Transection of the pituitary stalk in man: anatomical changes in the pituitary glands of 21 patients

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In recent years hypophysectomy (Luft and Olivecrona, 1953) and adrenalectomy (which is nearly always combined with ovariectomy) have been used as methods of treating cases of advanced cancer of the breast (Atkins, Falconer, Hayward, MacLean, and Schurr, 1966) and the results of comparative trials suggest that hypophysectomy is slightly the more effective of these two operations (Atkins, Falconer, Hayward, MacLean, Schurr, and Armitage, 1960). As an alternative to hypophysectomy neurosurgeons have sometimes used the operation of pituitary stalk section for relieving such cases and also for treating patients with cancer of the prostate (see Schurr, 1966). In addition pituitary stalk section has been used for patients with advancing diabetic retinopathy (Field, Schepsen, Sweet, and Appels, 1962; Cullen, Harris, Munro, and Duncan, 1965; Fager, Rees, and Bradley, 1966). In assessing the merits of this particular operation as a means of depressing pituitary function, it is important to know the extent to which the structure of the gland is altered and its functions impaired. There are few reports in the literature on the effects of stalk section on the human pituitary (Dandy and Goetsch, 1911; Russell, 1956; Daniel, Prichard, and Schurr, 1958; Le Beau and Foncin, 1960; Nicolaïdis, 1962; Adams, Daniel, Prichard, and Schurr, 1963), although much information has now been obtained on the effects of the operation on several species of animal (Harris, 1950; Barret and Greep, 1951; Greep and Barrettt, 1951; Benoit and Assenmacher, 1953; Campbell and Harris, 1957; Daniel and Prichard, 1958; Holmes, 1961, 1962; László, Dávid, and Kovács, 1962; Adams, Daniel, and Prichard, 1963a, b, c; 1964a, b, c; 1966a, b; Jacobsohn, 1966).

We have now had the opportunity of examining the glands of 21 human patients surviving for various periods of time after stalk section and in this paper we report our findings in these pituitary glands.

MATERIAL AND METHODS

The pituitary glands from 21 patients were available for study. In 20 cases the operation was undertaken for the relief of carcinoma of the breast or prostate but in one (case 4 in Table I) the indication was a rapidly advancing diabetic retinopathy. Fourteen of the patients were females and seven were males. The age range was from 36 to 67 years. The pituitary stalk was approached by way of a frontal craniotomy, and in some cases the pituitary stalk was clipped before it was transected at as low a level as was technically possible. In the majority of cases an inert and impermeable barrier or 'plate' (composed usually of dental acrylic resin or tantalum) was placed between the cut ends of the stalk to prevent the re-establishment of the hypothalamo-hypophysial portal circulation.

The period of survival after stalk section ranged from 30 hours to 11 months (see Table I). The necropsies on the majority of the cases were undertaken by P.M.D. or J.H.A. but in a few cases the pituitary glands were sent to us, and in these less detailed information is available. At necropsy care was taken to ensure that the plate did not become displaced during the removal of the brain, and a check was made that there was no vascular connexion between the hypothalamus and the pituitary gland and that the position of the plate was satisfactory. The gland was then carefully dissected from the pituitary fossa.

The pituitaries were fixed whole, either in 10% formal saline or in mercuric formol. After fixation two of the glands were cut sagittally into five blocks which were then embedded in paraffin wax. Sections (7 µ or 4 µ) were taken from each block (Fig. 1a), mounted and stained with haematoxylin and eosin, or with iron haematoxylin and Van Gieson's mixture, P.A.S., and a few other special stains. The remaining 19 glands were bisected in the horizontal plane and after embedding in paraffin wax were cut serially. The serial sections (usually at 7 µ or 4 µ) were all mounted, and selected sections at various levels were stained as above (Figs. 1b and 2-7). For technical reasons the two pituitaries which were cut sagittally and two of those cut horizontally were unsuitable for measurement, but in the other 17 glands the volumes of the anterior lobe, the infarct or the col-
TABLE I
MEASUREMENTS OF THE ANTERIOR AND POSTERIOR LOBES OF THE PITUITARY GLANDS OF PATIENTS AFTER TRANSECTION OF THE PITUITARY STALK

