dilatation; or any combination of the three. If the rate of C.S.F. formation was increased during the period of gas inhalation it would be expected that the pressure would remain elevated on discontinuing the gas mixture until absorption of the excess had restored normal volume and pressure. In fact, the pressure falls extremely rapidly—usually to 10–50 mm. below the pre-inhalation value (see Fig. 1). Raised venous pressure is thought to slow the rate of C.S.F. reabsorption via the arachnoid villae, and is the presumed cause of intracranial hypertension in congestive failure due to rheumatic heart disease. Inhalation of carbon dioxide does not, however, cause any significant change in venous pressure (Goldensohn *et al.*, 1951). This leaves mechanisms 2 and 3 as possibilities.

Wolff and Lennox (1930), by direct observation of the diameter of the pial blood vessels and measurement of the cisternal C.S.F. pressure in the cat, showed that inhalation of high carbon dioxide and high carbon dioxide plus low oxygen mixtures caused immediate vasodilatation with rise in C.S.F. pressure. Anoxia alone caused cerebral vasodilatation, but this effect was often offset by hyperventilation causing a fall of blood pCO_2 . White *et al.* (1942) made quantitative studies on changes in brain volume, cerebral blood volume, and C.S.F. volume in cats. With low oxygen inhalation, brain volume increased considerably, but the cerebral blood volume remained unchanged. This was attributed to the effect of anoxia in causing cerebral oedema by increasing the permeability of cerebral vessels. When carbon dioxide was added to the low oxygen mixture vascular dilatation with increase in cerebral blood volume occurred, but there was no further increase in brain volume. The effect of hypercapnia alone was not studied.

Thus it seems probable that raised intracranial pressure in emphysematous subjects with acute respiratory infections is due to the combined cerebral vasodilator action of anoxia and carbon dioxide retention. The antagonistic effect of low pO_2 and low pCO_2 may explain why the C.S.F. pressure in Case 8 was within normal limits—the vasodilator effect of moderate anoxaemia (O_2 saturation 69%) being offset by the lowered level of plasma carbon dioxide (7 vols. lower than the patient's normal level). The rise of C.S.F. pressure breathing oxygen in Case 6 may be explained as follows: in this patient resting ventilation was largely maintained by the stimulus of anoxia—as is shown by the fact that ventilation decreased by 30% on breathing oxygen. Although relief of anoxia *per se* would tend to produce cerebral vasoconstriction and a fall in C.S.F. pressure, this was more than counterbalanced by the increase in blood carbon dioxide content resulting from the fall in pulmonary ventilation. The net effect was a further increase of cerebral vasodilatation and rise in C.S.F. pressure. On breathing air once more ventilation increased, retained carbon dioxide was washed out, and C.S.F. pressure fell to its original (though raised) level.

An increase in blood carbon dioxide content invariably occurs during oxygen therapy in emphysematous subjects (Westlake, 1953) and accounts for the fact that the C.S.F. pressure often remains elevated (cf. Cases 9, 10, and 11) despite relief of anoxia. It is only on full recovery from the acute respiratory infection—when normal or near normal gas tensions are restored—that the C.S.F. pressure also falls to normal.

Is Raised Intracranial Pressure the Cause of Mental Disturbance During Oxygen Therapy?—Oxygen therapy in emphysematous subjects is often complicated by mental disturbance and neurological symptoms—acute mania, disorientation, profuse sweating, salivation, myoclonic twitching, stupor, and coma (Barach, 1937; Davies and Mackinnon, 1949; Comroe, Bahnson, and Coates, 1950; Westlake, 1953). These symptoms are often attributed to raised intracranial pressure, but careful analysis of the mechanism involved makes this view untenable. In cerebral tumour (or other space-occupying lesion) raised intracranial pressure causes drowsiness and coma by decreasing cerebral blood flow, with consequent cerebral anoxaemia. In the emphysematous subject the rise in C.S.F. pressure that occurs dur-

ing oxygen therapy is due to increased cerebral blood volume from pial vasodilatation. Cerebral blood flow, far from being diminished, is greatly increased (Kety and Schmidt, 1948; Patterson *et al.*, 1952). In the absence of any evidence that raised intracranial pressure *per se* (when unaccompanied by reduced cerebral blood flow) has any deleterious action on the function of cerebral neurones, we prefer to regard mental symptoms as manifestations of the direct action of hypercapnia and acidaemia on the brain (carbon dioxide narcosis) and do not believe that lumbar puncture has any therapeutic value.

