PERFORATION OF THE NASAL SEPTUM DUE TO SODA ASH

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Perforation of the nasal septum as a direct result of occupation has been recognized since the days of Rammazzini (Wampler, 1943). However, the unspectacular nature of the symptoms and its self-limiting nature have so conspired together to keep the condition from the public eye as to make references to it in the literature both few and cursory. Particularly is this true of perforation of the septum occurring amongst workers in soda ash.

Review of the Literature

St. Clair Thomson and Negus (1948) briefly mention perforation of the nasal septum due to syphilis and traumatic ulcers secondarily complicating rhinitis sicca. Marchand (1949) mentions the perforations of the septum which occur in cocaine addicts.

Perforations of the septum due to chrome and arsenical salts are frequently mentioned. Legge, (1934) writing of the effects of arsenic salts in the form of dust, says :

“The most characteristic lesion . . . is perforation of the septum of the nose, resulting in a circular hole varying from one-eighth to one inch in diameter. Perforation may be complete in a month from the time of commencement of work. The anterior and lower margins of the cartilage and the bones to which they are attached never become involved in the ulcerative process, so that there is no deformity. . . . Once the perforation is complete, no further inconvenience is felt ; not a few workers are ignorant of the existence of the condition.”

Collier (1940) claims that personal factors are more important than working conditions but admits the importance, as predisposing factors, of nasal deformity or obstruction. He quotes Prosser White (1934) as naming certain hygroscopic substances including lime, calcined spathic ores, cement, powdered sodium carbonate, tar and pitch, all of which may produce septal lesions. Collier is further of the opinion that ulceration and perforation occur below the level of the inferior turbinate

where the stream of inspired air impinges on the septum. He is alone in suggesting that varied atmospheric humidity may lead to an increase in septal ulceration.

Müller is quoted by Ritchie Rodger (1934) as finding nasal perforations in more than 25% of 165 salt packers and sifters.

Ballenger, Ballenger, and Ballenger (1947) suggest that the convex side of a deviated septum is dried and irritated by the current of inspired air and its secretion dessicated leading to retrograde epithelial changes and ultimately to crusting and ulceration.

Marchand (1943) described in some detail his findings in calcium nitrate workers. In two factories the combined incidence of ulceration and perforations was 67% and 81%. He described in detail the break in the continuity of the mucous membrane, the ulcerations and crusting, the excavation, and finally the perforation. He mentions the symptomless nature of the occurrence. He thinks the lesions are due to the hygroscopic and caustic nature of the calcium nitrate.

Bernabei (1950) found no less than 10 perforations in 13 glass workers employed in mixing silicon dioxide with anhydrous sodium carbonate. The mixing process gives off a fine powder. It is postulated that sodium hydrate (NaOH) is formed and, being a strong caustic, produces lesions. Bernabei thought that the progress of the lesions could be halted by removal from contact with the dust. He asserts that there is a relationship between the size of perforation and the length of exposure but produces no facts to support these assertions.

Naidu and Rao (1948), in describing the manufacture of dichromates in India, state that ulceration of the nasal septum is seen in workers who concentrate and centrifugalize the dichromate solutions but make no mention of such lesions in the first stage of the process which involves mixing dry powdered chrome ($\text{Fe}_2\text{Cr}_2\text{O}_3$), lime

(CaO), and soda ash (Na_2CO_3). The resultant dust is said to cause upper respiratory lesions and is thought to be predominantly the lighter lime and soda ash.

Aupetit and Prévost (1951) found that four out of 10 men who worked with calcium cyanamide had lesions of the nasal septum, three perforations and one ulceration. However all the affected men were said to have worked a long time in the lime industry and it was to lime rather than to cyanamide that the lesions were attributed.

Where prophylaxis is mentioned by the above authors, dust suppression is given pride of place although the elimination of potential cases by selection at the pre-placement medical examination is tentatively suggested.