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age</th>
<th>Sex</th>
<th>Survival after Stalk Section</th>
<th>Plate</th>
<th>Anterior Lobe</th>
<th>Posterior Lobe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Whole Lobe</td>
<td>Surviving Parenchyma</td>
</tr>
<tr>
<td>1 (M.L.)</td>
<td>47</td>
<td>F</td>
<td>30 hours</td>
<td>+</td>
<td>216-2</td>
<td>21-8</td>
</tr>
<tr>
<td>2 (J.T.)</td>
<td>57</td>
<td>M</td>
<td>2 days</td>
<td>+</td>
<td>127-7</td>
<td>25-4</td>
</tr>
<tr>
<td>3 (A.L.)</td>
<td>61</td>
<td>F</td>
<td>6 days</td>
<td>+</td>
<td>188-5</td>
<td>40-7</td>
</tr>
<tr>
<td>4 (T.McN)</td>
<td>36</td>
<td>M</td>
<td>7 days</td>
<td>+</td>
<td>95-8</td>
<td>83-3</td>
</tr>
<tr>
<td>5 (M.K.)</td>
<td>61</td>
<td>F</td>
<td>11 days</td>
<td></td>
<td>199-5</td>
<td>102-0</td>
</tr>
<tr>
<td>6 (V.B.)</td>
<td>49</td>
<td>F</td>
<td>15 days</td>
<td>+</td>
<td>Pituitary gland not measured</td>
<td></td>
</tr>
<tr>
<td>7 (R.B.)</td>
<td>37</td>
<td>F</td>
<td>19 days</td>
<td>+</td>
<td>Pituitary gland not measured</td>
<td></td>
</tr>
<tr>
<td>8 (S.)</td>
<td>45</td>
<td>F</td>
<td>3 weeks</td>
<td>+</td>
<td>Pituitary gland not measured</td>
<td></td>
</tr>
<tr>
<td>9 (B.L.)</td>
<td>45</td>
<td>F</td>
<td>33 weeks</td>
<td>+</td>
<td>Pituitary gland not measured</td>
<td></td>
</tr>
<tr>
<td>10 (J.McK)</td>
<td>57</td>
<td>M</td>
<td>4 weeks</td>
<td>+</td>
<td>116-9</td>
<td>33-6</td>
</tr>
<tr>
<td>11 (G.B.)</td>
<td>52</td>
<td>F</td>
<td>6 weeks</td>
<td>-</td>
<td>138-3</td>
<td>99-2</td>
</tr>
<tr>
<td>12 (J.H.)</td>
<td>53</td>
<td>M</td>
<td>25 months</td>
<td>+</td>
<td>43-7</td>
<td>17-1</td>
</tr>
<tr>
<td>13 (M.W.)</td>
<td>62</td>
<td>F</td>
<td>3 months</td>
<td>+</td>
<td>68-3</td>
<td>52-3</td>
</tr>
<tr>
<td>14 (A.W.)</td>
<td>40</td>
<td>M</td>
<td>3 months</td>
<td>+</td>
<td>111-1</td>
<td>31-8</td>
</tr>
<tr>
<td>15 (R.A.)</td>
<td>63</td>
<td>M</td>
<td>31 months</td>
<td>+</td>
<td>140-8</td>
<td>108-4</td>
</tr>
<tr>
<td>16 (C.H.)</td>
<td>67</td>
<td>M</td>
<td>4 months</td>
<td>+</td>
<td>46-1</td>
<td>39-8</td>
</tr>
<tr>
<td>17 (A.D.)</td>
<td>49</td>
<td>F</td>
<td>4 months</td>
<td>+</td>
<td>113-1</td>
<td>91-7</td>
</tr>
<tr>
<td>18 (J.V.)</td>
<td>45</td>
<td>F</td>
<td>6 months</td>
<td>+</td>
<td>103-9</td>
<td>67-9</td>
</tr>
<tr>
<td>19 (J.McE)</td>
<td>52</td>
<td>F</td>
<td>11 months</td>
<td>+</td>
<td>89-0</td>
<td>87-3</td>
</tr>
<tr>
<td>20 (E.J.)</td>
<td>45</td>
<td>F</td>
<td>11 months</td>
<td>+</td>
<td>107-3</td>
<td>164-0</td>
</tr>
<tr>
<td>21 (M.H.)</td>
<td>57</td>
<td>F</td>
<td>11 months</td>
<td>+</td>
<td>137-3</td>
<td>79-6</td>
</tr>
</tbody>
</table>

1+ means that an impermeable plate had been inserted at operation between the cut ends of the stalk. 
- means no plate: a blank means no information available.

lagenous scar within the lobe, and the posterior lobe were measured by a method in which Simpson's rule is applied to serial paraffin sections (Adams, Daniel, Prichard, and Venables, 1963). Using a projection microscope, the requisite areas were measured on graph paper, and from these the volumes of the various parts of the gland could be calculated.

