SURVIVAL OF CORTICAL BONE AFTER BONE-GRAFTING

BY

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Since the earliest days of bone-grafting there has been doubt whether any of the cells of the graft survive. Until recently this subject was thought to be largely of academic interest because cortical bone had been used as a graft almost exclusively, and it had often been noted that a cortical graft was just as successful in promoting union whether it was transplanted alive or had first been killed and sterilized by boiling.

A change has recently taken place in surgical opinion on this subject, notably as a result of the work of Mowlem (1941), who was able to secure histological specimens of iliac-bone grafts four or five months after their insertion for repair of the bridge of the nose. These sections seemed to show that transplanted cancellous bone transformed itself into cortical bone within the short space of four months after operation, and that the cells in this bone remained alive; while transplanted cortical bone remained cortical in structure, its lacunar cells appeared dead, and it had not yet been replaced by living bone five months after the operation.

It was concluded from these interesting observations that cortical bone was too dense to allow the passage of sufficient tissue fluid to nourish the lacunar cells. A tibial cortical graft might therefore be expected to die and be gradually replaced by creeping substitution from the adjacent bone, while its function in a bone-grafting operation was simply to act as a splint and as a source of readily available calcium. Cancellous bone, on the other hand, was regarded as of so spongy a structure that it could be permeated by tissue fluids and so survive after transplantation.

The truth of these observations has since been abundantly tested, and Higgs (1945) was able to quote comparative figures for bone grafts which indicated that osteogenesis was more rapid in those cases where a graft of cortical bone was combined with the use of cancellous chips than where cortical bone was used alone.

It seems of interest in this connexion to quote three cases of bone tumours which have been excised extraperiosteally and replaced by a tibial cortical bone graft. In each case the graft has apparently survived without showing any evidence of being replaced by creeping substitution, while in one case a fracture of the graft with subsequent union took place.

Illustrative Cases

Case 1.—Female aged 18: a case of rapidly growing enchondroma of the proximal phalanx of the right thumb which had recurred following incision and curettage. Operation (Feb. 1, 1940) consisted of extraperiosteal excision of the whole proximal phalanx of the thumb and replacement by a tibial cortical graft sharpened at each end and inserted between the rawed base of the distal phalanx and the head of the metacarpal bone of the thumb. Union of the graft had taken place at both ends by June 26, but a month later the union at the distal end broke down and a false interphalangeal joint began to form. When last seen on Dec. 8, 1943, the graft, which remained strongly united at its proximal end, was composed of strong bone throughout, and the false interphalangeal joint had acquired 30° of active flexion and extension. At present, nearly six years after the operation, the patient reports that her thumb remains as good as when she was last seen in 1943.

Case 2.—Female aged 24: a case of osteoclastoma of the lower end of the left radius which recurred after curettage. Symptoms were first noticed when the patient suffered a fracture through the tumour during an epileptic fit. Operation (Oct. 31, 1941) comprised incision over the postero-lateral surface of the hand and lower end of the forearm; separation of tendons and nerves from the front and back of the wrist-joint; division of the wrist-joint capsule so as to allow the hands to be capsized ulnawards, hinging on the ulnar collateral ligament; extraperiosteal removal of the whole lower end of the radius with the pronator quadratus muscle; and replacement by a large tibial cortical bone graft inserted into the split lower end of the radius and the denuded proximal surface of the carpus. During the operation the tendon of the extensor pollicis longus was ruptured; this was made good by transplanting the extensor carpi radialis longior into the distal end of the thumb extensor.

On April 23, 1942, the graft was regarded as united strongly enough to allow removal of the plaster, but, in view of the patient's epilepsy, she retained an aluminium splint on the arm for several months longer. On Dec. 28, 1942, she complained of pain in the wrist, and a skiagram showed a crack in the lower end of the graft. It was assumed that she had refractured the graft during a fit. The wrist was immobilized again in plaster. Union of the fracture subsequently took place, though the graft shortened during the process of the union and allowed radial deviation of the hand. At present, four years after the operation, the graft remains united at both ends and at the site of the fracture.

Case 3.—Female aged 36: a case of osteoclastoma of the lower end of the right radius. The operation (March 20, 1944) was essentially the same as in Case 2, except that the tendons of the extensor pollicis longus and abductor pollicis longus were deliberately divided and later resutured. Uneventful union of the graft took place by October, 1944. At present, 19 months after the operation, the skiagram shows sound union at both ends of the graft with good-quality bone intervening.