Soda Ash Manufacture : The Alkali Industry

It is only in the handling of soda ash that perforation of the nasal septum has been demonstrated so that this description will be confined to the terminal stages of manufacture and handling of this product.

Soda ash is manufactured from coke, limestone, and brine. It is a white powder, produced in chemically identical light, granular or dense forms, the microscopic appearances of which are illustrated in Fig. 1 (a-c).

The dried ash is mechanically packed into jute or paper bags. Dust is inevitably produced at the packing points despite exhaust ventilation. Soda ash causes rhinorrhoea and paroxysmal sneezing at first but the worker quickly becomes acclimatized. The taste can be detected in the mouth.

Packing soda ash, which is illustrated in Fig. 2, is a hot job and the packer does not like protective masks or mutton cloth. The temperature of the ash at the packing point varies from 120° to 130°F .

Considerable dust is also raised in the cleaning and repairing of returned jute bags. In busy periods up to 23,000 bags are handled daily in the bag plant. Bags caked with ash are mechanically beaten (Fig. 3). This is a very dusty operation performed exclusively by women who usually wear mutton cloth round their mouths and, sometimes, their noses. The volume of bags beaten is greater in wet weather when caking is more prevalent.

Bags which are not caked pass, together with those which have been beaten, to vacuum machines where residual dust is drawn from the interstices of the bag as illustrated in Fig. 4. Damaged bags are repaired by workers at sewing machines in the same room as the vacuums. There is generally a fine haze of dust over the whole room. Lastly there are checkers and "luggers" who stitch diagonally across the bottom corner of the bags to provide handholds.

Particle Size of Soda Ash Dust

Atmospheric samples of dust from a dense ash packing point in Factory A were examined by the combined thermal precipitator and settling tube methods. Counts showed that 66.14% by number and 0.22% by weight of the particles were less than 0.8μ in diameter and 95.80% by number and 4.19% by weight were less than 3.2μ in diameter. Much of this fine dust must be inhaled into the nose and an appreciable proportion will pass through into the respiratory passages.

Davies (1952) reviewing recent work suggests that 50% of particles with an effective diameter of between 3.5 and 5μ pass through the upper respiratory tract and that most of the particles larger than this are prevented by filtration from passing into the lungs.

FIG. 1.—The microscopic appearances of soda ash $\times 20$. (a) Dense soda ash ; (b) light soda ash ; (c) granular soda ash.

FIG. 2.—Packing of soda ash. The bag is secured to a spout. An automatic weighing machine is visible behind the packer on the right of the photograph.

FIG. 3.—“Beating” dirty bags. The bag is controlled by a pedal operated by the right foot. Note that this worker has mutton cloth round her neck but has not used it to cover her nose and throat.

Proetz (1941) points out

“the human nose, in general lying more under the cranium than in front of it, shows a greater tendency to depart from the normal. This tendency often exhibits itself in the form of a deflected septum. . . . The effect of restricting, deflecting, or otherwise concentrating air streams, particularly during inspiration, upon any localized area of the mucosa may be very serious. Inspired air playing in a jet upon a restricted area rapidly evaporates the mucus, increasing its viscosity and preventing its movement by the cilia.”

In writing of the effect of dust particles on the normal nose he avers: “The dusts react only through some specific physical or chemical property peculiar to them, for inert dusts, even in large amounts, are carried off without any disturbance of the membrane”.

Scope of Present Investigations

Reference has already been made to the types of work which involve exposure to soda ash dust. Three groups of work people were examined at factories A and B as follows:

Group 1.—This consisted of ash packers, bag-stitchers, and checkers of weight at factories A and B. These workers weigh and pack the ash from spouts into jute bags as illustrated in Fig.2, the bags being then stitched with twine by a manually operated machine. The men are constantly exposed

FIG. 4.—Cleaning bags by vacuum. The worker is about to operate the vacuum with his right foot. This will draw the bag up to the spout and in anticipation of this he has shut his eyes to avoid the puff of dust which arises with each operation.

to a heavy concentration of ash dust. They number 63, are all males, and are mostly shift-workers.

