Choanal atresia

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Introduction

The term choanal atresia is applied to a narrowing of the nasal apertures, a condition which can affect either the anterior or the posterior nasal apertures. Anterior choanal atresia (Figs. 8 and 9) is extremely rare and the term choanal atresia is usually loosely taken to mean posterior choanal atresia.

Most authors commenting on the publications devoted to this abnormality give the credit for the first paper to Otto, who, in 1829 described a case examined post-mortem. Otto, however, quotes Roederer (1755). The first operation for choanal atresia, on a boy of 7, was performed by Emmert in 1851 and the first paper describing the condition as a clinical entity was published by the same author in 1853. A description of an unusual case of a 21-year-old woman with bilateral choanal atresia which was detected only by chance at an ophthalmological examination is given by Hart (1926).

Durward, Lord and Polson (1945) have given the most comprehensive review of the condition and their bibliography includes over 300 references. In view of this, the references given with the present paper are those of papers published between 1945 and the present time, except in so far as some pre-1945 references are included if they are mentioned in the present paper or are of some special interest, or have been omitted by Durward *et al.* (1945).

Only the vaguest approximations to the correct incidence of the condition are available. For example, Campbell, Stokes and Jennings (1961) discovered five cases in a 407-bedded unit in a period of ten years. Stewart (1931) notes that of 27,863 cases registered at the Royal Infirmary, Edinburgh, under the care of Logan Turner and Fromer, only six cases of choanal atresia were discovered, all unilateral.

The present series of 65 cases was obtained from the records of patients attending The Hospital For Sick Children, Great Ormond Street, between 1945 and 1965. That is on average 3 to 4 per year attending a specialized hospital with about 20,000 patients registered each year.

The main potential danger in bilateral choanal atresia is death from asphyxia but it is important to be aware that the same possibility can occur in unilateral atresia if the patent side of the nose is obstructed. This risk of asphyxia and the very severe feeding difficulties usually compel early treatment but even in unilateral cases, if they are not

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corrected early, there is an impressive list of disadvantages, such as the persistent nasal discharge, the risk of rhinitis and sinusitis, the impaired sense of smell, the risk of persistent mouth breathing, speech difficulties in the older child and emotional problems in adult life, among which, at the risk of seeming frivolous, we might mention the difficulty encountered in kissing.

Aetiology of choanal atresia
(Embryology and anatomy)

There are three commonly accepted theories as to the cause of choanal atresia. Firstly, persisting bucconasal membrane, secondly, persisting buccopharyngeal membrane and thirdly, adhesions. The first two postulate a frustration of normal embryological development while the third theory suggests that adhesions form between developing parts of the nasal cavity and so produce the atresia. In order to understand the possible causes of choanal atresia more clearly it is helpful to consider the embryology of the development of the nasal cavity.

Olfactory placodes develop at the upper margins of the stomatodeal orifice. The olfactory placodes then become converted into olfactory pits (nasal sac) by proliferation and differentiation of the surrounding mesoderm of the lateral and medial nasal processes. At this stage the anterior nares are completely defined but widely separated by the globular process.

The olfactory pit (nasal sac) deepens, invaginating the mesoderm of the stomatodaeum thus forming the 'primitive' nasal cavity. The nasal cavity extends posteriorly, being separated from the stomatodaeum by the bucconasal membrane (Fig. 1). The bucconasal membrane breaks down at the 7th week, allowing the nasal cavity to communicate with the stomatodaeum by the primitive posterior nares.

The primitive palate fuses with a median partition which separates the nasal cavities and constitutes the primitive nasal septum. The primitive nasal cavities communicate freely with the mouth at this stage. The tongue lies above and behind the nasal cavity.

At the sixth week, the inner surfaces of the maxillary processes give rise to the palatine processes, the ventral ends of which grow medially to fuse with the primitive nasal septum. This process of fusion extends dorsally in the interval between the septum and the tongue thus forming the hard and soft palate (Fig. 2). There is later an upgrowth of 3rd arch mesoderm into the soft palate and around the caudal margin of the Eustachian tube. The line of this migration in the adult is indicated by the palato-pharyngeal arch.

The site of attachment of the margins of the atresic segment gives support to the theory that failure of breakdown of the bucconasal membrane is the cause of choanal atresia rather than failure of breakdown

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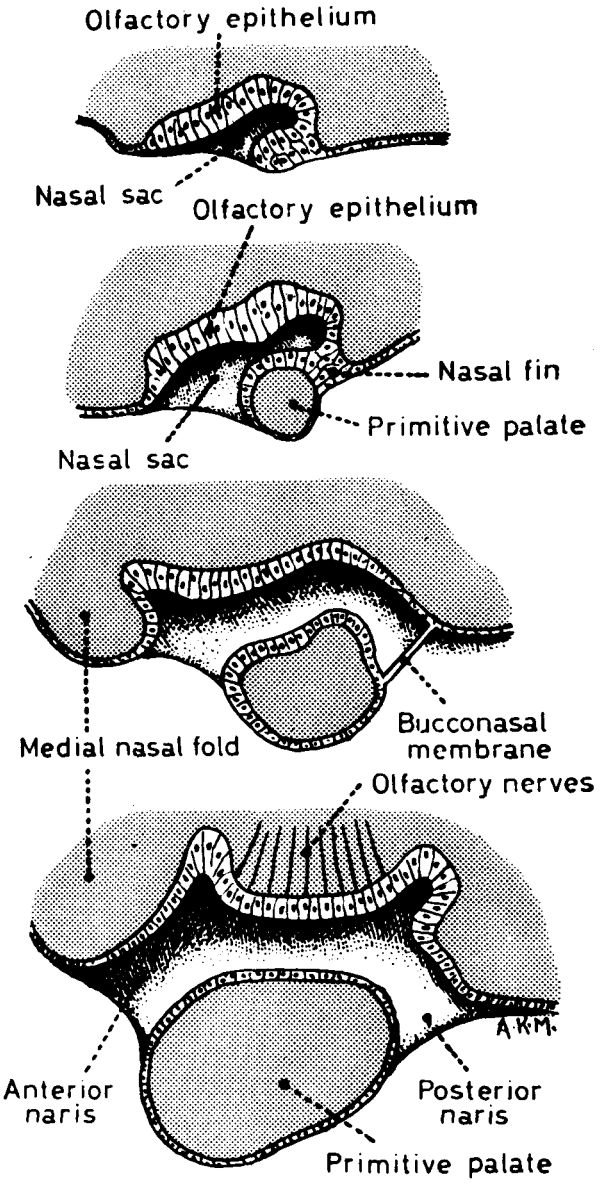


FIG. 1.

Development of nasal sac, nasal cavity and primitive palate

Reproduced from 2nd edition of *Diseases of the Ear, Nose and Throat*, edited by **W. G.** Scott-Brown, John Ballantyne and John Groves, Vol. I., page 6, Fig. 6.

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of the bucco-pharyngeal membrane, since superiorly the atresic segment is attached to the antero-inferior aspect of the basi-sphenoid in front of the foramen of Luschka. If the atresia was due to the persistence of the buccopharyngeal membrane the atresic segment would be attached superiorly to the basi-sphenoid behind the foramen of Luschka, since the foramen of Luschka represents the site of the

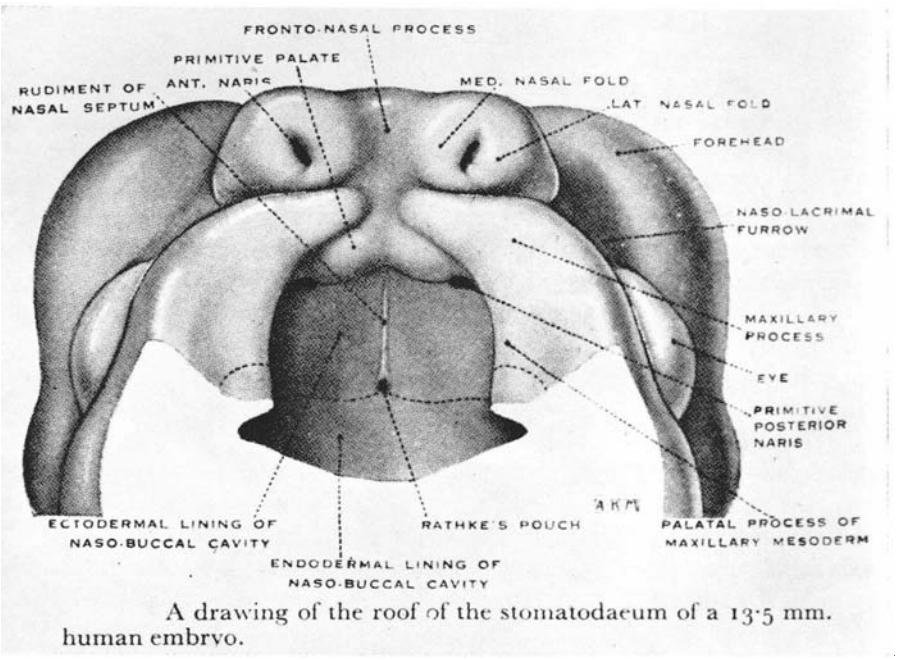


FIG. 2.