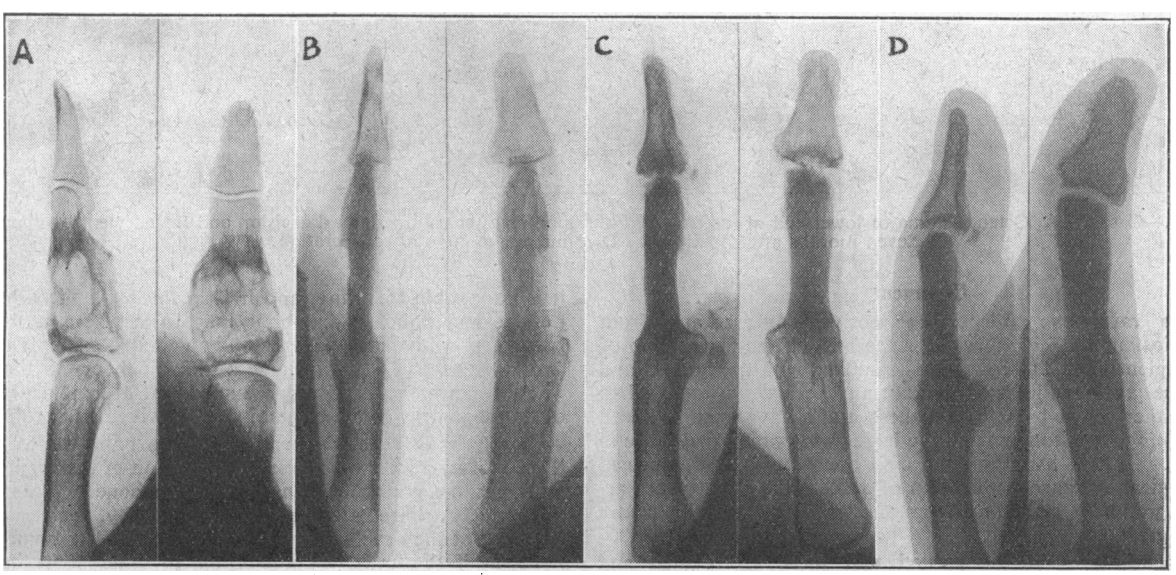

FIG. 1.—Case 1. A, Enchondroma of proximal phalanx of thumb. B, Five months after extraperiosteal excision and replacement by bone graft: union both ends of graft. C, Fifteen months after operation: false joint forming at distal end of graft. D, Three years and ten months after operation: actively movable false joint at distal end of graft.

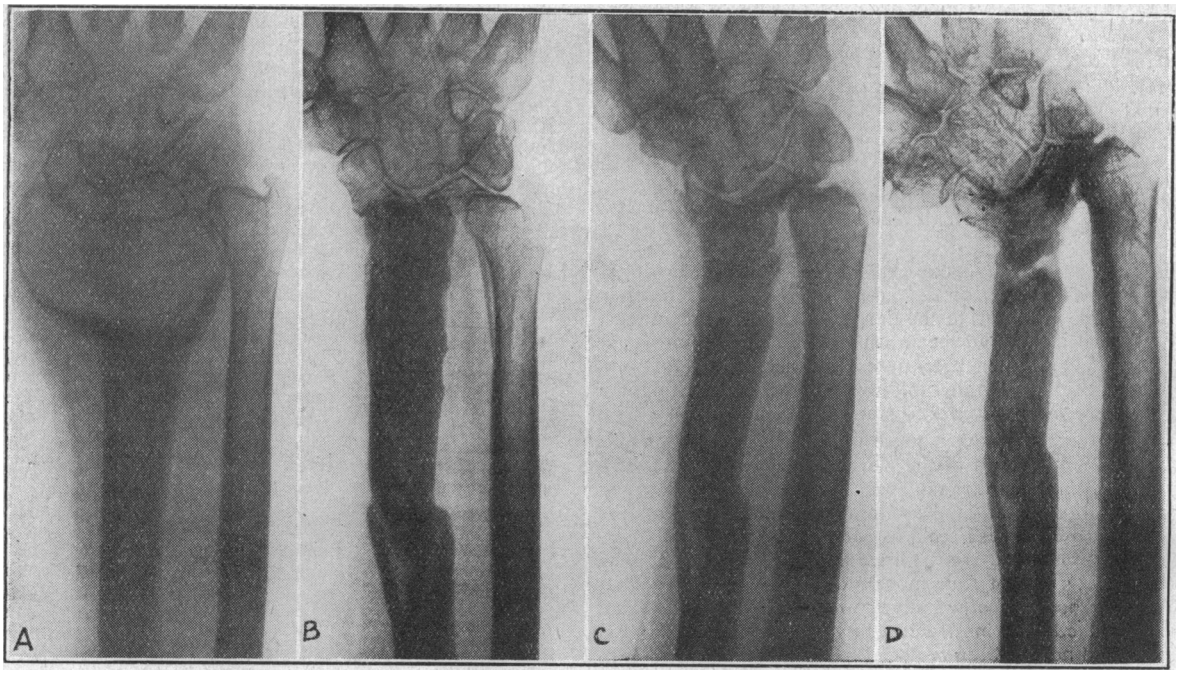

FIG. 2.—Case 2. A, Osteoclastoma of lower end of radius. B, Six months after extraperiosteal excision and replacement by bone graft. C, Fourteen months after operation: fracture of graft. D, Four years after operation: fracture remains united.

