturally occurring diaper dermatitis. The remaining 94 did not have diaper dermatitis. Forty-seven per cent of the latter group had positive reactions to the patch tests, and 51 per cent of those with natural diaper dermatitis had positive reactions (Table 5). The differences are not statistically significant.

TABLE 5
RESULTS WITH FIVE PER CENT NH_4OH AT pH 14 IN INFANTS WITH AND WITHOUT NATURAL DIAPER RASH *

Patch test with	Number of cases	Presence of natural diaper rash	Positive patch tests
5%NH_4OH (pH 14)	57	Yes	51 %
	94	No	47 %

* Five cm. patch tests were applied to the gluteal area for two hours.

Discussion

Diaper dermatitis is a common condition in the neonatal period. Pratt [3] observed the condition on over 35 per cent of infants receiving cow's milk formula, and Pratt and Read [4] reported that the incidence varied between 6.7 per cent and 22.5 per cent, depending on the race of the infant as well as on the type of feeding. Among the newborn babies who were studied in the present report, the incidence of diaper dermatitis noted on the third day of life was 25 per cent, the highest incidence noted in the first week of life.

Diaper dermatitis probably has multiple etiologies and many believe the pH of urine and stool to be especially important factors. [5,6] Stool and urinary pH are related to the type of milk ingested and possibly to the presence of parenteral infection. Tisdall and Brown [6] reported that the pH of stool from normal newborn breast-fed infants is relatively constant, varying from 4.6 to 5.6, whereas the pH of stool of artificially-fed (cow's milk dilutions) infants was found to vary from 7.8. to 8.2. Infants fed buttermilk formulas have alkaline stools, the average stool pH usually being 8.0. An alkaline pH favors the development of skin maceration and irritation.

In a controlled clinical study, Keitel, et al.,[7] showed that newborn infants kept in the supine position developed diaper dermatitis more frequently than infants who were kept in the prone position. It was postulated that feces tend to fall away from the baby when kept in the prone position.

Rapp [2] suggested that diaper dermatitis results from irritation and inflammation of the skin, followed by bacterial invasion. This hypothesis is illustrated in (Figure 1).

Although Rapp believed that diaper dermatitis is caused by both urinary ammonia and skin toxins, our data do not indicate that this hypothesis is valid in the case of newborn infants. We could not reproduce his results and were surprised that even five per cent ammonium hydroxide did not always result in dermatitis (Table 6).

There may be some reason to question the validity of Rapp's hypothesis because he used relatively few subjects for his tests. However, it should be noted also that Rapp's subjects were older infants and young adults, whereas our study was limited to newborn infants.

We noted that the incidence of positive results to patch tests with five per cent ammonium hydroxide was similar in babies both with and without natural diaper dermatitis. This finding does not lend