A drawing of the roof of the stomatodaeum of a 13·5 mm. human embryo. Reproduced from second edition of *Human Embryology*. By W. J. Hamilton, J. D. Boyd and H. W. Mossman. Page 180, Fig. 168.
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embryonic Rathke's pouch (from which the anterior lobe of the pituitary is derived) which develops in the ectodermal lining of the stomatodaeum in front of the buccopharyngeal membrane (Fig. 3).

Medially the atresic segment is attached not to the posterior edge of the nasal septum but usually a millimeter or two in front of it. Inferiorly, it is again attached just in front of the edge of the hard palate. Laterally, it is attached to the perpendicular plate of the palatine bone. The palatine bone develops in the mesoderm of the maxillary process and forms the lateral boundary of the bucconasal septum. These areas of attachment are further convincing evidence that the persistence of the bucconasal membrane is responsible for choanal atresia. The buccopharyngeal mem-

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brane breaks down at an earlier stage in the development of the embryo, at about the 4th week.

The presence of a bony atresia (90 per cent of cases have bony atresia) is more readily explicable by the failure of breakdown of the bucconasal membrane since the 'nasal fin', which is its precursor, has a core of meso-

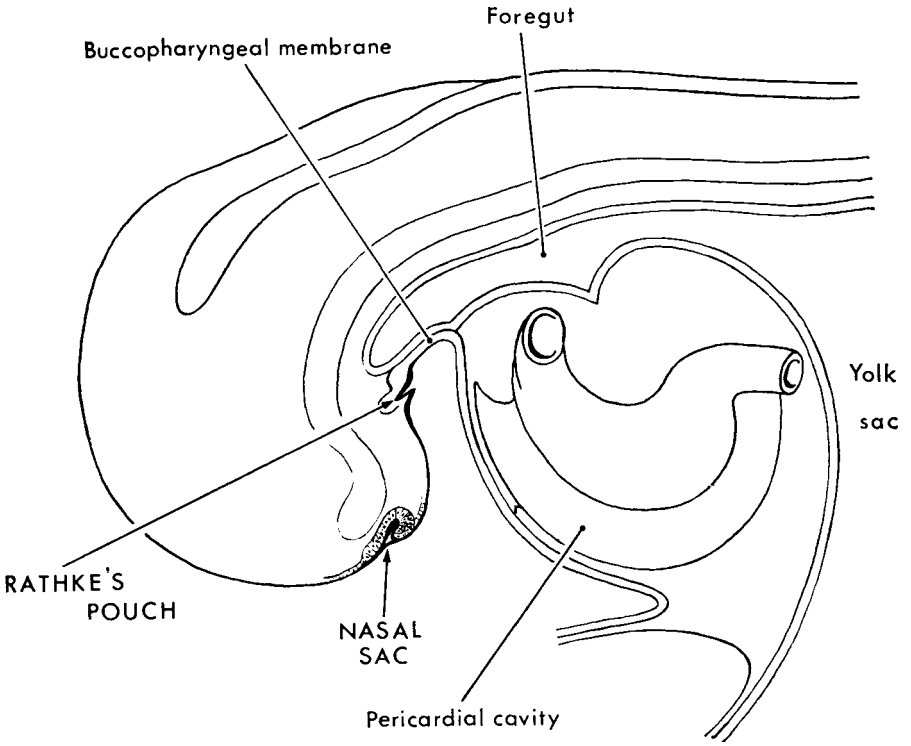


FIG. 3.
Diagrammatic longitudinal section of a 14 somite embryo.

derm. The buccopharyngeal membrane consists of two layers only, ectoderm and endoderm. The presence of a bony partition, were this structure to be the precursor of the atresic segment in choanal atresia, is therefore unlikely. The remarkable symmetry of the choanal pits, so characteristic of bilateral choanal atresia is a factor against the atresia being due to adhesions within the primitive nasal cavity. Failure of canalization or failure of embryonic membranes to rupture are by far the commonest cause of congenital abnormalities, whereas embryonic 'adhesions' are an extreme rarity. If the choanal atresia were due to adhesions, then it would be more likely to occur in the middle of the nasal cavity and to be a fibrous membrane, not bony.

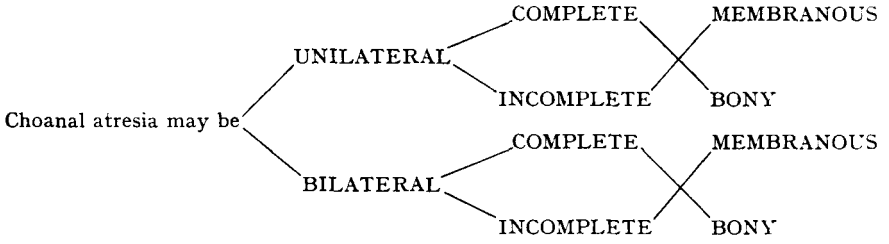
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It is interesting to note the association between choanal atresia and cleft palate (4 cases, 1 with bifid uvula) and Treacher Collins syndrome (3 cases) and one patient with a complete facial cleft and no nasal septum and three patients with high-arched palate. This is a failure of development of the facial skeleton in which the maxillary and frontonasal processes are involved.

A further point of embryological interest is the presence of choanal atresia and imperforate anus in one patient. Both the bucconasal and cloacal membranes break down at the 7th week. It is tempting therefore to postulate that some event which occurred at the 7th week caused a failure of both these membranes to break down.

TYPES OF CHOANAL ATRESIA

Choanal atresia may be unilateral or bilateral, complete or incomplete, bony or membranous.



For practical purposes it is only the bilateral complete choanal atresia which presents a difficult problem in management. The innate desire for nasal respiration is so strong that if nasal obstruction is present at birth the infant will die unless oral respiration can be temporarily established or the nasal obstruction corrected.

The present series

The series reported in this paper comprises 65 cases; 35 cases (54 per cent) were unilateral and 30 cases (46 per cent) were bilateral (Table I). Roopenian and Stemmer (1958) put the incidence of bilateral atresia, as judged from 300 cases collected from the literature at 36 per cent, while in the 40 cases published by Flake and Ferguson (1964), 55 per cent were unilateral and 45 per cent bilateral.

Within the unilateral group, 25 cases (71 per cent) are found to occur on the right and 10 cases (29 per cent) on the left. This difference is significant at the 5 per cent level (Table II).

The sex incidence of the condition is often reported to be in favour of females. Durward *et al.* (1945) found the sex distribution in their list of 292 cases to be 65 per cent females, 30 per cent males and in 5 per cent

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FIG. 4.
Lateral view of skull.

the sex of the patients had not been recorded. In the present series, there were 35 (54 per cent) females and 30 (46 per cent) males (Table III). This difference is not significant. Flake *et al.* (1964) consider the distribution between the sexes to be equivocal, their series comprising 27 females and 13 males, a difference which is significant at the 5 per cent level.

TABLE I.
INCIDENCE OF UNILATERAL AND BILATERAL CHOANAL ATRESIA.

Unilateral	Bilateral	Total
35 (54%)	30 (46%)	65

TABLE II.
INVOLVEMENT OF RIGHT OR LEFT CHOANA IN UNILATERAL CASES.

Right choana	Left choana	Total
25 (71%)	10 (29%)	35

TABLE III.
SEX INCIDENCE.