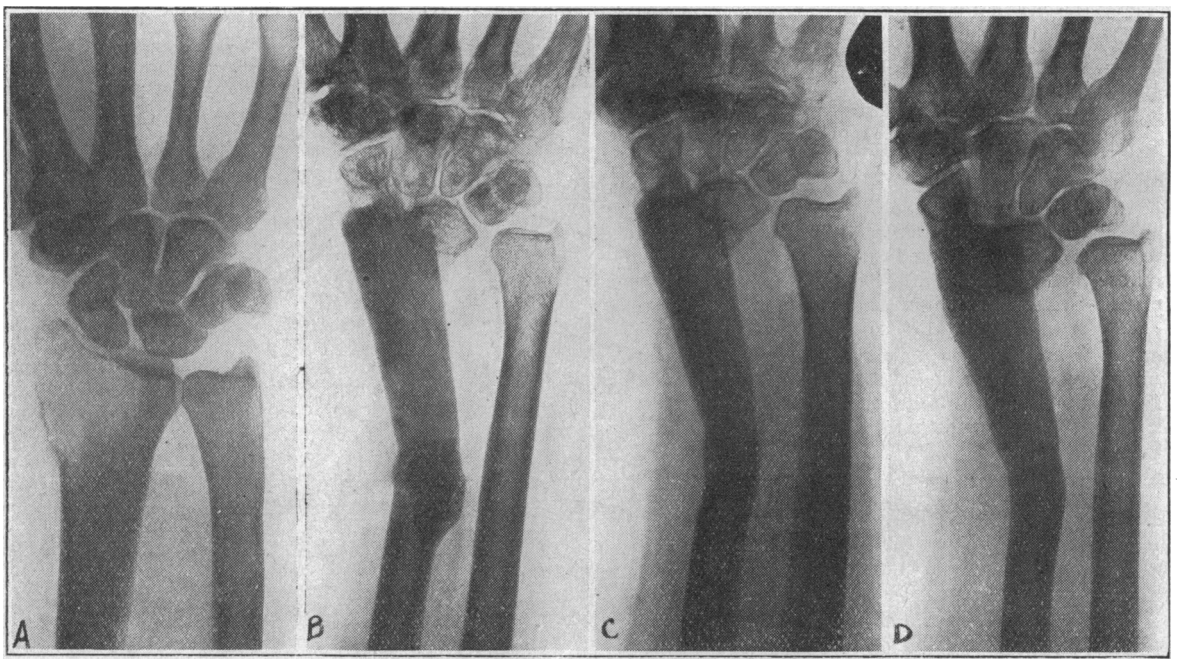

FIG. 3.—Case 3. A, Osteoclastoma of lower end of radius. B, Four months after extraperiosteal excision and replacement by bone graft. C, Seven months after operation. D, Nineteen months after operation.

Comment

These grafts have evidently not received any assistance from the periosteum in their survival, since in each the periosteum of the recipient bone was completely removed with the tumour and the bone graft was inserted without any periosteum attached to it. Neither can it be said that these grafts have been replaced by creeping substitution from the bones with which they were in contact. If this had been the case one would have expected radiological evidence in the form of a decalcified line of demarcation gradually spreading from the ends towards the centre of the graft.

It might, however, be argued that these grafts died and were replaced by an invasion of cells from the organizing haematoma which surrounded them, such cells subsequently becoming differentiated into bone elements. This suggestion it is impossible to refute, and it is in line with the teaching of Leriche and Policard that bone may form wherever there is a mass of primitive mesenchyma and an adequate supply of blood and calcium. But why postulate a difficult theory in these cases when it can be more simply assumed that at least a proportion of the bone cells of the original graft survived and proliferated?

Certain radiological appearances were common to each of these grafts. First, the coarse trabeculation of the original tibial graft became gradually transformed into bone of a denser and more finely trabeculated structure. Secondly, each case showed evidence of the development of a surface layer of homogeneous bone, as if the graft was attempting to differentiate itself into cortical and medullary structure. These radiological appearances seem to indicate that there was at least partial survival of cells throughout the whole substance of the graft.

The most important common factor in these cases, however, appears to be that each graft was transplanted into an area richly supplied with blood and devoid of any scar tissue. It would seem that when transplanted into such ideal surroundings even a cortical bone graft will survive and will rapidly become incorporated in the circulation of the host. These cases appear to emphasize once again that one of the chief functions of a bone-grafting operation must be the removal of scar tissue and the opening up of the whole vascular area for the promotion of osteogenesis at the site of fracture.