Group 2.—This group consisted of bag plant workers, all of whom are employed at Factory A. There are two shift teams, the majority of whose members rotate on specific jobs, namely, lugging, darning, vacuum-cleaning and beating dirty bags. The day workers are employed on a variety of jobs which involve the handling of both clean and dirty bags within the precincts of the plant. All workers are contaminated to some extent by soda ash dust although the degree of contamination varies. There are 156 employees in this plant, 91 men and 65 women.

Group 3.—Group 3 included workers of both factories, 100 consecutive patients who consulted the doctor at each works surgery for any reason being examined. Work people who are already included in the survey in Groups 1 or 2 were excluded. The remainder formed this control group. The exposure to soda ash might vary from slight to heavy and might be intermittent or constant.

The people employed in any one plant are continually changing for a variety of reasons, and in order to ensure constancy of the clinical material the members of Groups 1 and 2 consist of those actually employed in the work described on January 1, 1952. Whatever happened to them after that date they were still included in these groups. The collection of the controls in Group 3 was begun on the same date at both works. Where a patient's age is quoted it refers to age on January 1, 1952.

Group 4.—Group 4 was studied as a further control and consisted of 100 male applicants for employment. By reference to their previous occupations, as stated on the Ministry of Labour Form ED. 10, it was ascertained that 99 had not been employed in industries or manufactures in which soda ash is regularly used in more than small quantities. One man had a brief previous period of employment at Factory A.

Broadly speaking, therefore, the four groups resolved themselves as follows: Group 1, continuous exposure to soda ash dust; Group 2, fairly continuous exposure to soda ash dust; Group 3, intermittent, occasional, or slight exposure to soda ash dust; Group 4, no exposure to soda ash dust.

Method of Examination

A caliper, which could be inserted into the nose between the blades of a nasal speculum and by which the size of the aperture could be measured, was made by the instrument department (Fig. 5).

Fig. 5.—Caliper for measuring the diameter of perforation of the nasal septum.

Attempts have been made to photograph some perforated septa and the following technique was finally used. The patient lay on a trolley with the head steadied by sandbags to prevent movement. The light from an ophthalmoscope, from which the lens system had been removed, was inserted into the left nostril and directed towards the septum. The room was completely blacked out and the camera pointed into the right nostril, the ala of which was held back by one blade of a nasal speculum. The photograph was taken at an exposure of 10 seconds at *f*/11 on Una quarter plate.

Clinical Findings

The details of the age groups and length of exposure to soda ash (Groups 1 and 2) or length of service (Group 3) are shown in Table 1.

TABLE 1
AGE GROUPS AND LENGTH OF EXPOSURE AND SERVICE

Age (years)	Nos. Examined					Average Exposure to Soda Ash (yrs. mths.)					Average Length of Service (yrs. mths.)	
	Groups					Groups					Groups	
	1		2		3	4	1	2		3		
	M.	F.	M.	F.				M.	F.			
Up to 19	15	28	9	14	43	2	0	7	10	3	6	
20-29	17	33	19	41	44	6	0	6	3	5	2	
30-39	15	17	33	49	13	15	0	16	7	7	3	
40-49	11	13	7	41	0	15	7	27	7	10	5	
50-59	5	3	0	24	0	32	5	47	0	4	3	
60+												
Total	63	91	65	200	100							

Group 1.—Among 63 of the men, five cases of perforation of the nasal septum were found and two cases in which thinning of the septum was so marked on both direct inspection and transillumination that they were judged to be cases of impending perforation.

Five of these seven cases were in the 40-49 age group and had exposures ranging from 15 months to 20 years on this type of work. The youngest patient, one with impending perforation, was 26 years old and had had only nine months' exposure.