Female patients	Male patients	Total
35 (54%)	30 (46%)	65

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Tables IV and V show a further breakdown of sex incidence in unilateral and bilateral cases and the sex incidence within the unilateral group. Among the males, the difference between the occurrence of right and left atresia is significant at the 5 per cent level. This may, however, simply reflect the higher proportion of right-sided atresias in the group as a whole. Within the unilateral group, the sex difference becomes significant at the 5 per cent level. The other differences between the various sub-groups in Tables IV and V are not statistically significant.

TABLE IV.

SEX INCIDENCE IN UNILATERAL AND BILATERAL CASES.

Females with unilateral atresia	Females with bilateral atresia	Males with unilateral atresia	Males with bilateral atresia	Total
24 (37%)	11 (17%)	11 (17%)	19 (29%)	65

TABLE V.

SEX INCIDENCE WITHIN THE UNILATERAL GROUP.

Females with right atresia	Females with left atresia	Males with right atresia	Males with left atresia	Total
16 (46%)	8 (23%)	9 (26%)	2 (6%)	35

Associated congenital abnormalities

Of the 65 patients, 28 (43 per cent) had another congenital abnormality (Table VI). Statistically, this is a highly significant association. In Table VII are shown the abnormalities which were present in the individual cases. Of the patients with an associated abnormality, 25 per cent had a single minor abnormality, e.g. a prominent Eustachian cartilage or a supernumerary digit, 25 per cent had a single major abnormality, e.g. Treacher Collins syndrome and 50 per cent had multiple abnormalities with at least one major abnormality, e.g. a high-arched palate plus a vascular ring (Table VIII).

TABLE VI.

INCIDENCE OF ASSOCIATED CONGENITAL ABNORMALITY.

Patients with choanal atresia and other abnormality	28	(43%)
Patients with choanal atresia only	37	(57%)
Total	65	

Of the patients with an associated congenital abnormality, 18 were male and 10 female. The difference here is not statistically significant (Table IX).

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TABLE VII.

ASSOCIATED ABNORMALITIES.

Case	Abnormality	*Case*	Abnormality
1.	Large Eustachian cartilage	14.	Tracheo-oesophageal fistula
2.	Hare-lip and cleft palate	15.	Cleft palate
3.	Pulmonary stenosis		Microcephaly
	V.S.D.		Micrognathism
	Talipes	16.	V.S.D.
	Low-set ears		Pulmonary stenosis
	Conductive deafness		Patent ductus arteriousus
4.	Patent ductus arteriosus		Dysphagia
	Right aortic arch	17.	Treacher Collins syndrome
5.	Treacher Collins syndrome	18.	Cerebral agenesis
	V.S.D.		Small head and early closure of sutures
6.	Micrognathism		Hypertelorism
	Microglossia		Poor development of nose and maxilla
7.	Genu valgum		Protuberant tongue
	Varus of big toe		Very small naso-pharynx
8.	Cleft palate	19.	A.S.D.
9.	Ileal atresia		Facial nerve paralysis
	Coloboma		Mental deficiency
	Facial cleft		Bat ears
	Absent nasal septum		High-arched palate
	Cleft palate		Deafness
	Left superior oblique sheath syndrome		Cranio-cleido-dysostosis
10.	High-arched palate	20.	Treacher Collins syndrome
11.	Aortic vascular ring	21.	Hiatus hernia
	High-arched palate		Microcephaly
	Patent foramen ovale	22.	Abnormality of tongue and mandible
	Patent ductus arteriosus	23.	Supernumerary digit
	Upper left superior vena cava	24.	Micrognathism
12.	Multiple cardiac abnormalities		Glossoptosis
	Micrognathism	25.	Microcephaly
	Low ears rotated backwards		Oxycephaly
13.	Absent spleen	26.	Imperforate anus
	Diaphragmatic hernia with left eventration		Hydronephrosis
		27	Cervical meningocele
	Malformed nasopharynx		Bat ears
	Abnormal soft palate	28.	Bifid uvula

TABLE VIII.

SEVERITY OF THE ASSOCIATED ABNORMALITY.

Cases with single minor associated abnormality	7	(25%)
Cases with single major associated abnormality	7	(25%)
Cases with multiple abnormalities (at least one major abnormality)	14	(50%)
Total	28	

TABLE IX.

SEX INCIDENCE OF ASSOCIATED ABNORMALITIES.

Male patients ..	18	(64%)
Female patients ..	10	(36%)
Total	28	

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Seventeen patients with bilateral atresia also had some other abnormality, while 11 patients with unilateral atresia showed another abnormality (Table X). This is a significant difference at the 5 per cent level, suggesting that patients with bilateral atresia are more likely to have some other congenital abnormality or abnormalities than those where the atresia occurs only on one side.

The several groups of patients with a further abnormality, grouped according to sex and whether the atresia is unilateral or bilateral, are arranged in rank order in Table XI.

From Table XII can be seen the incidence of associated abnormalities which are especially relevant to otolaryngology.

TABLE X.

INCIDENCE OF ASSOCIATED ABNORMALITY IN UNILATERAL AND BILATERAL ATRESIA.

Bilateral atresia	Right atresia	Left atresia	Right or Left atresia	Total
17 (61%)	8 (28%)	3 (11%)	11 (39%)	28

TABLE XI.

OCCURRENCE OF ASSOCIATED ABNORMALITIES IN THE TWO SEXES AND DIFFERENT TYPES OF ATRESIA (TABULATED IN ORDER OF FREQUENCY).

Males with bilateral atresia ..	13	(46%)
Females with right atresia ..	5	(18%)
Females with bilateral atresia..	4	(14%)
Males with right atresia ..	3	(11%)
Males with left atresia	2	(7%)
Females with left atresia ..	1	(4%)

TABLE XII.

ASSOCIATED ABNORMALITIES PARTICULARLY RELEVANT TO OTOLARYNGOLOGY.

Branchial arch abnormalities ..	6	(21%)
Treacher Collins' syndrome ..	3	(11%)
Nasopharyngeal abnormality ..	4	(14%)
Deafness (excluding cases of cleft palate) .. .. .. Conductive 1 Mixed 1	2	(7%)
Total	15	(53%)

From the practical point of view, it is thus important to be aware of the possibility of other abnormalities. The list of abnormalities and the distribution discussed above will give a good idea of what might be expected in the individual patient. When considering the chances of whether an associated abnormality is likely to be single and minor, or major and multiple, it is important to realize that there is no correlation between the severity of the associated abnormality and whether the atresia is unilateral or bilateral.

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Choanal atresia

Clinical features and diagnosis

Table XIII shows the frequency of the various ways in which the cases of this series presented. The striking differences between the unilateral and bilateral groups are clearly seen (Table XIV). Fifty-one cases presented within the first year of life (Table XV). The early appearance of the bilateral cases is clearly seen in the histogram. The remaining 14 cases occurred in the second to the twelfth years. Of those, only two cases were complete bilateral atresia, both presenting only with the complaint of nasal discharge, one in the third year of life and one in the sixth year. Of the cases presenting in the first month, 10 appeared within the first 24 hours of life, 10 in the first week and one at two weeks, all having complete bilateral atresia. The remaining three cases presented towards the end of the first month, two being unilateral and one with one choana only partially closed.

TABLE XIII.

TYPE OF PRESENTATION.

Nasal obstruction and/or discharge	35 (one purulent)
Breathing difficulty	18
Feeding difficulty	6
Incidental finding	6
Total	65

TABLE XIV.

PRESENTING SYMPTOMS IN UNILATERAL AND BILATERAL CASES.