It would have been of interest to have been able to compare the volumes of the anterior and posterior lobes of the pituitary in these stalk-sectioned patients with the volumes of these lobes in the normal subject. However, the difficulty in obtaining absolutely normal glands from patients of the various age groups and the great labour and time needed to process and measure such glands has deterred us from this extension of the present work.

FINDINGS IN THE PITUITARY GLANDS

The anterior lobe (pars distalis) of the pituitary gland was abnormal in every case. In the patients of short survival (cases 1-5 in Table I) the typical finding was a large infarct occupying the greater part of the lobe. The necrotic tissue was always much paler than the surviving epithelial cells (Fig. 3) which were usually restricted to a narrow subcapsular band and to a broader zone adjacent to the posterior lobe (Fig. 2 a-c). Within the necrotic area the microscopical appearances varied according to the length of survival. First the cytoplasm of the epithelial cells became swollen and homogeneous and the nuclei became pyknotic. Then the cell boundaries disappeared and the nuclei became fragmented. Many of the sinusoids within the infarct contained red blood cells. Immediate reactive changes were restricted to a mild peripheral infiltration of polymorphonuclear leucocytes, but within about a week macrophages could be seen within the infarct and there was an early mild peripheral fibroblastic reaction. In the three cases that survived for less than a week the infarct occupied from 78% to 90% of the lobe (cases 1-3). In case 4 (survival seven days) there was a very broad band of surviving parenchyma adjacent to the posterior lobe with the result that the anteriorly placed infarct was unusually small, occupying only 13% of the lobe. In case 5 (survival 11 days), where there was also an unusually broad band of surviving epithelial cells posteriorly (Fig. 2c), the infarct occupied 49% of the anterior lobe.

In the cases of longer survival there was a collagenous scar in the central and anterior parts of the anterior lobe (Figs. 4-6). There was a sharp line of demarcation between the scar and the surviving parenchyma. Most of the surviving parenchyma
occupied the posterior part of the anterior lobe (Figs. 1 and 2) although occasionally some epithelial cells had survived in other regions (as in Fig. 2e). In the patients who had lived for four to six months after stalk section (cases 10-18) the scar occupied from 14% to 71% of the lobe. In two of the patients who lived for 11 months (cases 19 and 20) the scars were very small (Fig. 7), but in the third (case 21) the scar occupied 49% of the lobe (Fig. 2i).

The epithelial cells in the living parenchyma in the posterior part of the anterior lobe were much smaller than in the normal pituitary; they also showed some loss of intracytoplasmic granules (Figs. 8 and 9).

In the patients who died in the first week or so after operation the posterior lobe (infundibular process) showed no characteristic abnormalities. In case 2 the lobe was abnormally small and the nuclei of its cells were closely packed together, but in view of the short survival of this patient (two days) these abnormalities cannot be attributed to transection of the stalk, but must have been due to a pre-existing degenerative process. When survival was four weeks or longer, the posterior lobe was obviously shrunken and showed a marked increase in the density of its cells (Figs. 10 and 11). The mean volume of the lobe in cases surviving 11 days or less (excluding case 2) was 28.9 mm³, while in those surviving from four to 11 months it was 17.2 mm³, i.e., a reduction of just over 40%.

**DISCUSSION**

To understand the consequences of cutting the pituitary stalk it is essential to know the anatomy and especially the vascular anatomy of the stalk and the pituitary gland (Xuereb, Prichard, and Daniel, 1954a, b).