Summary

Raised intracranial pressure in emphysematous subjects suffering from respiratory infections is attributed to the vasodilator action of anoxia and hypercapnia on cerebral vessels. During oxygen therapy the C.S.F. pressure may remain raised (despite relief of anoxic vasodilatation) owing to further rise in blood carbon dioxide content. Mental disturbance accompanying oxygen therapy cannot be directly related to raised intracranial pressure.

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EARLY TREATMENT OF CLEFT-LIP AND CLEFT-PALATE

BY

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The effective closure of congenital clefts of the lip and palate has presented a challenge which has been taken up by most of the great surgeons of the past century, and considerable ingenuity and daring have been evoked. Many lips and palates were closed without anaesthesia of any kind. To-day, with the help of anaesthesia, electric lighting, suction, and fine instruments and sutures, the surgeon works under improved conditions. Fewer babies with this deformity die than formerly, and actual closure of the clefts can be achieved with certainty. Fairly general agreement has been reached in this country on what procedures are desirable, but there is uneasiness concerning their shortcomings. Any surgeon who operates on these conditions realizes that some of his cases do not turn out as well as he would like. He knows that some will improve with the passage of time, but he will also have the fear that some may become worse. Little is known of the effects of operation on the development of the facial skeleton, and these may be serious enough to prohibit procedures otherwise commendable. Investigation along these lines requires the construction in each case, and with unoperated controls, of a series of models of the dental arches covering the period of growth, and no such survey is likely to be available for a number of years.

Bearing the above in mind, and also the inadequacy of any classification based on personal appraisal of cases, it has nevertheless seemed worth while to attempt to assess the effectiveness of treatment in a series of 100 consecutive patients with cleft-lip and/or cleft-palate admitted to Rooksdow House, the plastic surgery unit for the eastern area of the South-western Metropolitan Hospital Region.

Causation

As long ago as 1757 Trew mentioned heredity as a factor in the formation of congenital clefts, and since then many writers have pointed out the frequency of a family history of the condition: Muller (1886) and Haug gave 12%, Birkenfeld (1927) 20%, and Hinrichsen (1935) 24%. In 85 cases of the present series the parents had a reasonable knowledge of the child's forebears, and in 16 (18.8%) there was someone in the family with a cleft. Affected relatives were equally divided between the fathers' and mothers' families; they included the father's brother, sister, uncle, and great-aunt, and the mother's brother, uncle, great-uncle, and great-aunt. Few of us know much about our families two generations back, and the true figure would be greater than that given. From an examination of 703 family histories in cleft cases occurring in Denmark, Fogh-Andersen (1942) concluded that there was no genetic connexion between isolated cleft-palate and cleft-lip with or without cleft-palate. The positive family histories obtained in our series support this view.

Little is known of the manner of formation of clefts of the lip and palate, but they lie in the line of approximation of the nasal and maxillary processes and are presumably the result of failure in development and fusion of the mesoderm of these parts. Normally this fusion is first seen in the region of the nostril floor, and thereafter successively in the upper and lower portions of the lip. A little later union spreads through the hard and soft parts of the palate to the uvula. Failure to join may be complete, in which case a cleft extends through lip, alveolus, and palate; or incomplete, only part of the line of fusion being open. The nostril floor is the part least often cleft, and partial lesions extend towards this site from the lip border or from the uvula.

Table I shows that in 51 cases the cleft extended through the lip and palate, though in several there were small skin bridges in the region of the nostril and in 10 the alveolus

TABLE I.—Extent of Clefts and Sex Incidence

	No.	Male	Female
Cleft lip and palate ..	51	38 (41.1%)	13 (16.4%)
Cleft-palates ..	36	20 (6.9%)	16 (13.6%)
„ lips ..	13	8 (14.4%)	5 (7.6%)
Total		66 (62.4%)	34 (37.6%)

Figures in parentheses are, for comparison, from Fogh-Andersen's analysis of 703 patients.

was intact. In 36 the cleft was confined to the palate, and in 13 the lip was cleft and the palate intact, though in 4 of these 13 the alveolus was cleft.