Symptom	Unilateral	Bilateral	Total
Nasal obstruction and/or discharge	30	6	36
Breathing difficulty	0	18	18
Feeding difficulty	1	4	5
Incidental finding	4	2	6

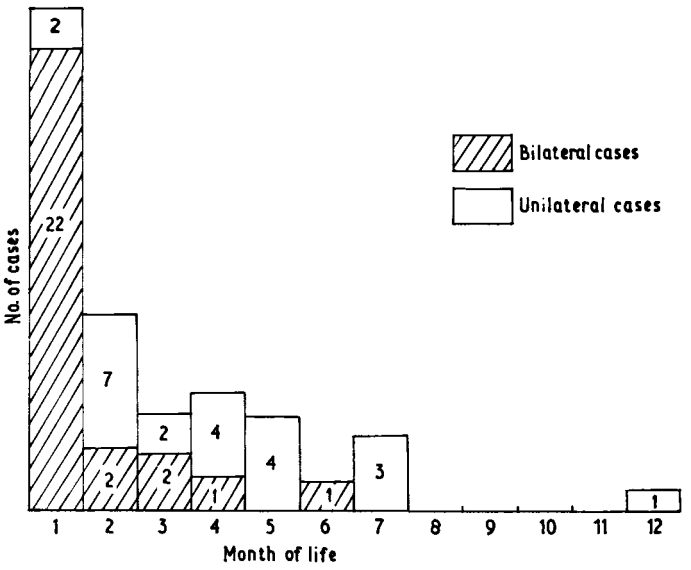
The neonate with choanal atresia usually presents with a fairly typical history. Immediately post partum, the baby cries and during this period there is no evidence of any respiratory distress. It is only when the baby settles down after birth that evidence of respiratory distress is noted. A classic cycle of events is then seen. There is obvious respiratory obstruction, superasternal and intercostal recession become marked during the inspiratory effort, the accessory muscles of respiration become active and cyanosis develops. The baby then cries, the respiratory obstruction being dramatically relieved, the cyanosis disappearing and when the fit of crying ceases the whole cycle of respiratory obstruction is repeated. This chain of events is quite diagnostic of obstructed nasal respiration. Feeding difficulties are noted since the baby is unable to stay on the

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breast or to keep a teat in its mouth and breathe at the same time so it has to make one or two swallows and then 'come up for air'.

Unilateral cases of choanal atresia present some months later, the presenting symptom being that of a mucoid nasal discharge rather than nasal obstruction. Examination of the nose shows one side to be full of mucus. If this is carefully aspirated, the nasal mucosa is seen to be pale and oedematous. There is often asymmetry of the palate, the bony palate being higher on the side of the atresia. There is a high incidence of palatal clefts in these patients. Deafness on the affected side due to secretory otitis is sometimes present.

TABLE XV



Time of Presentation.

This typical clinical picture is almost pathognomonic but a few simple confirmatory tests are desirable. The simplest test consists of attempting to pass a catheter through the nose. Failure of the catheter to pass into the nasopharynx and an assessment of where it is being stopped can provide good confirmatory evidence of choanal atresia. A metal probe should also be gently passed through the nasal cavity and in this connection, the measurements suggested by Beinfield (1959) are helpful. He suggested that, if the probe passes 44 mm. or further from the edge of the infant's nostril, there is no atresia, but failure to pass beyond 32 mm. from the edge of the nostril is evidence of atresia. If choanal atresia is wrongly suspected of being the cause of some breathing or feeding difficulty in an infant, a convincing demonstration of a patent nasal airway

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can be given by holding a short length of cotton thread about 5 mm. from each nostril in turn. The rapid flicking backwards and forwards caused by the free flow of air through the patent nasal cavity is unmistakable. Similarly the steaming of a mirror held close to the nostril will demonstrate a patent airway. Radiological confirmation of an atresia is obtained by filling the nasal cavity with a radio-opaque substance, e.g. 'gastrografin' and taking lateral radiograms as shown in Figs. 4 and 5. Other suggestions for confirming the diagnosis include filling the nasal cavity with water or methylene blue and observing if it appears in the nasopharynx. A potentially dangerous test is described in which the pressure in the nasal cavity is raised by means of a Politzer bag and any escape of air into the nasopharynx assessed. Hough (1955) makes the observation that there is expiratory obstruction in bilateral choanal atresia caused by ballooning of the nasopharynx with downward movement of the soft palate. This can be seen on a lateral X-ray of the skull. Finally, examination of the nose and nasopharynx can be made under a general anaesthetic as a final check preparatory to operation.

It is unnecessary to enumerate all the causes of unilateral or bilateral nasal obstruction when considering the differential diagnosis since most of them will not cause any real practical difficulty. Less common causes of nasal obstruction to be borne in mind include encephalomeningocele and dermoids of the nasopharynx. Cases of severe vasomotor or allergic rhinitis are surprisingly frequently met with and it is not rare to encounter infants who have been started on regular doses of nasal decongenstant drops before they even leave the maternity unit and who have developed well established rhinitis medicamentosa (King, 1954). These conditions can closely simulate bilateral choanal atresia in the small infant. It is interesting to note the two patients who had had repeated adenoidectomy before the diagnosis of choanal atresia was finally made (Cherry and Bordley, 1966). Ersner (1953) recommends routinely passing a sound through each nasal cavity in children having tonsillectomy and adenoidectomy and in this way he discovered five cases of unilateral choanal atresia.

Infants with micrognathism and glossoptosis and some infants with cardiovascular abnormalities or brain damage may show the cyclical type of respiratory difficulty and cyanosis which is so typical of bilateral choanal atresia. No difficulty in attributing the clinical picture to micrognathism will be met with if the condition is kept in mind and looked for. The brain-damaged infant will have several neurological abnormalities which direct the clinician to the correct diagnosis. It is well known that severe abnormalities of the cardiovascular system can exist in the newborn infant with little evidence on clinical examination. To avoid missing these cases, it is recommended that a paediatric cardiovascular opinion with access to all modern sophisticated cardiovascular investiga-

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tions is sought in cases where there is any doubt about the explanation for cyclical respiratory difficulty.

Treatment

Once the diagnosis of a complete bilateral choanal atresia is established, then arrangements for its immediate surgical correction should be made. There is no place in our opinion for delaying surgical treatment since delay definitely increases the mortality, and certainly no indication for medical management as suggested by Erickson (1963) unless, due to prematurity or congenital abnormality, the prognosis is deemed to be too poor. Pneumonia due to inadequate pulmonary ventilation and inhalation of food are a common sequel of medical management and since other congenital abnormalities are commonly present the additional stress of pneumonia is usually sufficient to prejudice their chances of survival.

The treatment of bilateral complete choanal atresia may be considered in two phases, the first being immediate First Aid treatment, the second being definitive surgical correction. First Aid treatment consists of establishing oral respiration. This is best achieved by inserting a Guedel airway size oo into the mouth and taping the flange to the mandible with adhesive strapping. It may be necessary to trim a centimeter or so off the airway if it provokes prolonged retching but with persistence the child will usually tolerate the airway provided it does not extend beyond the base of the tongue.

If the child is dehydrated or debilitated then feeding by an orogastric tube may be necessary. We have rarely found this to be necessary since early operation and establishment of a nasal airway will allow the child to feed normally (Table XVI).

Blood should be available but transfusion is rarely necessary except in the presence of a very thick, long bony atresia where bleeding may be severe. A general anaesthetic should be administered using an endotracheal tube. A Boyle-Davis tonsillectomy gag is then inserted, the child being placed in the usual position for tonsillectomy, the operator sitting at the child's head. A careful examination of the nose and post-nasal space is then carried out using a mirror and digital examination. In one of our patients a very large Eustachian cushion was found.

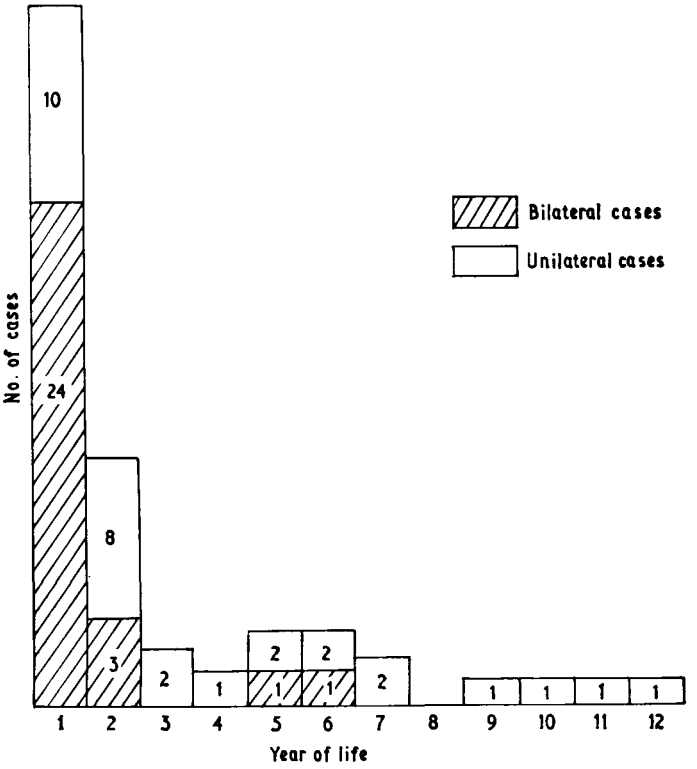
The next step is to perforate the choanal partition. If it is membranous, this can easily be done using a small, curved, child's urethral sound, the instrument being pushed through the membrane on to a finger guarding the post-nasal space. If the partition is bony and thick then it may not be possible to perforate it using a urethral sound. In this case the bony partition can be perforated using a hammer and finest mastoid gouge. This is undoubtedly the most difficult and probably hazardous part of the operation, but provided one passes the instruments along the floor of the nose and marks the depth of the partition from the anterior nares

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by marking the gouge and, since the thickness of the partition has been assessed radiologically before operating, the point at which the puncture into the nasopharynx should occur is known with accuracy. The operator's finger is placed in the post-nasal space and as soon as the instrument has perforated the partition, it is felt by the examining finger and damage to the basi-sphenoid and basiocciput prevented.

