

# THE AMMONIACAL DIAPER IN INFANTS AND YOUNG CHILDREN \*

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## I

Several years ago I was asked to see a little girl, 17 months old, suffering from a severe dermatitis of the diaper region. The skin of the buttocks, perineum, genitals, thighs, and lower abdomen was severely inflamed and numerous vesicles and blebs were scattered over this area. The infant appeared perfectly well otherwise. The mother stated that the diaper removed that morning had a very strong odor, "just like ammonia." She had saved the diaper in a closed receptacle. On unfolding the wet diaper, a very strong penetrating odor of ammonia was noticed. So strong was this gas that it irritated my eyes very disagreeably during the examination. It seemed clear to me that the skin lesions were induced by the ammonia in the urine, since ammonia is a powerful rubefacient and vesicant.

This case served to interest me in the study of ammonia in the urine and the resulting lesions, and for many years facts in regard to this condition were collected and form the basis for this study. The term *ammoniuria* was used to designate the presence of free ammonia in the urine, as well as the skin lesions produced by this irritant.

## CLINICAL PHENOMENA

The ammoniacal diaper is frequently encountered by the practitioner. Usually, the odor of ammonia is faint, especially in young infants. Only occasionally does the concentration become sufficiently intense to produce the characteristic irritation of the skin. The severest grade occurs in infants between 1 and 2 years of age.

The lesions consist of inflamed areas on the inner side of the thighs, the genitals, the buttocks and lower abdomen. Sometimes the whole diaper region shows a diffuse redness.

More characteristic is the appearance of vesicles and blebs. There may be only one at the end of the prepuce; often this is associated with others on the prominent parts of the genital region. It is the parts which come in direct contact with the diaper which show the blisters. Rarely the whole diaper region may show numerous confluent blisters. No vesication may be observed, but after the intense

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congestion, sometimes the whole epidermis becomes hard, cracked, and the skin seems covered with thin parchment. The dead skin separates in a flaky desquamation.

A very important lesion to which no attention has been given by pediatricists, is the formation of a blister at the meatus. This occurs only in boys who have been circumcised. The prepuce protects the meatus in the uncircumcised. The blister ruptures and a superficial ulceration remains. This causes distress in urinating and may be the source of hemorrhage. The ulcer is exceedingly troublesome at times. It becomes covered by a thin crust, which may partially or entirely occlude the orifice of the urethra, so that urination is painful and difficult. The passage of the urine removes the crust and the ulcer is irritated again by the urine. Healing, therefore, may take several weeks.

The skin lesions nearly always appear in the morning when the infant has lain for a long period during the night. Infants who do not wet the diaper are not subject to this trouble. In fact, enuresis and ammoniuria go together. The assumption that the enuresis depended on the ammonia in the urine was entertained for awhile; the reverse is probably true.

The ammoniacal diaper is a frequent precursor of pyelocystitis in female infants. The irritated genital region becomes more susceptible to infections. On account of the protection afforded by the labia, the urethral orifice in the female is not subject to the blistering.

The association of the ammoniacal diaper and the exudative diathesis is frequent. The irritating urine initiates patches of eczema in the diaper region, which are exceedingly intractable unless the urinary condition is relieved.

The onset is usually abrupt and the course is very irregular and indefinite. The irritating urine may be present for one day only; then, it may last for weeks.

#### ILLUSTRATIVE CASES

CASE 1.—C. C., girl, aged 8 months; fed on dextrinized flour and milk; has had a tendency to eczema on the face. Lately she has been very irritable and urinates frequently. She is rather constipated, but the nutrition is very good. The mother noticed that the diaper every morning had a strong odor like ammonia. There is considerable irritation of the buttocks, but no blistering.

CASE 2.—B. C., boy, aged 4 years, has nocturnal enuresis. The mother has observed a very strong odor of ammonia. This morning she detected blood stains on the sheets, which alarmed her. Examination revealed the glans penis congested, and an ulcer covered by a crust at the meatus.

CASE 3.—R. D., boy, 1 year old, has been artificially fed since birth. His nutrition is very good at present. His diet consists of whole cows' milk, cereals, bread, custard, orange juice, apple sauce and prune juice. He is usually constipated. He passes much urine through the night; the bedding is soaked in the

morning. Considerable irritation of the genital region has been present for the last two days. This morning the whole prepuce was swollen and edematous, and a large blister is present on the dorsum. Another vesicle is found on the inner side of the thigh. The bedding has a very strong odor of ammonia.