The preponderance of the condition in males has been mentioned by numerous writers. Fogh-Andersen remarked on the greater incidence of cleft-palate in girls, among whom in his series it was twice as common as in boys, but in the present series the incidence was greater in boys (5:4).

Table II shows that clefts on the left side of the lip greatly outnumber those on the right and double clefts; this fact has been noted by many observers.

TABLE II.—64 Cases of Cleft-lip: Extent

	Lip Only	Complete Cleft	Lip and Palate
Left	10	22	7
Right	2	8	2
Double	1	11	1
Total ..	13	41	10

Associated Abnormalities.—Six children had associated abnormalities (Table III). It will be noted that none of these were situated in the extremities, although in the past these have been noted as the sites of most frequent allied

TABLE III.—Associated Abnormalities

Mental deficiency, ..	2
„ nystagmus, and optic atrophy ..	1
Hydrocephalus ..	1
Otitis media ..	1
Blindness; right eye absent, left cornea opaque ..	1

anomalies (v. Verschuer, 1938). Fogh-Andersen estimates the incidence of such anomalies as 10%. This would be in approximate accordance with our figure, which takes no account of neonatal deaths or abnormalities becoming manifest later in life.

Treatment of Cleft-lip

With a large lip a good operative result is more readily obtained, but, in view of the unsightliness of the deformity, delay to allow growth of the parts is unwarranted, and the majority of these babies were operated on between the third and sixth months of life. One complete cleft was closed on the day of birth, and a partial lesion was treated for the first time at the age of 23 years. By the third month the parts have grown sufficiently for the surgeon to be able to make a shapely lip and nostril, and the child has a good enough hold on life to withstand the anaesthetic and the operative hazards.

On the whole, the general health of the children on arrival at hospital has been excellent. It seems now to be recognized that the existence of the widest cleft is no threat to life from the point of view of interfering with feeding or permitting nasopharyngeal infections, and no case has been referred for urgent closure for either of these reasons. Operation has occasionally been postponed because the child had a cold, or was underweight, or because the haemoglobin level was low (under 10.5 g.%), but in no case has operation proved impossible or injudicious. In 15 cases palate closure was carried out when haemolytic streptococci had been grown from the throat swab, and in none were there complications. No transfusions have been given, before or after operation, and in only one case, with post-operative gastro-enteritis, was intravenous fluid required. The absence of any mortality is explainable partly by insistence on absolute fitness for operation and partly by the care given by experienced anaesthetists and nurses.

In treating single cleft of the lip there are two methods of approach. The first is simply to pare the cleft edges at the primary operation, joining the lip in layers with minimal tension so as to spare the maxillary arches from pressure where the cleft is complete. This postulates the necessity for a scar excision in all layers at a later date, when the construction of a lip of normal shape will be facilitated by the growth which has taken place in the interim.

The second method is to attempt at the outset to make the lip and nose perfect. In the minute lip of the infant this is not easy, and any mistakes will be magnified by growth. On the other hand, the scar obtained early in life, even when the gap is wide, can be less noticeable than any made subsequently.

This series includes 10 cases of single cleft which had been closed on the former principle at other hospitals, and a further 17 children were treated similarly at Rooksdow House. With varying success, the attempt was made in most of these to adjust the nostril floor and alar base at the first operation.

In 22 others an attempt was made to perfect the lip and nose at the initial operation. Since the deficiency of lip tissue is most marked towards the margin, no simple paring of the cleft can produce a lip which pouts like that of a normal child, and it is necessary to cut into the lip and design complementary flaps. The Barrett Brown (Brown and McDowell, 1945) procedure was used in eight cases,

the Blair (Blair and Brown, 1930, 1931) in five, the Hagedorn in five, the Le Mesurier (1952) in three, and in one concavo-convex incisions as used by Vaughan and others. All of these cases, when reviewed, were found to have some fault which seemed worthy of surgical correction, and in this regard the primary operation failed in its objective. However, all such adjustments were minor, and there was no call to alter the original scars, which proved less obvious than those resulting from the two-stage method. A perfect result, though infinitely desirable, is not to be expected, and the tendency to seek perfection through a series of trimming procedures has been resisted. Even if the particular defect under consideration were corrected, each such operation takes something from the part and leaves it smaller. To quote Veau and Borel (1931), "Les petits détails de la lèvre qui souvent retiennent toute notre attention, n'ont pas la même importance que la forme générale du visage qui nous préoccupe moins."