**ANATOMICAL CONSIDERATIONS**

In man the pituitary, or the hypophysis cerebri, comprises two main parts, the adenohypophysis, consisting of epithelial cells, and the neurohypophysis consisting of neural tissue (Fig. 12). The adenohypophysis is made up of the anterior lobe (pars distalis) and an upward extension of epithelial cells (pars tuberalis) which forms a thin incomplete sleeve around the stalk and contains prominent thin-walled blood vessels. Beneath this sleeve the stalk consists of neural tissue, part of the neurohypophysis, a term used to include the median eminence of the hypothalamus (not prominent in man), the infundibular stem and the posterior lobe or infundibular process of the pituitary gland. The infundibular stem consists largely of a nerve tract running from the hypothalamus to the posterior lobe and can be regarded as having two portions, the upper infundibular stem which lies in the free part of the stalk, and the lower infundibular stem which lies within the body of the gland (for nomenclature see Xuereb et al., 1954a). The transection of this nerve tract at the operation of stalk section leads to the immediate onset of diabetes insipidus and, later, to the severe atrophy of the posterior lobe which is regularly found in these cases (Fig. 10).

The blood supply of the pituitary gland and stalk is derived from the inferior and superior hypophysial arteries. These are bilateral vessels and spring from the internal carotid artery on each side at different levels, the inferior arteries arising below and the superior arteries above the diaphragma sellae. The posterior lobe is supplied from the inferior hypophysial arteries and the blood traverses the lobe through a conventional system of arterioles, capillaries, and efferent veins (Fig. 13). The anterior lobe, however, has a unique pattern of circulation; essentially it has no arterial blood supply and all the blood which it receives comes from the hypophysial portal vessels, so called because they carry blood from a first (or primary) to a second capillary bed.
FIG. 2. Pituitary glands of nine patients who survived for various periods after transection of the pituitary stalk, showing the areas of living and infarcted (or scarred) anterior lobe tissue found in the mid-horizontal plane of the gland. The extent of the surviving tissue is not constant, but in each case the parenchyma adjacent to the posterior lobe has survived. This is because the blood flow through the short portal vessels (see Fig. 13) is not interrupted by transection of the stalk (tracings of sections all projected at the same magnification).
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**FIG. 3.** Case 1. Horizontal section at two levels (a and b) through the pituitary gland of patient who died 30 hours after transection of the pituitary stalk. The posterior lobe (PL) and part of the lower infundibular stem (LIS) are seen above. There is massive necrosis of the anterior lobe, the infarct (pale area, I) involving 90% of the lobe. The small areas of surviving parenchyma (P) seen posteriorly (dark) have been preserved by the unimpaired blood flow through the short portal vessels which arise in the lower infundibular stem (see Figs. 12 and 13). Haematoxylin and eosin × 4·5.

**FIG. 4.** Case 10. Horizontal section through mid-part of pituitary gland of a patient who died four weeks after pituitary stalk section. (Glands of this shape are not uncommon.) The large scar (pale, S) indicates the very large amount of anterior lobe tissue which had been destroyed. The parenchyma (P) adjacent to the posterior lobe has survived as usual, although the epithelial cells here are abnormally small (see Fig. 8). The posterior lobe (PL) is greatly shrunken. At A is a small adenoma. Haematoxylin and eosin × 6.

**FIG. 5.** Case 12. Pituitary gland of a patient who survived for two and a half months after operation. The distribution of the scar (S) and the living parenchyma (P) in the anterior lobe is typical. PL, posterior lobe. Haematoxylin and eosin × 6.
FIG. 6. Case 17. Pituitary gland of a patient who lived for four months after operation. In this case there is a considerable amount of living anterior lobe parenchyma (P) which suggests that either the initial infarct had been small or that some regeneration of parenchymal cells had occurred. S, scar in anterior lobe; PL, posterior lobe. Haematoxylin and eosin × 6.


FIG. 8. Pituitary four weeks after stalk section (case 10). Living anterior lobe cells in area preserved by the short portal vessels. Note the small size of the cells compared with the normal (Fig. 9). Haematoxylin and eosin × 485.