The perforations are circular or oval and the margin appears to be totally covered by mucous membrane which presumably dips in from either

FIG. 6.—(a) Normal septum. (b) Perforation of the septum. The perforation is approximately 0.7 cm. in diameter. (c) Perforation of the septum. The perforation is 1.3 cm. in its greatest diameter.

side as the lesion develops and ultimately becomes continuous. All the perforations are sited anteriorly in the cartilaginous portion of the septum. A normal septum and two perforated septa are shown in Fig. 6. The greatest diameter varies from a few millimetres to centimetres.

The appearance of an ulcerated septum is as follows. There is loss of mucous membrane, shallow, sloping edges leading down to the hollowed area which is often covered by a crust of caked ash or inspissated mucus. Careful removal of the crust reveals the raw ulcerated surface. Ulceration may be found on either the convex or concave side of a deviated septum.

Without exception, no workman examined was aware of or complained of any abnormality in the nose. Even large perforations appear to be entirely symptomless.

There were also five cases in which atrophy of the septal mucosa was obvious to the naked eye. The appearance of the atrophic mucosa is characteristic. The septum is gently cleaned with a moistened swab after which the mucosa appears pearly grey to dull off-white with no sharply defined margin, shading rather into the normal mucosa.

There were thus in this group 12 cases (19%) with abnormal findings which might fairly be attributed to the effects of soda ash.

Group 2.—In this group of 156 workers there were 14 perforations of the septum, five impending perforations, and 10 cases in which there was some degree of atrophy of the nasal mucosa. This makes a total of 29 cases (18.6%) with abnormal findings which could be attributed to the effects of soda ash. Perforations were seen more frequently in women, there being 11 (17%) as

opposed to three in male workers (3.3%). On the other hand, abnormal appearances of the nasal mucosa were commoner in men (nine cases, 10%) than in women (one case, 1.5%). Altogether 24.6% of the women and 14.2% of the men showed some abnormality.

Group 3.—In this group of 200 employees only two perforations were found but there were some 11 cases in which atrophy of the nasal mucosa or thinning of the septum could be demonstrated, that is 13 cases (6.5%) with abnormal findings. The perforations were found in a shift-worker with over 50 years' service and a labourer with barely two years' service. The abnormalities noted were similar to those found in the previous group. The ages of the two subjects with perforation of the septum were 64 and 42 respectively.

Group 4.—The previous occupations of the 100 consecutive applicants for employment were very various and many had changed their occupations so frequently in the last 10 years as to render invalid any conclusion which might have been tentatively drawn. The average age of the group was 31 years 6 months. No significant abnormalities were found in this group. It is realized that the age groups are not strictly comparable to those of Groups 1–3, but it is felt that this does not materially affect the validity of this control group.

One man in this group had had 15 months' previous service at one of the factories, otherwise none had been previously employed in alkali manufacture.

No reference has been made to other abnormalities which were found, such as deviation of the septum with or without spurs, hypertrophy of one or more

turbينات, and polypi. It became obvious that the appearance of the nose gave little indication of what one might expect to find on further examination. Lesions were found in narrow and broad noses, in symmetrical noses with straight septa and in noses with gross deviations, in noses where chronic hypertrophy was marked, and in others where there was no evidence of inflammation or infection. As it is not the intention of this paper to study the incidence of such abnormalities they have not been considered in the final conclusions.

Discussion

Although the numbers are not large these results show that there is a definite occupational factor in the production of perforations of the nasal septum.

No figures of the general incidence of perforation of the nasal septum in the general population are available but J. A. Kilpatrick (personal communication) states that in his experience it is considerably less than 1%.