Other methods which involve use of operating microscope and the electric drill have also been advocated, in this case, the posterior aspect

TABLE XVI



Early establishment of airway.

of the atresic partition, being directly inspected by a nasopharyngeal mirror. The opening is then enlarged with a small pair of Citelli punch forceps or by hammer and gouge if the bone is too thick to be removed with punch forceps. Particular care should be taken to remove the posterior edge of the nasal septum. When the choanae have been enlarged it should be possible to insert a urethral sound size 16 FG. into the nose so that it passes easily into the nasopharynx.

Stenoses occurring at the site of the excised atresic segment can still occur in spite of adequate removal and in order to prevent this we have

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found the insertion of 12 FG. polythene tubes invaluable. The tubes are cut so that they just project through the choanae but do not interfere with the closure of the oro-pharyngeal isthmus. They are sutured together anteriorly over a firm polythene tube, which is used as a distance-piece to separate the two intranasal tubes. The polythene tubes have one or two holes cut in them so that the nasal mucus which would otherwise accumulate in the nasal cavity above the tubes can be aspirated (Fig. 6). These tubes are retained in the nose for six weeks (Fig. 7). After-care of the tubes is vitally important if crusting and obstruction is to be prevented. In the immediate post-operative phase 2 ml. of saline are instilled into each tube and then aspirated. A spare set of tubes must be kept by the bedside so that, should one set of tubes become blocked they can immediately be changed. If any difficulty is encountered in reinserting the tubes through the choanae, a small urethral sound can be inserted into the lumen of the tube so that it can be used as an introducer to slip the bevelled end of the polythene tube through the choanae.

Retention of the tube is sometimes a problem in which case a continuous thread can be passed through both tubes and tied anteriorly. The continuous thread is best inserted by passing two 'intracaths.' through the polythene tubes from the front and delivering them from the naso-pharynx into the mouth. A single thread is then tied to the ends of the catheters and the catheters withdrawn, leaving a thread passing from the posterior ends of the tubes around the back of the nasal septum.

Forty-four cases underwent the type of transnasal excision with post-operative intubation and subsequent dilatation as described above. One patient in this group required, at a later date, a transpalatal excision for persistent atresia. Sixteen cases were managed with dilatation only (Table XVII).

TABLE XVII.

OPERATIVE TREATMENT.

Dilatation	16
Transnasal excision ..	44
Transpalatal excision	1 (previously had Transnasal excision)
Nil	5
Total	66

Five cases underwent no treatment. In two of the cases, surgical intervention has yet to be undertaken (both patients have unilateral atresia). A further two cases were deemed unfit for operation on account of severe cardiovascular and neurological abnormality respectively, the one with bilateral atresia dying at three days and the one with unilateral atresia dying at eighteen months, the cause of death being unrelated to the atresia. The fifth case had a Eustachian cartilage which completely precluded

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operation involving instrumentation in the nasopharynx. The nasal approach using the operating-microscope or a transpalatal approach may be employed at a later date.

Operation morbidity

Great care must be taken to avoid damage to the basisphenoid during the initial penetration of the atresic partition. A case has been recorded where the basisphenoid was perforated, and the mid-brain was damaged during the operation.

Dislocation of the vomer and perpendicular plate of the ethmoid have been noted. This is more likely to occur when the operation is performed for unilateral cases. Intranasal adhesions may be produced by repeated instrumentation. We have found that division of the adhesions and insertion of a sheet of 'silastic' is a very effective method of eliminating the adhesions. The Eustachian cushions are at risk but damage to them can usually be avoided with care.

We have noticed that infants who fail to thrive post-operatively in spite of an apparently normal nasal airway have usually a further congenital abnormality which is responsible. It is worth remembering that 60 per cent of cases with complete bilateral atresia have another congenital abnormality.

Several patients in the series have had a post-operative regime of nasal dilatations using urethral sounds. It is hoped that the regime of prolonged intubation post-operatively will avoid the necessity for repeated dilatations which are traumatic both to patient and surgeon alike!

When unilateral choanal atresia is diagnosed, we feel that an attempt at intra-nasal treatment should be instituted before the child goes to school. In the present series one-third were operated on in the first year of life.

Transpalatal excision should be delayed in our opinion and in this series only one case required transpalatal excision.

In discussing the technique for correction of the choanal atresia it must be stressed that the post-operative care and management of these patients requires devoted skilled nursing and meticulous supervision. The risks of obstruction of the nasal tubes are considerable and if they are to be avoided the post-operative regime of instillation of saline and careful aspiration of secretions must be adhered to to prevent obstruction. If one is in any doubt as to the patency of the tubes then they should be changed and in these circumstances one usually finds that the lumen of the tube has been considerably diminished by dried nasal secretions.

It has not been found possible to follow up all the cases in our series but some illustrative examples with detailed case histories will be described.

Patients with complete bilateral bony atresia are the most difficult to manage surgically, as illustrated by Case 1.

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P.C., an example of a complete bilateral bony choanal atresia

He was shocked and pale at birth showing signs of asphyxia. His respirations were described as grunting and it was further noted that his colour improved on crying. His blood *p*H was 7·235 and his p^{Co_2} 50 mm. Hg. The diagnosis of choanal atresia was confirmed when a nasal catheter failed to pass into the nasopharynx. He was transferred to The Hospital for Sick Children, Great Ormond Street. 'Gastrografin' studies of the nose (Fig. 5) demonstrated that the atresic segment was about 2 mm. in thickness.

Some 18 hours post partum the child was operated on and the presence of a complete bony bilateral choanal atresia was confirmed. It was difficult to effect the initial penetration of the bony partition but this was achieved by pushing a very small pair of Citelli's bone-nibbling forceps through the centre. The margins of the hole were then enlarged with the Citelli bone-nibbling forceps and the posterior edge of the nasal septum was removed with a hammer and gouge. A pair of nasal tubes was manufactured using 14 FG. 'Portex' tubes as illustrated.

Fourteen days later an E.U.A. of the nose was performed since difficulty had been found in changing the nasal tubes. More bone was nibbled away with the punch forceps and the nasal tubes again inserted.

On the 28th post-operative day, difficulty was again found in changing the nasal tubes. On the 31st post-operative day, i.e. some $4\frac{1}{2}$ weeks post-operatively, the nasal tubes were removed, but his nasal airway was felt to be inadequate and 3 days after this the choanae were dilated under general anaesthesia to 16 FG. using paediatric urethral sounds. Nasal tubes were again inserted.

On the 58th post-operative day, just over 8 weeks after the original operation a further dilatation was necessary (3 days after the tubes were removed). This time the nasal tubes were tied in place with a continuous thread running through the tubes and joining them posteriorly and anteriorly because difficulty was still being found in retaining the tubes.

On the 68th post-operative day, the nasal tubes were removed and his nasal airway was found satisfactory. He was discharged from hospital about 10 weeks after admission. He has been followed up for $2\frac{1}{2}$ years. Apart from some noisy nocturnal breathing in the first few post-operative months his convalescence has been uneventful.

Apart from the surgical difficulty in removing sufficient bone from the margins of the choanae to establish an adequate airway this case illustrates the problem of how long to leave the nasal tubes *in situ*. There is a temptation to remove the tubes early and to see how the patient will manage. This temptation must be resisted and it is now our policy to keep the nasal tubes *in situ* for at least six weeks in the patients with complete bilateral bony atresia.