FIG. 9. Normal human pituitary. Same area as in Fig. 8 to show size and appearance of normal anterior lobe cells in this region. Haematoxylin and eosin × 485.
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McConnell (1953) and Stanfield (1960) believe that the anterior lobe of the human pituitary is supplied by some small arteries as well as by portal vessels, but in our view such an arterial supply when it exists at all is so small as to be insignificant. True, there is an artery which enters the anterior lobe and passes through it surrounded by a thick sheath of fibrous tissue, the artery of the trabecula (Fig. 13), but although this vessel, which links the superior and inferior hypophysial arterial systems, was a prominent feature in many of our injected preparations, we never found any branches distributed to the parenchyma. At one point, namely, in the ‘fibrovascular tuft’ (Xuereb et al., 1954a, Fig. 3), the artery of the trabecula does give off a few very small, short twigs; these do not, however, as a rule pass beyond the fibrous tissue of the trabecula, and though it is possible that in some instances a little blood may spill over from these vessels into sinusoids of the immediately adjacent parenchyma, any arterial contribution that may be provided in this way must be small and be confined to a very limited region of the anterior lobe.

The hypophysial portal vessels which provide the anterior lobe with its blood supply are disposed in two distinct groups: the long portal vessels which run down the stalk, and the short portal vessels which lie below the level of the diaphragma sellae. Both groups, on entering the anterior lobe, break up into sinusoids, and this network of vessels, which extends throughout the lobe, forms the second capillary bed of the portal system. Each group, the long and the short portal vessels, feeds a well-defined territory in the anterior lobe, the long portal vessels supplying a large area in the anterior and central part of the lobe, while the short portal vessels supply a much smaller area adjacent to the posterior lobe. The first capillary beds which these two groups of portal vessels drain are both situated in neural tissue, but lie at different levels in the neurohypophysis (Fig.

**FIG. 10.** Pituitary four weeks after stalk section (case 1). Closely packed cells in the greatly shrunken posterior lobe. Compare with the normal appearance in Fig. 11. Haematoxylin and eosin × 350.

**FIG. 11.** Normal human pituitary. Cells in posterior lobe, for comparison with Fig. 10. Haematoxylin and eosin × 350.
The long portal vessels drain a capillary bed in the median eminence and the upper infundibular stem, a bed supplied by the superior hypophysial arteries. The short portal vessels drain a bed in the lower infundibular stem and this bed is supplied mainly by a branch of the inferior hypophysial artery but partly also by the artery of the trabecula.

**EFFECTS OF TRANSECTION OF THE STALK** When the pituitary stalk is cut immediately above the level of the diaphragma sellae (as in Fig. 12) the transection should be sufficiently low to sever all the long portal vessels, but the short portal vessels and their supplying vessels will remain intact (see Fig. 13). It would be expected, therefore, that although an infarct would develop in the anterior lobe, part of the lobe would survive, namely, the territory supplied by the short portal vessels. This is indeed the case, a constant feature of the pituitaries reported here being the survival of the posterior region of the anterior lobe which is adjacent to the lower infundibular stem and the posterior lobe (see Figs. 1-6). A superficial rim, only a few cells thick, along the other borders of the lobe also regularly survives, preserved presumably by diffusion from the adjacent highly vascular dura mater or by intermittent venous reflux.

It is important to know how much of the lobe is destroyed by infarction, since the extent of the infarct will be one factor in determining the degree to which anterior pituitary function is depressed. Much depends on the level at which the stalk has been cut, since if the transection was not at a really low level some of the long portal vessels will have escaped transection and the infarct produced will not be of the maximum possible size. In our experiments on animals with a pituitary blood supply similar to that of man, a low transection of the stalk was usually achieved and the results in goats, sheep, and monkeys were on the whole very consistent, the immediate infarct produced involving 80-95% of the lobe (Adams et al., 1963a, b, c, 1966b). Very occasionally an unexpectedly large proportion of the lobe escaped infarction, and in the rat the figures were more variable than in the other species (Adams et al., 1963a). We attribute these differences not only to possible variations in the level of the transection but also to variations in the size of the territory supplied by the short portal vessels in individual animals.