Two broad lines of approach to the problem of causation become apparent. First, it might be suggested that the longer an employee works with soda ash the more likely is he to show signs of septal damage. Accordingly Groups 1 and 2 were analysed by length of exposure to soda ash (Table 2). The average exposure of each age group was

TABLE 2
SEPTAL DAMAGE RELATED TO LENGTH OF EXPOSURE
TO SODA ASH

Duration of Exposure (years)	Group 1	Group 2		Total	Percentage Affected
		M.	F.		
Under 1	$\frac{1}{6}$	$\frac{0}{2}$	$\frac{0}{4}$	$\frac{1}{12}$	8.3
1-3	$\frac{1}{15}$	$\frac{0}{20}$	$\frac{4}{21}$	$\frac{5}{56}$	9.0
4-7	$\frac{1}{10}$	$\frac{3}{22}$	$\frac{2}{8}$	$\frac{6}{40}$	15.0
8-9	$\frac{1}{6}$	$\frac{0}{5}$	$\frac{2}{10}$	$\frac{3}{21}$	14.3
10-19	$\frac{2}{14}$	$\frac{1}{21}$	$\frac{7}{22}$	$\frac{10}{57}$	17.5
20-29	$\frac{1}{7}$	$\frac{0}{8}$	$\frac{0}{0}$	$\frac{1}{15}$	6.7
30+	$\frac{0}{5}$	$\frac{0}{13}$	$\frac{0}{0}$	$\frac{0}{18}$	—
Total	$\frac{7}{63}$	$\frac{4}{91}$	$\frac{15}{65}$	$\frac{26}{219}$	11.9

also computed (Table 3). The number of lesions found in each group are also shown.

The numbers are too small to show any statistical

TABLE 3
SEPTAL DAMAGE RELATED TO AGE

Age Groups (years)	Group 1	Group 2		Average Exposure for All Groups	Percentage Affected
		M.	F.		
20-29	$\frac{1}{2y. 1m.}$	$\frac{0}{7y. 10m.}$	$\frac{1}{3y. 5m.}$	$\frac{2}{5y. 5m.}$	4.0
30-39	$\frac{1}{6y. 1m.}$	$\frac{2}{6y. 3m.}$	$\frac{4}{5y. 10m.}$	$\frac{7}{5y. 1m.}$	10.1
40-49	$\frac{5}{15y. 1m.}$	$\frac{1}{16y. 7m.}$	$\frac{8}{7y. 5m.}$	$\frac{14}{11y. 7m.}$	23.7
50-59	$\frac{0}{15y. 9m.}$	$\frac{1}{27y. 7m.}$	$\frac{2}{10y. 4m.}$	$\frac{3}{19y. 6m.}$	9.9
60+	$\frac{0}{32y. 7m.}$	$\frac{0}{47y. 0m.}$	—	$\frac{0}{38y. 0m.}$	—

significance. Nevertheless the incidence of perforations and near perforations rises with increasing length of exposure up to 20 years. For longer exposures the incidence falls for which no explanation can be offered.

If the workers in Groups 1 and 2 are split into under-40 and over-40 years of age it is found that the incidence of perforations and impending perforations in the former group is 7.4% and in the latter 17.3%. In spite of the longer exposures of the older men, these figures suggest a greater incidence in the older workers but give no indication of the age of onset of the lesion.

It is also noteworthy that the incidence of perforation and impending perforations in women in Group 2 is 16.9% as compared to 3.3% for men in the same group. The main difference between the two groups is that the dustiest job of all, namely beating returned bags, is done entirely by women and the next dustiest job, namely the vacuum-cleaning of returned bags, is done largely by women. Lugging, done solely by men, is not a dusty occupation. Possibly this difference in the type of work done is related to the higher incidence of lesions in women.

The second possible approach is that there is some factor in the structure or function of the nose which predisposes to perforation. This would not seem to be borne out by the above findings. It might be suggested that lesions would start on the convex side of a deviated septum. But examination of cases of perforation in which a deviation coexists gives no clue as to which side was first affected. Similarly mucosal atrophy and thinning have been observed on both convex and concave sides of deviated septa.

In the light of our own experience it is thought that the stream of inspired air containing fine particles of sodium carbonate does in fact impinge on the

septum. A solution of continuity presumably occurs followed by ulceration and perforation as already described. Cases can be demonstrated, however, in which the septal mucosa is grey and lustreless and it is thought that this appearance may precede ulceration.