As the ulcer would not heal, after ten days the family had the boy circumcised. After the operation the ammoniuria continued. The head of the penis and wound edges became irritated, swollen and a large blister formed on the glans penis. He had difficulty in urinating and a crust formed at the meatus. The urine continued to give this strong ammoniacal odor for several weeks longer, so that the little boy became known as the "ammonia factory." Treatment had no effect.

CASE 4.—C. A., boy aged 23 months; on a general diet; passed about half a teaspoonful of blood after urinating. The glans penis showed ulceration and a crust covered the meatus, occluding the opening. The mother said the urine was very strong.

CASE 5.—J. P., 2 years old, boy, has always been well. Was breast fed to 11 months. Was seen first in February, 1915. Because he has been housed too much, he looked pale and appetite was poor. He was on a general diet. Was suffering from incontinence of the urine. Clothes wet all the time. He was restless at night. During the last week mother noticed severe irritation of the genital region. One blister was found on the scrotum and the urinary meatus showed an ulceration. The mother observed an ammoniacal odor of the bed clothes. Bowels rather constipated.

CASE 6.—S. L., boy, aged 2 years. Was operated on for adenoid vegetations one week ago. The mother noticed a remarkable penetrating odor of ammonia in the diaper, which alarmed her very much. Very slight genital irritation.

The boy was on mixed diet. Has had recurrent attacks of intestinal indigestion. The mother noticed a similar odor one year before when she changed her washwoman. She was directed to supervise the rinsing of the diapers and the odor from the diapers disappeared.

#### ETIOLOGY

Ammonia in the urine of infants and young children has been observed by pediatricists. The ammoniacal diaper has become a well-known term, following the suggestion of Southworth. In St. Louis this condition is very frequent. While we pass over the cases in which a slight ammoniacal odor of the bedding is noticed, in the last five years, I have collected brief notes of seventy-eight cases, in all of which the patients showed some skin lesions, and the ammonia was sufficiently intense to warrant more than a passing notice.

Of these seventy-eight cases, fifty-four, or about three-fourths, occurred in children over 10 months of age. The worst cases are observed, not in infants, but in young children, from 1 to 4 years of age. By far the greater number of cases occur in the winter months.

The severest lesions in my series have occurred in boys. As already mentioned, pyelocystitis, not infrequently, follows the occurrence of severe ammoniacal condition in girls. It seems to me this predisposing cause to pyuria should be given more attention.

While several infants were fed partially on the breast, the disorder seems to be almost limited to artificially-fed infants. The severest

grades arise at the time when the infant is beginning to take solid food. Mixtures containing cow's milk and cereal decoctions are especially prone to result in the ammoniacal diaper. Taking large quantities of bread was etiologically related in a few cases. Egg also seemed to be a disturbing factor.

Several careful tests were made to determine the effect of orange juice. In three infants the mothers insisted that the ammoniacal odor was stronger when orange juice was given. Repeated tests in one little girl showed that the diaper was ammoniacal when orange juice was given, and had little odor when the juice was omitted.

High percentages of fat in the milk seemed provocative of this disorder in young infants. The removal of the fat from the food had very little effect on the ammonia in older infants.

Buttermilk, casein-buttermilk, whole milk, and condensed milk stood etiologically related in some cases.

The majority of the infants were constipated; often the stools were reported normal.

The administration of alkalis often aggravated the condition; no relief was observed from their use.

The disorder usually came on suddenly and disappeared as mysteriously. Sometimes it lasted one or two days; at other times, several weeks. Recurrent attacks were frequently observed.

The only disorder apparently connected with this phenomenon was the exudative diathesis, eczema, asthma, etc.

## II

For several years I have been trying to ascertain the cause of this trouble. After satisfying myself that this emanation from the bedding was really ammonia (by holding a splinter dipped in hydrochloric acid over the diapers), the further origin of this gas was pursued. That the ammonia was not due to bacterial activity was shown by the fact that the odor was perceptible in a very short time after the urine was passed. Then the odor was different, in that the offensive odor of decomposed urine was absent.

Since Keller discovered that infants with digestive disturbances have a great increase in the ammonia content of the urine, it was at first assumed that the ammoniuria really was a symptom of an acute indigestion, although the clinical symptoms by no means corroborated this view. At any rate, following out the theory of an enterogenic acidosis, the cases were treated by the restriction of fats and the administration of alkalis; but this therapy was so disappointing that it was evident that our theory was erroneous.