Double clefts of the lip are usually associated with a serious deficiency of tissue, and their treatment presents the biggest problem in the field of lip and palate surgery. The method used in the 11 cases in this series was to close the lip in stages, first one side and a month later the other. The edges of each cleft were pared with care to preserve as much tissue as possible, closure being effected with three layers of sutures. In this way the soft tissues were draped in front of the prominent premaxilla, which was thereby subjected to a measure of tension and brought nearer alignment with the maxillae. While the appearance is improved by these operations, a number of secondary operations are needed, and a result comparable to that available in single clefts is extremely difficult to achieve.

Where a cleft is complete, closure of the anterior part of the palate at the time of lip closure is a convenience, since this region is relatively inaccessible later. With three

exceptions this was attempted in the lip closures of this series; the exceptions were those done by the Le Mesurier technique, in which there was no time. In 23 the nasal mucosa was sutured with interrupted mattress sutures (Fig. 1, a). Dissection and suturing in this delicate layer is difficult, and closure was successful in only 14. In six cases the mucosa dissected from the nasal septum was sutured to the under aspect of the buccal mucoperiosteum raised at the cleft edge (Fig. 1, b), after the

FIG. 1.—Alternative methods of closing the anterior palate.

manner recommended by Dorrance (1933) for closing the hard palate. Closure was successful in four of these. This is easier than direct suture of the nasal mucosa, and the saving in time is important when there is so much to do.

Treatment of Cleft-palate

The primary reason for operating on the cleft-palate is to permit normal speech. The aim is to produce a palate which is long enough to be able to meet the posterior wall of the pharynx when in the elevated position and sufficiently mobile to achieve this with rapidity. Eighty-five operations were performed, six different techniques being used.

1. *Two-flap Method* (Fig. 2) (24 cases).—This resembles the original operation of Langenbeck (1861), but differs in that the nasal mucosa is not divided transversely. Closure is with two layers of sutures—one in the nasal mucosa, the other in the buccal mucoperiosteum. In the soft palate these buccal sutures approximate the muscles. Catgut was used in the first four; thereafter silk (2/0) was preferred

because it seemed less irritating to the mucosa. These sutures do not require removal, since they come away by themselves.

2. *Three-flap Method* (Fig. 3) (33 cases).—This method differs from the above in that the mucoperiosteum is divided obliquely, a step which permits lengthening of the palate.

3. *Four-flap Method* (Fig. 4) (15 cases).—This is similar to the three-flap method, but employs two small flaps based in front for closure of the anterior part of a long cleft as described by Wardill (1933).

FIG. 2.—The two-flap operation.

FIG. 3.—The three-flap operation.

FIG. 4.—The four-flap operation.

FIG. 5.—The X operation.

4. *X Operation* (Fig. 5) (11 cases).—Here the transverse division of the buccal mucoperiosteum is made further back, over the horizontal plates of the palate bones. As with the above operations, the nasal mucosa is not divided transversely, and is carefully sutured in the midline. This operation has only one advantage: it does not disturb the distribution of the greater palatine vessels and the blood supply of the transverse palatine suture, which may be a growth centre.

5. *Cuthbert (1951) Operation* (Fig. 6) (1 case).—Swinging across the left mucoperiosteal flap breaks the longitudinal suture line, which is an undesirable feature of the above procedures. To allow the flaps to move, the greater palatine vessels must be divided. Transverse section of the nasal mucosa opposite the posterior border of the hard palate favours increase in length.

FIG. 6.—The Cuthbert operation.

FIG. 7.—The Gillies-Fry operation.