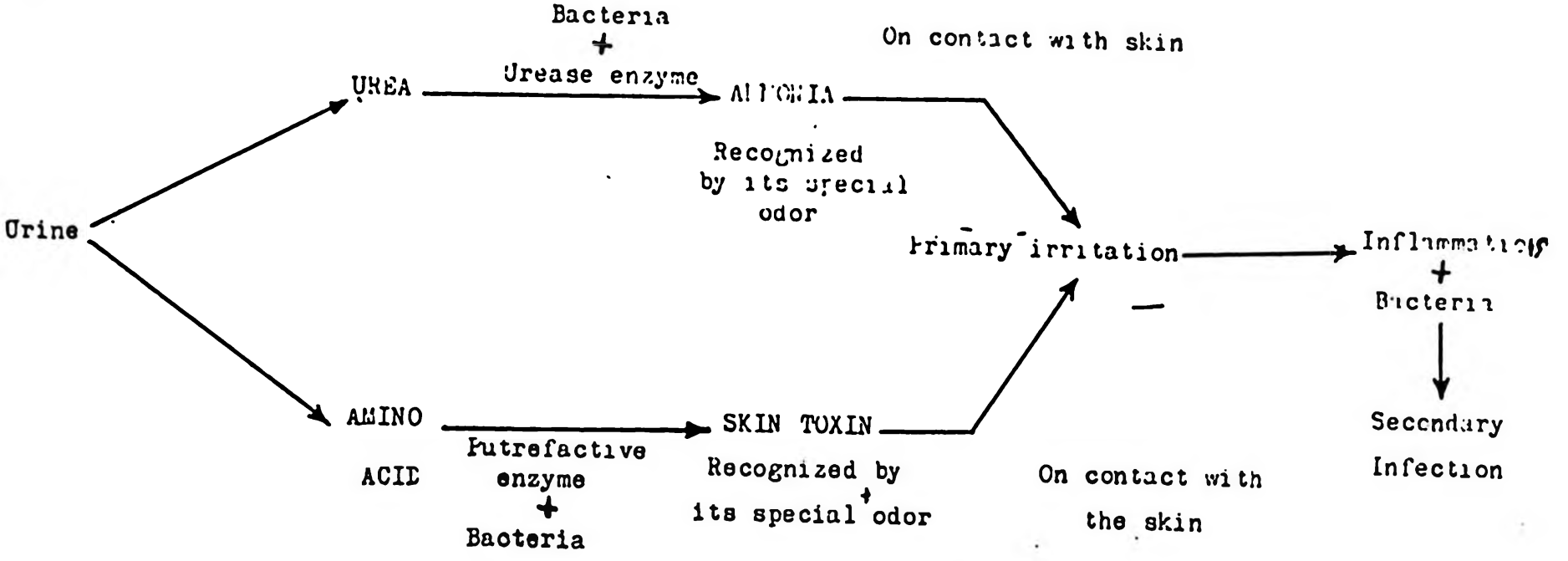

Figure 1. Dermatitis resulting from irritation and bacterial invasion.

TABLE 6

PATCH TESTS WITH 1 % NH_4OH AND PUTREFIED URINE : A COMPARISON OF THE FINDINGS OF RAPP AND OF THE PRESENT STUDY

FINDINGS OF RAPP							PRESENT STUDY						
pH	Area applied	Age	Patch Tests				pH	Area applied	Age in days	Patch Tests			
			1 % NH_4OH		Putrefied Urine					1 % NH_4OH		Putrefied Urine	
			No. of cases	Result	No. of cases	Result				No. of cases	Result	No. of cases	Result
5	skin of the back	young adults	5	Neg.	5	Pos.	5	Gluteal	1 to 5	22	Neg.	15	Neg.
6	" "	" "	5	Neg.	5	Pos.	6	"	"	22	Neg.	15	Neg.
7	" "	" "	5	Neg.	5	Pos.	7	"	"	22	Neg.	15	Neg.
8	" "	" "	5	Pos.	5	Pos.	8	"	"	22	Neg.	15	Neg.
9	" "	" "	5	Pos.	—	—	9	"	"	22	Neg.	—	—
10	—	—	—	—	—	—	10	"	"	22	Neg.	—	—
11	—	—	—	—	—	—	11	"	"	22	Neg.	—	—
12	—	—	—	—	—	—	12	"	"	22	Neg.	—	—

support to the concept that the skin of babies who develop diaper rash is more sensitive, at least to ammonium hydroxide.

An etiologic relationship between diaper dermatitis and candidiasis has been reported often.[8,9] Robinson[9] reported that *C. albicans* was cultured from 36 per cent of his infants with diaper rash, none of whom however were under one week of age. In some of his infants, cutaneous candidiasis was found in association with oral thrush, and the stools of these infants invariably harbored albicans. We failed to isolate candida from the stool of several patients with diaper rash. Surprisingly, the three infants in the present study who developed clinically significant oral moniliasis did not develop diaper dermatitis. The use of Vioform (containing hydroxyquinoline) which is reported to have antiyeastic properties, has not, in our experience prevented diaper rash.[8-11]

That ammonia is a major etiologic factor predisposing to diaper rash in older infants seems established on clinical groups, but in the case of the newborn this would not appear to be a good possibility. We are struck by the relative resistance of newborn skin to ammonium hydroxide; the skin remained non-reactive unless a five per cent solution of ammonium hydroxide was used. The high concentration of ammonia that is required to produce dermatitis does not seem to be in keeping with ammonia as an explanation for diaper rash in newborn infants. Furthermore, an ammonical odor can rarely be detected in infants under one week of age.

We are left with few positive concepts relative to the etiology of diaper rash in the newborn except that the presence of feces seems to be fundamental. Diaper rash in the newborn is almost exclusively perianal or gluteal, rarely pubic in location. Stool irritants (bacteria, enzymes, etc.) may be fundamentally related to this problem in the newborn, but we were not even able to obtain evidence supporting this view; when stool was used on the patch tests, negative results were obtained. It seems reasonable to postulate that a combination of several events must be present in order for diaper rash to occur in the newborn infant.

Conclusions

1. Diaper rash occurs relatively frequently in the neonatal period; up to 25 per cent of infants showing some gluteal dermatosis on the third day of life.

2. Patch tests with urine, feces and one per cent ammonium hydroxide were negative in infants under five days of age. The process which Rapp described (Figure 1) did not seem to be operative in newborn infants.

3. The incidence of positive patch test reactions with five per cent ammonium hydroxide (pH 14) was not significantly different in infants with and without natural diaper rash. Using this approach, we could not identify a host skin-resistance factor.

4. It seems unlikely that ammonia plays a significant etiologic role in neonatal dermatitis since an ammoniacal odor can rarely be detected in infants of this age.

5. Monilia *(Candida albicans)* were not felt to play an important role in the pathogenesis of neonatal diaper rash.

It is concluded that feces in some way play a dominant role in the production of neonatal diaper (gluteal-perianal) rash, but the method by which fecal irritant (s) contactants, bacteria, toxins, and enzymes cause dermatitis was not identified.

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