From the present series of cases it is not easy to assess how much of the anterior lobe undergoes infarction when the pituitary stalk is cut in man, because it is only in the first few days after operation that a true estimate of this can be made. The immediate infarct is rapidly replaced by fibrous tissue; the latter then shrinks, so that the size of the final

![Diagram of human pituitary gland in mid-sagittal plane. To show the relations of the glandular (black) and neural (stippled) components. The level of a low transection of the stalk is also indicated. UIS, upper infundibular stem; LIS, lower infundibular stem.](image1)

![Diagram of human pituitary gland showing its blood supply. When the stalk is cut at a low level, as in Fig. 12, all the long portal vessels (LPV) are severed, and this produces the largest possible infarct in the anterior lobe. Even with a low cut, however, the short portal vessels (SPV) and their afferent supply remain intact, so that some part of the lobe always survives (see Fig. 2). IHA, SHA, inferior and superior hypophysial arteries; AT, artery of the trabecula; V, venous sinus.](image2)
scar does not represent the size of the original infarct (see Adams et al., 1963a; b; 1964a; 1966a). Only four patients of the present series died within a week of operation. Of these, three had infarcts involving 78-90% of the anterior lobe, but in the fourth the infarct was small, involving only 13% of the lobe. The first report in the literature of an acute infarct after stalk section was that of Cushing's case in which the stalk was accidentally cut during an intracranial operation (Dandy and Goetsch, 1911), and this infarct was clearly of very large size. Equally extensive infarcts have been reported by Russell (1956) in three cases and in one case by Nicolaidis (1962), who, however, also reported a second case in which the acute infarct involved only 45% of the anterior lobe. Very large infarcts have also been seen in cases in which the stalk had been ruptured as a result of head injury (Daniel, Prichard, and Treip, 1959).

In the group of longer surviving cases the large size of the scar seen in some of the glands indicates that the original infarct had been very extensive. However, in others (particularly cases 19 and 20) the scar was small, and this suggests that the initial infarct, as in one of the acute cases, had also been small. It would seem, therefore, that although in theory pituitary stalk section in man should cause massive destruction of the anterior lobe, in practice this is not invariably the case.

Several factors could explain why in some instances the infarct or scar produced is smaller than expected. First, the stalk may not have been cut at a sufficiently low level to ensure that all the long portal vessels are transected. Secondly, the gland may have been one in which there was some slight variation from the usual pattern of the pituitary blood supply. For instance, the territory supplied by the short portal vessels may have been unusually large, or the artery of the trabecula may, exceptionally, have contributed a small supply to the immediately surrounding parenchyma (as suggested in Fig. 2c and e), or an atypical vessel may have penetrated the anterior lobe from the dura mater, thus preserving a localized area of superficial parenchyma broader than the usual narrow rim (as suggested in Fig. 2b and c). Thirdly, one cannot exclude the possibility that in patients who survive for several months some regeneration of anterior lobe parenchyma may have taken place. In animals we found that although normally regeneration of parenchymal cells did not occur to any appreciable extent a substantial regrowth of these cells might occur under certain conditions (Adams et al., 1963b). Nicolaidis (1962) believed that in man regeneration of parenchymal cells was a factor of some importance after pituitary stalk section.

The amount of living parenchyma that remains after stalk section should not, however, be taken as a true indication of residual pituitary function since, if an effective barrier was inserted at operation, this parenchyma no longer has any connexions with the hypothalamus. It is now generally believed that the functional activity of the epithelial cells of the anterior lobe is largely controlled by the hypothalamus (Harris, 1955, 1960). The nerve tract which runs down the pituitary stalk consists of the axons of hypothalamic cells, particularly those of the supraoptic and paraventricular nuclei. A large number of these axons pass to the posterior lobe and are concerned with the production of posterior lobe hormones, but it is believed that many of them terminate on the loops of the primary capillary beds which feed the portal vessels (Rinne, 1960). The theory is that neurohumours are released from the terminations of these latter axons into the primary capillary beds, and that these neurohumours are then carried in the blood through the portal vessels to the epithelial cells, causing them to secrete (or release) their hormones (Fig. 14). When the pituitary stalk is cut all the nerve fibres which run down it are severed and the short portal vessels are therefore

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**FIG. 14.** Diagram to show the pathways by which it is thought that neurohumours, elaborated by cells in the hypothalamus, are transmitted to the pituitary gland. Note in particular the axons of hypothalamic cells (H) which terminate on the primary capillary beds (P) which feed the portal vessels. Here the neurohumours enter the bloodstream, to be carried through the long and short portal vessels (LPV, SPV) to the parenchymal cells (C) in the anterior lobe. One axon is shown ending on capillaries (Cap) of the posterior lobe. IHA, SHA, inferior and superior hypophysial arteries.
now draining a denervated primary capillary bed (see Adams et al., 1964b, 1966b). Consequently the blood that these vessels carry to the epithelial cells in the surviving areas of the anterior lobe no longer contains the neurohumours on which these cells normally depend for their functional activity. To ensure that the pituitary gland is permanently separated from direct hypothalamic influence it is necessary at operation to insert a barrier of some inert and impermeable material (e.g., dental acrylic resin) between the cut ends of the stalk to prevent the possible regeneration of the long portal vessels (Harris and Jacobsohn, 1952; Jacobsohn, 1954) and also to obstruct the growth of new nerve fibres (Beck and Daniel, 1961) which might re-innervate the primary capillary bed of the short portal vessels. The accurate placing of a barrier of adequate size is of vital importance.