Examination of our cases does not enable us to say whether the initial lesion arises on the concave or convex side of a deviated septum, as once the perforation is complete there is nothing to indicate which side was first affected. Ulceration has been found on both convex and concave sides.

The presence of deformities of the septum is no indication that ulceration will take place as many workers with deviated septa show no pathological changes.

The perforations do not appear to enlarge once the margins have become covered with mucous membrane. This is presumably because no further dust impinges on the septum and also because of alteration in the flow of inspired air which enables the dust to disperse more widely within the normal cavity.

Conclusion

When a symptomless condition such as this is discovered there must always be the temptation to "let sleeping dogs lie" and do no more about it. On the other hand, the septum has a physiological and anatomical role to play and alteration or modification of its structure must be potentially, if not actually, harmful.

With this in mind, it is obvious that the main approach must be to reduce the dust, and if possible, eliminate it. A nasal examination of all applicants for employment and subsequent periodical examinations in our own works would probably lead to an undesirable focusing of attention on the nose and a consequent possible production of neurosis. To exclude from employment those with nasal abnormalities would be equally impracticable even if we were quite sure what types of abnormal nasal structure or function predispose to perforation.

A parallel could be drawn with the far graver problems of pneumoconiosis where the solution lies not in the hands of the doctor so much as in those of the engineer.

Summary

Perforation of the nasal septum has received little mention in medical literature.

The scope of the present investigation is defined and two groups of workers, namely ash packers and bag plant workers, and two control groups, one chosen from the two works and one from applicants for employment, are analysed. These groups are exposed respectively to large, moderate, slight, and negligible quantities of soda ash dust.

The incidence of perforations and impending perforations in four groups with large, moderate, slight, and no exposure to soda ash dust was respectively 11.1, 12.1, 1, and 0%. In addition, abnormalities of the septal mucosa which might be attributed to the effects of soda ash were seen in 8.0, 6.4, 5.5, and 0% respectively.

A caliper to measure the diameter of the perforations is described.

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REFERENCES

- Aupetit, J., and Prévost, R. (1951). *Arch. Mal. prof.*, 12, 335.
- Ballenger, W. L., Ballenger, H. C., and Ballenger, J. J. (1947). *Diseases of the Nose, Throat and Ear*, 9th ed. Lea and Febiger, Philadelphia.
- Bernabei, L. (1950). *Atti Accad. Fisiocr. Siena*, Ser. 12, 18, 338.
- Collier, H. E. (1940). *Outlines of Industrial Medical Practice*. Arnold, London.
- Davies, C. N. (1952). *British Journal of Industrial Medicine*, 9, 120.
- Kilpatrick, J. A. (1952). Personal communication to Royal Infirmary, Chester.
- Legge, T. (1934). *Industrial Maladies*. Oxford University Press, London.
- Marchand, M. (1943). *Arch. Mal. prof.*, 5, 167.
- (1949). *Hygiène et Sécurité du travail*. Maloine, Paris.
- Müller, G. Quoted by T. Ritchie Rodger (1934).
- Naidu, V. R., and Rao, R. Narayana (1948). *Indian med. Gaz.*, 83, 431.
- Proetz, A. W. (1941). *Essays on the Applied Physiology of the Nose*. Annals Publishing Co., St. Louis.
- Rodger, T. Ritchie (1934). "Occupational Diseases: Ear, Nose and Throat", In *Occupation and Health*. vol. 2. International Labour Office, Geneva.
- Thomson, St C., and Negus, V. E. (1948). *Diseases of the Nose and Throat*, 5th ed. Cassell, London.
- Wampler, F. J. (1943). *The Principles and Practice of Industrial Medicine*. Williams and Wilkins, Baltimore.
- White, R. Prosser (1934). *The Dermatogoses*, 4th ed. Lewis, London.