It is reasonable to pursue a rather optimistic expectant attitude

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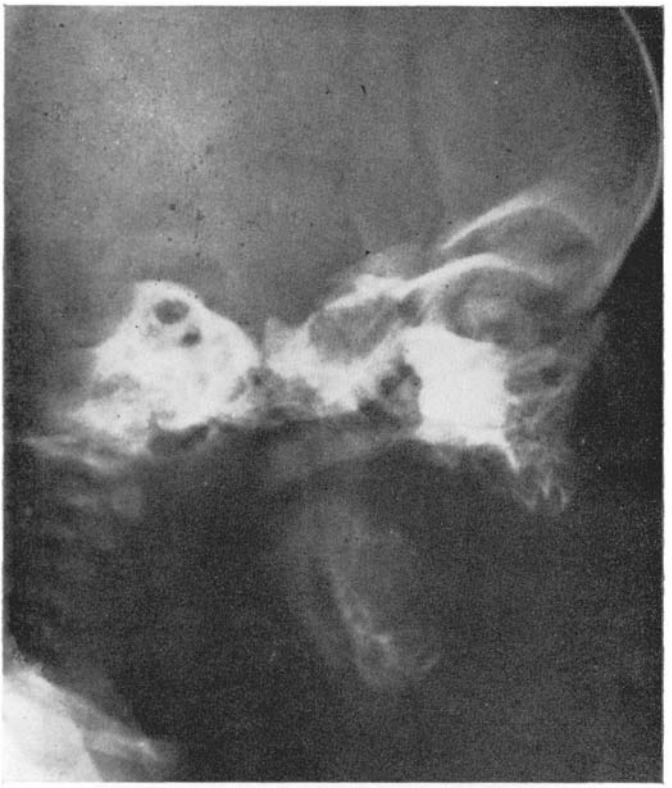


FIG. 5.
Lipiodol filling nasal cavity and outlining choanal atresia.

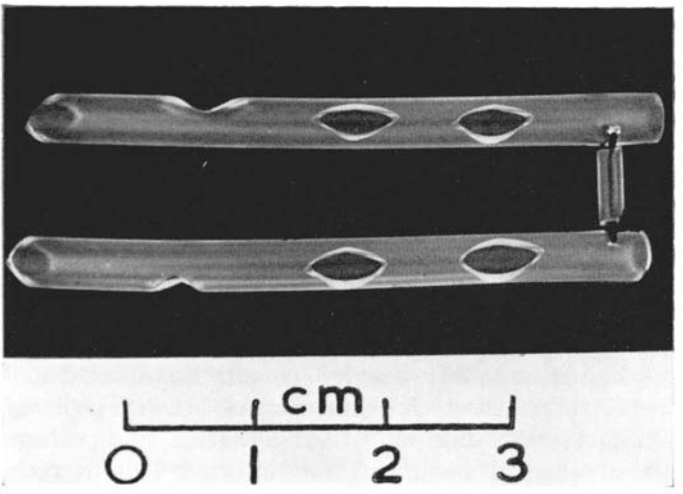


FIG. 6.
Intranasal polythene tubes.

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as to the eventual outcome of the patient's nasal airway, as the following case illustrates.

S.B., who was first seen in the E.N.T. department aged $9\frac{1}{2}$ years with a purulent left-sided nasal discharge. This was diagnosed initially as being due to a maxillary sinusitis. At the age of 10, an examination of the nose under general anaesthesia was performed and a left-sided choanal atresia

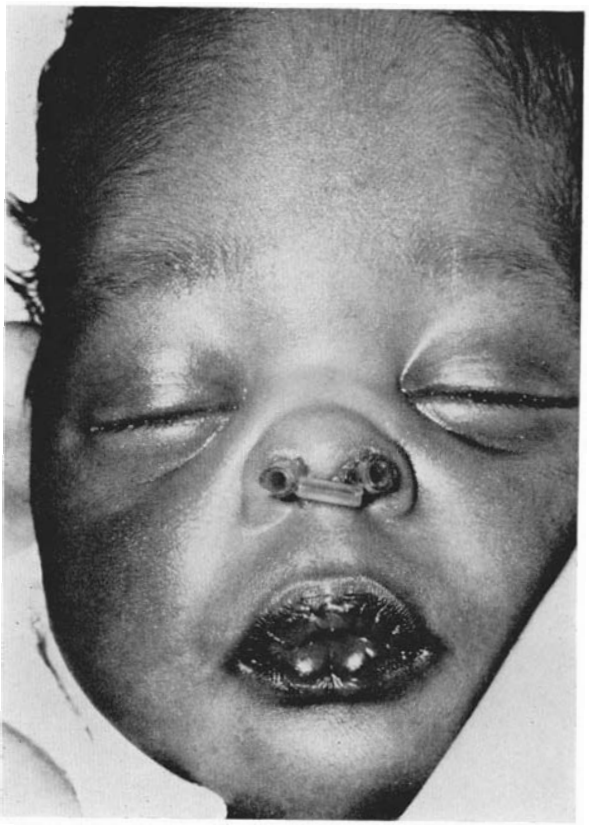


FIG. 7.
Polythene tubes *in situ*.

found; this was probably both bony and membranous in nature. The choanal partition was perforated and the hole enlarged with punch forceps and dilated to 14 FG. The left choana was dilated daily for one week. It was found that the left choana was closed with oedematous nasal mucosa. On the eighth day, a further dilatation was performed under general anaesthesia and a 'portex' tube inserted. On the 16th day, the nasal tube was removed and an attempt at dilatation with anaesthesia failed. It was decided that a transpalatal excision would be necessary.

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Six weeks after the original operation, at a routine out-patient visit it was noted that the left choana was grossly narrowed by a hard atresic segment. The nasal airway was greatly reduced and mucus was present in the left side of the nose.

At the age of 17 she attended the out-patients at our request for a follow-up examination. She was completely symptom free. Anterior

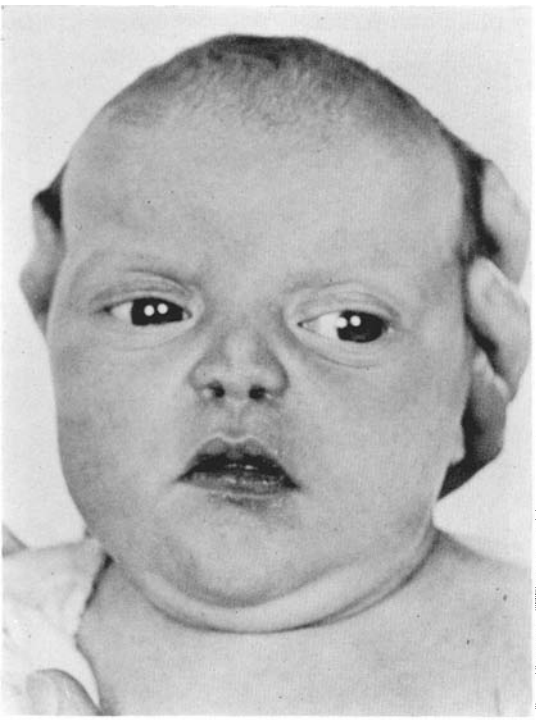


FIG. 8.
Anterior choanal atresia.

rhinoscopy was entirely normal. Examination of the postnasal space showed a slight reduction in size of the left choana.

This last case J.S. illustrates some of the difficulties which may be encountered due to the presence of a multiplicity of congenital abnormalities.

He was found to have an imperforate anus at birth and shortly afterwards was noted to have rather noisy nasal respiration and was described as being 'snuffly'. Some twelve hours after birth he had a cyanotic episode which was relieved by crying. A right-sided complete choanal atresia was suspected when a catheter could not be passed through the right side of the nose into the naso-pharynx. He was transferred to The Hospital for Sick Children when he was one day old.