6. *Gillies-Fry (1921) Operation* (Fig. 7) (1 case).—Here the soft palate is united after division of its elements from the hard palate. The latter, along with the aperture created behind it, is covered with an obturator.

In 39 cases, mostly early ones, the greater palatine vessels were divided at the point of emergence from the palatine foramina so as to permit easier approximation of the mucoperiosteal flaps. This step is rarely required, and preservation of the vessels must promote the viability of the flaps.

In 51 cases the pterygoid hamuli were fractured as recommended by Billroth. This permits prolapse of the tensor palati tendons and reduces transverse tension on the suture line. In the majority of cases in which early palate closure fails one of the tensor tendons is found in place and undisturbed, and its action would inevitably jeopardize closure. After fracture this bony process moves medially and dorsally under the influence of the fibres of the superior constrictor which are attached to it. There seems to be a danger that displacement of the hamuli may weaken the formation of Passavant's ridge, a fold of mucosa which forms on the posterior pharyngeal wall at the time of elevation of the palate. This ridge results from the contraction of a band of muscle fibres the majority of which are attached to the hamuli, and it is difficult to see how the muscle can contract effectively if both its bony attachments are mobile.

The ridge is probably an important element in closing off the nasal from the buccal pharynx, as occurs constantly in speaking. In 34 cases, therefore, instead of fracturing the hamuli, tenotomy of the tensor tendons was performed.

Complications.—In two patients the operation failed, in that the entire soft palate broke down. One of these was a two-flap closure in which the hamuli had been fractured and the greater palatine vessels divided. In the other a four-flap closure had been done in conjunction with tenotomy of the tensors, the vessels being preserved. In neither case were haemolytic streptococci grown from the pre-operative throat swab, though in the second there was a staphylococcus. Fifteen cases, including 4 of the 11 X operations, developed small fistulae (Fig. 8) in the median suture line which required surgical closure. The 15 operations for obliteration of the fistulae were successful in all but two, and here the fistulae were close to the alveolus and therefore barely accessible.

FIG. 8.—Location of post-operative fistulae. (All were in the midline.)

In two cases otitis media developed within a week of operation. In both the pre-operative haemoglobin levels were high (13.8 and 11.9 g.%), and in neither were streptococci grown from the throat swab. One occurred in November, the other in April, and both followed three-flap closures.

Results

Many difficulties arise in attempting to interpret speech results, and in this series there is the further obstacle that many of these children are very young and have a lot yet to learn about speaking. In 15 cases no estimate of the result is possible, and for the other 70 the figures given below are published in the realization that subsequent review may indicate inaccuracies.

Speech has been classified as follows: class I, apparently faultless; class II, faults distinctly minor, so that no one has any difficulty in understanding even in moments of excitement; and class III, unsatisfactory.

The results for the various operations are given in Table IV, and, while there is little between them, the four-flap comes out best. It is interesting to note that of the 15 cases

TABLE IV.—Speech Results

	No. of Cases	Class I	Class II	Class III
Two-flap operation	22	46%	36%	18%
Three " "	25	48%	40%	12%
Four " "	12	50%	42%	8%
X operation	9	45%	33%	22%
All methods	68	47%	38%	15%

1 Gillies-Fry operation: speech improved.
1 Cuthbert operation: not yet speaking.

operated on for post-operative fistulae 5 developed first-class speech. The following previously published results are given for comparison.

Ritchie (1937) (100 cases): in 42 the speech was excellent, in 43 good, in 14 fair, and in 1 bad.

Oldfield (1949) (183 cases): in 87 the speech was excellent, in 79 good, and in 17 bad.

Bentley and Watkins (1947) (90 cases): in 46 the speech was perfect, 26 had minor faults, in 15 the speech was imperfect, and 3 were imbeciles.

Table V was made with a view to elucidating the respective merits of fracture of the pterygoid hamulus and tenotomy of the tensor palati. The results favour the latter, and,

TABLE V.—Comparison of the Speech Results Following Fracture of the Pterygoid Hamulus With Those Following Tenotomy of the Tensor Palati

Speech	Fracture	Tenotomy
Class I	16	15
" II	18	9
" III	10	—
	44	24

of 31 patients who achieved class I, 16 had had fracture and 15 tenotomy, although almost twice as many were treated by fracture.