We (Dr. Coffin, Dr. Koessel and myself) made numerous tests to determine the concentration of the ammonia in the urine. We availed ourselves of the very simple method described by Rosenbloom<sup>1</sup> of determining the ammonia nitrogen in the urine. Dr. Koessel, at first, made a series of tests in the Bethesda Foundling Home. His results are given in Table 1. The figures give the cubic centimeters of decinormal sodium hydroxid used in titrating 10 c.c. of urine after the addition of neutral potassium oxalate (first column) and after the addition of formic aldehyd (second column). By multiplying the figures in the last column by 0.0014, the quantity of ammonia nitrogen in 10 c.c. of urine may be obtained.

TABLE 1.—ESTIMATE OF AMMONIA NITROGEN IN 10 C.C. URINE OF BETHESDA BABIES

Case	First Titration *	Second Titration	Remarks
1 .....	3.5	2.5	
2 .....	1.0	1.0	
3 .....	1.0	0.8	
4 .....	3.1	4.9	Intoxication
5 .....	1.3	1.3	
6 .....	1.6	1.2	
7 .....	1.5	2.6	Diarrhea
8 .....	2.0	1.1	
9 .....	2.4	1.6	
10 .....	3.8	3.1	Constipation
11 .....	1.3	0.6	
12 .....	0.8	0.3	
13 .....	1.7	1.2	
14 .....	2.2	0.9	
15 .....	3.4	1.6	
16 .....	2.4	8.4	Green Stools
17 .....	1.6	0.8	
18 .....	3.8	7.0	Intoxication
19 .....	3.5	2.1	
20 .....	3.7	3.8	Intoxication
21 .....	6.3	6.0	Diarrhea
22 .....	2.2	1.1	

\*The figures give cubic centimeters decinormal sodium hydroxid. Infants less than 1 year of age.

It will be seen that the concentration of ammonia nitrogen in infants is not high, as a rule, yet infants with digestive disturbances show a high percentage of ammonia nitrogen in the urine.

Then Dr. Coffin made a series of tests on older children who presented themselves at the clinic or office. The results are shown in Table 2.

1. Rosenbloom, J.: Clinical Methods for Estimation of Total Nitrogen and Ammonia Nitrogen in Urine, Jour. Am. Med. Assn., 1913, lxi, 87.

The ammonia nitrogen in children is relatively higher than in infants. Occasionally a surprisingly high figure may be obtained without apparent cause.

We have examined the urines of a few children who have shown symptoms of ammoniuria. Obviously, the urine which caused the irritation could not be examined. These figures are given in Table No. 3.

TABLE 2.—AMMONIA NITROGEN IN URINES OF OLDER CHILDREN

Initials	Age Years	First Titration	Second Titration	Diagnosis
F. S. ....	1	3.7	7.2	Marasmus
A. W. ....	3	2.3	3.9	Enuresis
W. W. ....	13	6.3	7.4	Bronchitis
F. P. ....	4	2.3	3.9	Vaginitis
R. S. ....	1	3.6	0.3	P a r t i a l starvation
F. N. ....	6	5.1	4.0	Neuritis
A. L. ....	10	11.5	9.5	Acute indiges- tion
M. E. ....	.....	5.3	4.3	
J. M. ....	$\frac{3}{4}$	3.1	1.9	Malnutrition
L. K. ....	11	4.5	6.9	Enuresis
M. B. ....	5	2.0	2.2	Hemorrhagic nephritis
E. G. ....	3	5.6	3.3	Pyelitis
V. W. ....	3	3.6	3.0	Acute nephri- tis
L. B. ....	2	3.5	2.6	Healthy
S. B. ....	6	4.1	4.2	Enuresis
S. S. ....	3	5.3	8.9	Asthma
H. F. ....	6	4.2	5.4	
M. S. ....	4	4.6	4.8	Enuresis
S. S. ....	6	6.1	4.6	Enuresis
S. H. ....	.....	1.5	1.2	
E. S. ....	.....	4.0	4.0	Enuresis
E. W. ....	4	3.9	3.7	Eczema
F. H. ....	1	4.0	4.2	Mucous colitis
R. S. ....	2	7.0	5.8	Indigestion
D. B. ....	5	4.6	2.7	
W. D. ....	3	5.4	6.9	Anorexia
B. M. ....	2	1.5	2.8	Cystitis
J. P. ....	2	4.5	3.1	
A. P. ....	2	8.0	3.6	

As will be seen, the ammonia content is rather high, but not higher than in some other children who did not present the symptoms.

As the concentration of the total solids might account for the variation in the figures, we compared the specific gravity with the ammonia content. Table No. 4. In general, a high ammonia content is found in the urine with high specific gravity.

We made a few tests to ascertain what effect rest and activity have in the ammonia content. Table No. 5.