In animals, when a permanent isolation of the gland from the hypothalamus has been achieved, the cells in the anterior lobe which survive show the effect of their isolation within a few weeks of operation by becoming much smaller than normal (Adams et al., 1964a; 1966b) and there is a marked loss of secretory granules in their cytoplasm (Daniel, Duchen, and Prichard, 1964a, b). Unfortunately in most of our human cases necropsy had been delayed and autolytic changes made an assessment of cell size difficult, but in the one case (surviving for four weeks) where accurate assessment was possible the small size of the surviving parenchymal cells made a striking contrast with the normal (Figs. 8 and 9). On the whole, however, the loss of secretory granules in the surviving cells does not seem to be as marked in man as it is in animals. We are surprised that in their longer surviving human cases Ehni and Eckles (1959) and Nicolaidis (1962) noted no abnormality in the surviving cells, but they may also have been faced with the difficulty of autolytic changes confusing the picture.

It may well be, therefore, that in man the actual size of the infarct is of only limited importance as an indication of depression of pituitary function. In animals it has been found that once the anterior lobe has been effectively and permanently isolated from the hypothalamus the functional activity of the cells which survive is greatly impaired (Daniel and Prichard, 1964; Cowie, Daniel, Prichard, and Tindal, 1963; Cowie, Daniel, Knaggs, Prichard, and Tindal, 1964; Daniel et al., 1964a, c). Whether this is also true in man, however, is not known, for although various tests of pituitary function have been made on patients after stalk section the results are vitiated by the hormone replacement therapy that has to be given, and often by the fact that the patients have also had other endocrine glands removed. It might be expected that isolation from the hypothalamus would depress all anterior pituitary function, but there is some evidence that in these circumstances the output of lactogenic hormone may actually be increased. For example, Ehni and Eckles (1959) and Dugen, Van Wyk, and Newsome (1962) found that milk might be secreted by non-pregnant women after stalk section.

In this paper we have concentrated on the anatomical changes which occur in the human pituitary gland as a result of stalk section. It is important to know what these changes are if one is to understand the rationale for the operation. However, the important question remains as to whether stalk section (which is not as radical an operation as hypophysectomy and therefore has some practical advantages) achieves the object for which it is performed. This question is beyond the scope of the present paper, but it is known that the beneficial effects of stalk section include a dramatic relief of pain in patients with carcinoma, regression of metastases in some patients (see Schurr, 1966), and a frequently striking relief of symptoms in patients suffering from diabetic retinopathy (Field, et al., 1962; Cullen et al., 1965). In rats with experimentally induced mammary tumours we found that stalk section was highly successful in causing regression of tumours in some instances, but that hypophysectomy produced more consistently favourable results (Daniel and Prichard, 1963). This may or may not be the case in man. The question could probably be answered by a controlled trial of the two operations in the human subject.

SUMMARY

The pituitary glands of 21 patients surviving for periods ranging from 30 hours to 11 months after transection of the pituitary stalk were examined. In 17 cases the volumes of the anterior lobe, the infarct or scar within it, and the posterior lobe were measured. In every case the anterior lobe was abnormal. Infarcts or scars were present, usually of considerable size, but some parenchyma, in a characteristic situation in the posterior part of the lobe, had always escaped destruction. The epithelial cells in this surviving anterior lobe tissue were abnormally small.

The information provided by this series of glands suggests that although pituitary stalk section will usually cause extensive infarction of the anterior lobe, this result will not be invariable.

As a result of the operation the posterior lobe of the gland shrank and showed an increased density of nuclei.

The findings are explained in the light of the
Anatomy and the vascular arrangements of the pituitary stalk and gland.

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