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After an initial assessment on arrival it was felt that his nasal airway was probably adequate and a right transverse colostomy was performed. During his recovery from this operation it became obvious that his nasal airway was inadequate. He was anaesthetized again and examination of the posterior choanae showed the presence of a right incomplete bony atresia, the left side being normal. The atresic segment was removed with bone-nibbling forceps and a 3·5 mm. 'portex' tube was inserted into the

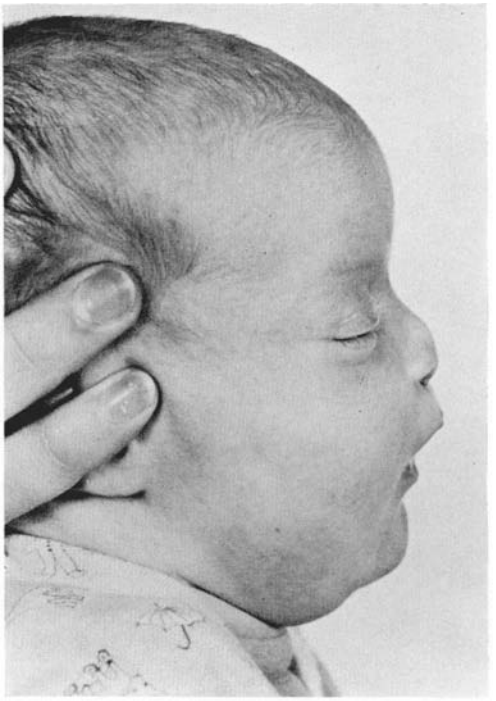


FIG. 9.
Anterior choanal atresia.

right nostril. A 2·5 mm. tube was inserted into the left nasal cavity since there was some obstruction here due to oedema of the nasal mucosa, the cause of which was not apparent but the appearances suggested that it could have been allergic or vasomotor in type. The presence of a bifid uvula and submucous palatal cleft were also noted at this examination.

In the next few post-operative days he was having obvious difficulty with his feeds and failed to gain weight. There were no episodes of cyanosis, but because of his feeding difficulty a further examination under anaesthesia with dilatation of the right choana was performed, and fresh 'portex' tubes inserted. This improved his nasal airway but he still failed to thrive and gain weight. During the next six weeks his weight remained more

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or less static; he was pyrexial with a mean temperature of 99 °F. His white count was persistently raised, with 21,000 polymorphonuclear leucocytes per cubic millimetre of blood. The presence of a sterile pyuria made some abnormality in his urinary tract a distinct possibility. An I.V.P. and cystocopy were performed and uretric reflux demonstrated.

His nasal tubes were removed six weeks after the original operation, but six days later he developed respiratory distress, but his nasal airway was patent. A bronchoscopy was performed but no abnormality was found in his larynx, trachea or major bronchi.

Ten weeks after the initial operation he was noted to have nasal obstruction and dilatation of the right posterior choana was performed and 'portex' tubes again inserted. These were retained for six weeks. He was discharged from hospital four months after his admission.

Unfortunately he developed pneumonia some three days after discharge and it again became all too obvious that his nasal airway was inadequate to cope with this additional stress. The posterior choanae were dilated and 'portex' tubes again inserted. They were removed after five weeks and he was discharged from hospital gaining weight and thriving; he was by now six months old.

At routine out-patient appointments his nasal airway was found to be adequate, but a little obstructed on the left side due to adhesions presumably caused by the instrumentation earlier.

At the age of thirteen months he was readmitted and a rectal 'pull-through' performed, after which his convalescence was uneventful. He was, however, thought to be retarded and an assessment at the age of fourteen months showed his intellectual and motor functions to be at about the 5–6 month level. He was noted to have a small head and a convergent squint.

At the age of $2\frac{1}{2}$ he was still having difficulty in breathing through his nose and a further examination under anaesthesia performed. This showed adhesions between the right inferior turbinate and the nasal septum. These were divided and 'teflon' sheeting inserted and retained in the nose for six days. His choanae were patent. He was last seen on 1 December 1970 and was noted to have a satisfactory airway. He is obviously mentally retarded and has to attend a special school.

Thus, in this case, the nasal obstruction was due to choanal atresia, complicated by oedematous nasal mucosa and the formation of adhesions. However, the main problem in the early stages, despite adequate nasal airways via the polythene tubes, was failure to thrive. The urinary infection no doubt contributed to this problem but probably the main clue to the difficulties, more apparent in retrospect than in the very early stages, is the general retardation. The management of this case illustrates how essential it is for virtually all departments of the hospital to work closely together.

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Prognosis

It is extremely important to make an early assessment of the various factors which enable an accurate prognosis to be made. The surgeon has to be in a position to cope with the variety of questions posed by anxious parents and to be able to inform them at the appropriate time, of the relevant facts of the condition.

Cases of unilateral atresia are attended by relatively little parental anxiety and therefore fewer questions. Reassurance can be given that the local condition itself is not of a serious nature but this encouragement should be given together with the information that more than one operative intervention might be required to deal with the condition completely. Since there is a 40 per cent chance of some other abnormality being present, the parents should be advised that further observation and investigations are necessary from this point of view. The chances of a severe and multiple associated abnormality are just as great in unilateral cases as in bilateral since these degrees of abnormality are distributed equally between the unilateral and bilateral group.

The respiratory and feeding difficulties associated with bilateral choanal atresia cause a great deal of parental concern and lead to more detailed questions. In the parents' mind the main question is of course whether the infant will survive or not. The parents have to be warned that it is a dangerous condition but, provided the infant has no other serious abnormality endangering life or precluding surgery this warning can be tempered with a considerable degree of optimism. After this question has been settled, the parents will usually enquire about whether normal feeding and growth are to be expected, if an abnormal facial appearance is likely, and whether speech and hearing will be involved. In general, reassurance is available here with the one exception that hearing problems are likely to be encountered in those infants with cleft-palate. In bilateral choanal atresia it is even more essential than in unilateral cases to touch on the possibility of associated abnormality since in this group, the chances are increased to around 60 per cent. Male infants with bilateral atresia are particularly at risk in this respect. The likelihood of prolonged hospitalization and repeated surgical procedure should be mentioned as soon as the subject can be broached tactfully.

Parents will sometimes ask about the risk of the condition occurring with future children. In the present series, most cases were presumably due to mutant genes and the risk of hereditary transmission is about 6 per cent. It is not possible to generalize from the small numbers involved, but only one of the four cases with a positive family history had an associated abnormality, viz., cleft-palate. It may be that the associated abnormalities are more likely to occur with the mutant genes. Ideally, full investigation and genetic counselling would be desirable, at least for those parents who are very concerned about the possibility of further

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children having choanal atresia. Although the risk is fairly small, there is perhaps a good case to be made out for future confinements taking place in hospital.

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REFERENCES

ABOULKER, P. (1951) *Annals d'Otolaryngologie*, **68,** 225.
BAKER, D. C. JR., WALTNER, J. G., and NOVICK, W. (1960) *Annals of Otology, Rhinology and Laryngology*. **69,** 805.
BAKER, M. C. (1953) *Archives of Otolaryngology*, **58,** 431.
BECKER, W., MATZKER, J., and SCHIFFER, K. H. (1957) *Acta Oto-laryngologica*, **47,** 377.
BEINFIELD, H. H. (1951) *Archives of Otolaryngology*, **53,** 530.
——— (1954a) *Journal of the International College of Surgeons*, **22,** 447.
——— (1954b) *Archives of Otolaryngology*, **59,** 65.
——— (1954c) *Journal of Pediatrics*, **45,** 679.
——— (1955a) *American Journal of Surgery*, **89,** 957.
——— (1955b) *Eye, Ear, Nose, Throat Monthly*, **34,** 575.
——— (1956) *Transactions of the American Academy of Ophthalmology*, **60,** 778.
——— (1957) *New York State Journal of Medicine*, **57,** 3160.
——— (1959a) *Journal of the American Medical Association*, **170,** 647.
——— (1959b) *Archives of Otolaryngology*, **70,** 1.
——— (1961) *Archives of Otolaryngology*, **73,** 659.
——— (1966) *Archives of Otolaryngology*, **83,** 480.
BERGLAND, O. (1963) *Acta Odontologica Scandinavica*, 21 Supp. **35,** 82 and 65.
BEYER, T. E., and BLAIR, J. R. (1947) *Laryngoscope*, **57,** 719.
BLEGVAD, N. R. H. (1954) *Acta Oto-Laryngologica*, Suppl. **116,** 46.
BONHAM, W. L. (1942) *Southern Medical Journal*, **35,** 252.
——— (1946) *Eye, Ear, Nose, Throat Monthly*, **25,** 387.
BRIERRE, J. T. JR. (1963) *Pediatrics*, **31,** 290.
BROPHY, J. W. (1962) *Rocky Mountain medical Journal*, **59,** 36.
CAMPBELL, W., STOKES, D. E., and JENNINGS, R. E. (1961) *Journal of the Medical Society of New Jersey*, **58,** 468.
CHALKLEY, T. S. (1953) *Virginia Medical Monthly*, **80,** 398.
CHERRY, J., and BORDLEY, J. E. (1966) *Annals of Otology, Rhinology and Laryngology*, **75,** 911.
COHEN, H. J., and WITCHELL, I. S. (1952) *American Journal of Diseases of Children*, **83,** 328.
COTTENOT, P., and ROUGET, J. (1948) *Annals of Otolaryngologie*, **65,** 183.
CRACOVANER, A. J., and GOODMAN, M. (1956) *Archives of Otolaryngology*, **64,** 267.
CRAIG, D. H., and SIMPSON, N. M. (1959) *Journal of Laryngology and Otology*, **73,** 603.
CRAWFORD, H. H., HORTON, C. E., and ADAMSON, J. E. (1965) *Southern Medical Journal*, **58,** 1402.
DAVIS, D. R. (1964) *Journal of the Kansas Pediatric Society*, **65,** 456.
DIAMANT, H., and KINNMAN, J. (1963) *Acta Paediatric Scandinavica*, **52,** 106.
DICKSON, J. C. (1950) *Texas State Journal of Medicine*, **46,** 115.
DOLOWITZ, D. A., and HOLLEY, E. B. (1949) *Archives of Otolaryngology*, **49,** 587.
DURWARD, A., LORD, O. C., and POLSON, C. J. (1945) *Journal of Laryngology and Otology*, **60,** 461.