There has been considerable discussion about the optimal age for operation, with little in the way of statistics to substantiate the various views expressed. Wardill (1933) advocated operation early, in the expectation that the provision of an intact mobile palate before speech was attempted would permit this to develop in the normal way. Dorrance (1933) operated regularly at the age of 3 or 4 years, and claimed that speech was as good as with the early operation.

The results analysed in Table VI suggest that children operated on before the age of 9 months have a much better chance of achieving normal speech than those treated later,

TABLE VI.—Age at Which Palate was Closed

Age	No. of Cases	Class I speech in 77%
6 to 9 months ..	16	..
10 " 12 " ..	17	..
13 " 15 " ..	18	..
16 " 18 " ..	12	..
19 " 24 " ..	7	..
2 years ..	5	..
3-4 " ..	3	..
5 to 10 years ..	3	..
11 " 15 " ..	1	..
Over 15 " ..	3	..

and it should also be noted that no case operated on after the age of 3 years had a class I result.

Summary

In 100 cases of cleft-lip and/or cleft-palate both lip and palate were affected in 51, the palate alone in 36, and the lip alone in 13.

All lesions were more common in males.

In 18.8% there was known to be a relative of the child with a cleft.

Six children had associated congenital abnormalities, but in none was operation impossible.

Sixty-one operations were performed for primary lip closure and 85 for palate closure. There was no mortality.

Of the children born with cleft-palate, 47% are speaking without detectable abnormality, and a further 38% have only minor faults. Of the patients operated on under the age of 9 months, 77% speak normally.

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PERSISTENT ADULT BED-WETTING TREATED BY SACRAL NEUROTOMY

BY

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Definition and Aetiology

When the wide and varying group of cases loosely termed enuresis has been analysed and from it excluded all instances of precipitancy, defective control, and unintended bladder evacuation, diurnal or nocturnal, in which organic disease of the urinary tract (infections, developmental abnormalities of bladder and urethra) or of the nervous system has been demonstrated, there remains the clearly defined essential enuresis. This is a continuation of the irregular bladder action of infancy, commoner in the male than in the female, tending in most cases to be outgrown before puberty, though persisting in some cases until much later. It consists in bladder evacuation during sleep without awakening; in a great many cases there is an accompanying diurnal precipitate micturition amounting almost to incontinence and almost a strangury when it is attempted to hold back the urine. When in severe cases the enuresis finally ceases by degrees—as a rule with sporadic recurrences—the patient is left with a “weak” bladder with lifelong diurnal precipitate action.

During the years of active and frequent enuresis the life of the young patient is miserable; to go away from home is a recurring terror and shame, particularly as the most recent attitude appears to be that enuresis is a form of juvenile delinquency to be treated by “pep” talks and putting the young patient “on his honour”—the implications of which he greatly resents if he is at all sensitive and intelligent. Psychiatric thought regards it as an Oedipus matter—the boy, right on to adult life sometimes, wetting his bed to spite his mother and father for sleeping together. It is to the good that the time-honoured hunt for exciting causes (phimosis, worms, enlarged tonsils, etc.) has been abandoned, likewise the consequent operations, even as cures by suggestion. It is true that the patient can be “trained” to endure an uncomfortable bladder during the day for fairly long periods. This, however, is no more curative of the underlying condition than is inducing nocturnal anuria by fluid abstinence during the latter part of the day. The exceptionally good results claimed on hospitalization, when the patient is wakened every hour or so during the night, are open to similar criticism. Treatment by belladonna (as a parasympathetic inhibitor) and by amphetamine (partly a mild sympathetic stimulant, but acting mainly by producing light if any sleep) have equally transient effects.

The unsatisfactory position of treatment is reflected in the enormous literature by the vagueness of views expressed regarding the underlying cause. In the agreed absence of identifiable organic disease, recourse is had to mental and psychiatric defects, reflex factors, and so on; the most positive view was the old expression “pelvic neurosis.” It is interesting to note that some fifty years ago Cathelin practised the flooding of pelvic nerves with saline or anaesthetic solutions by epidural injection into the sacral hiatus for the treatment of