TABLE 3.—SHOWING THE ACIDITY AND AMMONIA IN THE URINE OF CHILDREN WHO HAD THE SYMPTOMS OF AMMONIURIA

Initials	Age Years	First Titration	Second Titration
H. B. ....	2	6.9	5.8
E. G. ....	3	5.6	3.3
L. B. ....	2	3.5	2.6
E. D. ....	3	4.6	5.1
A. J. ....	2	5.4	4.8
R. S. ....	1	7.0	5.8
J. P. ....	2	4.5	3.1
S. L. ....	2	2.0	2.2
E. J. ....	2	3.3	6.0
S. L. ....	2	2.0	2.4

TABLE 4.—SHOWING QUANTITY OF AMMONIA IN THE URINE OF CHILDREN, AS COMPARED WITH THE SPECIFIC GRAVITY

Initials	Age Years	First Titration	Second Titration	Specific Gravity
A. L. ....	9	11.5	9.5	1.025
H. S. ....	8	2.2	2.4	1.010
P. A. ....	5	6.2	4.8	1.014
P. A. ....	5	1.7	2.4	1.022
S. H. ....	3	1.5	1.2	1.020
E. W. ....	4	4.6	3.9	1.020
R. S. ....	2	4.0	2.7	1.014
D. D. ....	6	4.4	4.0	1.015
P. G. ....	2	3.2	4.9	1.012
H. S. ....	8	1.4	1.7	1.008

TABLE 5.—SHOWING THE DIFFERENCE IN THE ACIDITY AND AMMONIA CONTENT IN THE URINE PASSED AFTER A NIGHT'S REST, AND LATER DURING THE DAY

Initials	Age Years	First Titration	Second Titration	Diagnosis
P. A. (rest)...	4	6.3	7.4	Nephritis
(active) .....	.....	4.0	5.3	
A. S. (rest)...	9	2.8	3.0	Orthostatic albuminuria
(active) .....	.....	3.5	2.8	
A. J. (rest)...	1	6.3	7.2	Ammoniuria
(active) .....	.....	3.0	2.5	
A. R. (rest)...	9	4.0	4.5	Cystitis
(active) .....	.....	3.1	4.7	

This was suggested by the fact that the morning diaper is the one usually showing the strongest odor of ammonia. It is curious that all but one of the patients so examined showed the ammonia nitrogen higher in the morning after the night's rest. As a rule children who have the symptoms of ammoniacal urine have a high content of ammonia nitrogen in the morning urine.

But this by no means solves the difficulty. This ammonia is combined with acids, but the clinical evidence proves that the ammonia, which causes mischief, is *free* ammonia. We thought at first that the young child, under certain conditions, passes free ammonia, and thus arose the term ammoniuria. While it is clear enough that free ammonia gas was arising from the diaper, we never could obtain a specimen of urine in a vessel or bottle which gave off free ammonia, except in traces. We could not prove, in a single instance, that a child ever passes ammonia in its free state.

It is only recently that I succeeded in demonstrating the origin of the free ammonia in two cases. It is not necessary to give the details. The immediate cause of the ammoniacal diaper is the presence of an alkali in the diaper or bedding.

This fact was tested at the bedside and at the laboratory. When the diaper, which has been washed in a strong alkaline soap, is not thoroughly rinsed in clear water, sufficient alkalinity remains in the cloth to decompose the ammonia in the urine. This is the origin of the "common" saying that strong soap or lye in the diaper blisters the baby. It is not the alkali or soap on the skin, but the ammonia produced, which causes the skin irritation. An alkaline stool mixed with urine acts the same way, and we have often attributed an intertrigo to irritating feces, when it was really caused by ammonia.

It is clear that the neutral or nearly neutral urine would be the most dangerous, since a highly acid urine would neutralize all the alkali before the ammonium salts would be decomposed.

This fact also explains the failure of dieting and the administration of alkalies. It would explain the action of orange juice, since this makes the urine less acid. Its more frequent occurrence in older children, its occurrence in the winter months, and the irregular course, are easily explained when we adopt this theory. One mother told me that her baby invariably passed ammonia after a certain woman washed the diapers. Another mother had no more trouble when she was told to oversee the washing of the nursery bedding.

In St. Louis, on account of the high content of lime in the water, it is possible that this alkaline earth may be a possible cause in certain babies, since in drying the bedding considerable lime would remain.



CONCLUSIONS

Free ammonia in the diapers of young children is a frequent condition.

If much ammonia is present, severe irritation and vesication of the diaper region may occur.

The ammonia is derived from the ammonium compounds in the urine, and is liberated by an alkali present in the diaper—soap, lye, lime, or stool.

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