https://doi.org/10.1017/S0022215100074235 Published online by Cambridge University Press

El Mofty, A. (1954) *Journal of the Egyptian Medical Association*, **37,** 1230.
Erickson, D. J., Lodge, J. L., and Tomsovic, E. J. (1963) *Journal of Pediatrics*, **63,** 561.
Ersner, M. S. (1953) *Archives of Otolaryngology*, **58,** 96.
Evans, A. (1924) *Lancet*, **1,** 1002.
Fabre, L. (1946) *Revue de Laryngologie, Otologie, Rhinologie*, **67,** 148.
Fatin, M. (1955) *Journal of the Egyptian Medical Association*, **38,** 428.
Flake, C. G., and Ferguson, C. F. (1964) *Annals of Otology, Rhinology and Laryngology*, **73,** 458.
Franck, E. (1950) *Revue de Laryngologie, Otologie, Rhinologie*, **71,** 389.
Grahne, B. (1966) *Acta Oto-Laryngologica*, **62,** 193.
Hanckel, R. W. (1949) *Annals of Otology, Rhinology and Laryngology*, **58,** 852.
——— and Bates, G. W. (1957) *Southern Medical Journal*, **50,** 1054.
——— (1967) *Eye, Ear, Nose, Throat Monthly*, **46,** 1043.
Hart, V. K. (1926) *Southern Medical Journal*, **19,** 703.
Hobolth, M., Buchmann, G., and Sandberg, L. E. (1967) *Acta Paediatrica Scandinavica*, **56,** 286.
Hough, J. V. D. (1955) *Southern Medical Journal*, **48,** 588.
James, W. W., and Hastings, S. (1932) *Proceedings of the Royal Society of Medicine*, **25,** 1343.
Jarvis, W. C. (1887) *Transactions of the American Laryngological Association*, **9,** 222.
Jay, P. (1959) *Medical Journal of Australia*, **1,** 151.
Johnsen, S. (1960) *Acta Otolaryngologica*, **51,** 533.
Johnson, G. E. (1952) *Journal of the Medical Association of the State of Alabama*, **21,** 357.
King, B. J., and Lynn, H. B. (1964) *Surgery*, **56,** 1018.
King, D. S. (1954) *Archives of Otolaryngology*, **60,** 723.
Lang, J. (1912) *Monatschrift für Ohrenheilkunde und Laryngo-Rhinologie*, **46,** 970.
Lemariey, A., and Muler, H. (1954) *Annales d'Otolaryngologie*, **71,** 466.
MacLean, R. G., and Hammack, W. (1959) *Archives of Otolaryngology*, **70,** 137.
McGovern, F. H. (1950) *Laryngoscope*, **60,** 815.
——— (1953) *Annals of Otology, Rhinology and Laryngology*, **62,** 894.
——— (1961) *Laryngoscope*, **71,** 480.
———, and Fitz-Hugh, G. S. (1961) *Archives of Otolaryngology*, **73,** 627.
McKibben, B. G. (1957) *Laryngoscope*, **67,** 731.
——— (1959) *Archives of Otolaryngology*, **69,** 95.
McNeil, K., and Wynter-Wedderburn, L. (1953) *Journal of Laryngology and Otology*, **67,** 365.
Maier, I. (1966) *H.N.O.*, **14,** 33.
Medovy, H., and Beckman, I. H. (1951) *Pediatrics*, **8,** 678.
Meurman, Y. (1953) *Acta Oto-laryngologica*, Suppl. **109,** 113.
Moncrieff, A. (1936) *British Medical Journal*, **1,** 1295.
Morrow, R. C. (1957) *Annals of Otology, Rhinology and Laryngology*, **66,** 135.
——— (1958) *Journal of the Maine Medical Association*, **49,** 135.
Muler, H. (1960) *Annales d'Otolaryngologie*, **77,** 659.
Owens, H. (1951) *Laryngoscope*, **61,** 304.
——— (1965) *Laryngoscope*, **75,** 84.
Peebles, E. McC., Dent, J. H., and Rutledge, L. J. (1965) *Laryngoscope*, **75,** 783.
Phelps, K. A. (1926) *Annals of Otology, Rhinology and Laryngology*, **35,** 143.
Poch-Vinals, R., and Ramos-Calvo, R. (1956) *Archives of Otolaryngology*, **63,** 559.
Puyo, R., and Boinpoint (1950) *Revue de Laryngologie, Otologie, Rhinologie*, **71,** 418.
Rawdon, R. E., and Beady, E. A. (1960).

https://doi.org/10.1017/S0022215100074235 Published online by Cambridge University Press

RANSOME, J. (1964) *Journal of Laryngology and Otology*, **78,** 551.
ROOPENIAN, A., and STEMMER, A. L. (1958) *American Journal of Surgery*, **96,** 802.
ROYER, L. (1956) *Laval Medical*, **21,** 751.
RUDDY, L. W. (1945) *Archives of Otolaryngology*, **41,** 432.
SCHULZ-SCHÖNHAGEN, H. W. (1949) *Archiv für ohren-nasen-und Kehlkopfkunde*, **155,** 693.
SHEARER, W. L. (1947) *Nebraska State Medical Journal*, **32,** 116.
SHEEHAN, J. E., and SWANKER, W. A. (1949) *Laryngoscope*, **59,** 1320.
STEIN, G. E. (1967) *Revue de Laryngologie, Otologie, Rhinologie*, **88,** 65.
STEWART, J. P. (1931) *Archives of Otolaryngology*, **13,** 570.
STONER, L. R., and FREEMAN, M. S. (1949) *Annals of Otology, Rhinology and Laryngology*, **58,** 226.
TSCHOPP, C. F., and MORROW, R. C. (1966) *Archives of Otolaryngology*, **83,** 607.
VELCOVICI, D., MAIOREANU, A., and SEGAL, M. (1965) *Pediatria* (Buc.), **14,** 165.
WALKER, J. S. (1954) *Journal of the American Medical Association*, **154,** 753.
WHITEHOUSE, W. M., and HOLT, J. F. (1952) *Radiology*, **59,** 216.
WILD, CH., CALVERT, J., and LAFON, J-C. (1955) *Annals d'Otolaryngologie*.
WILKERSON, W. W. JR., and CAYCE, L. F. (1948) *Transactions of the American Academy*, **52,** 234.
WILLENBERG, W. (1952) *Monatschrift für Ohrenheilkunde und Laryngo-Rhinologie*, **86,** 301.
WILSON, C. P. (1957a) *Journal of Laryngology and Otology*, **71,** 616.
——— (1957b) *Annals of Otology, Rhinology and Laryngology*, **66,** 5.
WRIGHT, A. J. M. (1922) *Journal of Laryngology and Otology*, **37,** 556.
WRIGHT, W. K., SHAMBAUGH, G. E., and GREEN, L. (1947) *Annals of Otology, Rhinology and Laryngology*, **56,** 120.
WYNN, S. K., and CONWAY, J. P. (1956) *Wisconsin Medical Journal*, **55,** 428 and 454.

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