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ARGENTAFFIN (CARCINOID) TUMOURS OF THE SMALL INTESTINE

BY

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Argentaffin tumours are most commonly met with in the appendix, but it is now well recognized that they may occur in any part of the gastro-intestinal tract. According to McLeod (1944) about 283 cases of carcinoid tumours of the small intestine had been reported in the literature up to May, 1944. There is general agreement that, after the appendix, the most common site is the terminal ileum.

Carcinoid tumours of the appendix are generally stated to be innocent, but in the ileum the behaviour is quite different. Humphreys (1939), reviewing 152 cases, found that 37 (24.4%) had metastases. Dangremond (1942) in a study of 46 cases found that 24 (52%) had metastases. Ariel (1939) tabulated 111 cases of carcinoids reported in the literature since 1930. In this series metastases were reported in 33 cases (29.7%). Obviously, therefore, the tumour as found in the small intestine may behave as a metastasizing malignant growth, calling for radical surgical treatment.

Case Report

Mrs. P., aged 52, was admitted to hospital on April 24, 1943. The provisional diagnosis was chronic appendicitis. The history was that in the last two years she had had intermittent attacks of abdominal pain—five in all. The last attack occurred 14 days before admission. Each attack started with pain, at first felt in the right iliac fossa, but gradually spreading over the abdomen. When asked about the radiation of the pain, she stated that it tended to travel in a direction roughly following the course of the colon. The pain was of a colicky type. During each attack the bowel was constipated. The pain was severe enough to make her go to bed. On only one occasion did she vomit, though she often felt nauseated. Each attack lasted about four days. An interesting statement was that after the attack she invariably had diarrhoea. She was not certain as to the presence of distension during an attack. Examination was largely negative. She appeared to be a healthy woman, perhaps rather stout. The skin was clear, and there was no jaundice. The mucous membranes were well coloured and the tongue was clean. No abnormality was detected on examination of the chest and cardiovascular system. The urine was normal. The abdominal wall was rather stout and the muscles were flabby. No masses were palpable. Slight tenderness was noted in the right iliac fossa, and there was unusual gurgling. P.V. and P.R. examinations were negative.

In view of the history of ? obstructive attacks a barium enema *x*-ray examination was advised. This was carried out by Dr. D. Ramage, who reported as follows: "Apparently a developmental anomaly of the colon. The right flank is empty of colon; the caecum and ascending colon are near the midline. There is no evidence of filling defect." This unexpected report raised the question of recurring volvulus as an explanation of the symptoms, and operation was accordingly advised.

Operation was carried out on May 10. The abdomen was opened by an oblique muscle-cutting incision in the right iliac fossa. The caecum and ascending colon were found to have well-developed mesenteries. There was no distension of the caecum. The appendix was healthy. On further investigation a lesion of the ileum was found. The last few inches of the ileum were distorted by adhesion, and on palpation a hard mass was felt in the centre of the adherent bowel. The bowel proximal to the tumour was not distended. A presumptive diagnosis of scirrhous carcinoma was made. The mesenteric lymph nodes were not enlarged, and no secondary deposits were found in liver or peritoneum. In view of the proximity of the growth to the caecum, a radical ileocolectomy was performed, and the ileum anastomosed to the transverse colon by the side-to-end method. No difficulty was encountered, as the colon was extremely mobile. The wound was closed, with drainage. The patient made an excellent recovery, despite some wound sepsis. She was discharged home on June 5, and has remained in excellent health since.

The specimen, unopened, was sent to Prof. A. Bernard Shaw for opinion, and he reported as follows:

"The specimen consists of the lower end of the ileum, 16 cm. long, the caecum and ascending colon, and the appendix. The attached mesenteries are loaded with fat, and the site of extensive operative haemorrhage. At 4 cm. from the ileo-caecal junction there is a transverse constriction on the outer aspect of the ileum. Embedded in the constriction is a hard mass 2 by 5 cm., which projects into the lumen of the ileum. The opaque bright-yellow material constituting this involves the submucosa and subserosa, while the muscular coat passes through it. The appendix shows no gross change. Microscopically, this is an argentaffinoma of the ileum which has infiltrated the muscular and subserous coats. The neoplastic cells give a positive reaction to Masson's silver stain, thus establishing the identity of the tumour."

Discussion

It is not proposed to discuss the pathological histology of these tumours. Masson's theory (1928, 1930) that these tumours arise from the Kultschitzky cells of the crypts of Lieberkühn, appears to be generally accepted. The cells contain granules which acquire a dark-brown stain when treated with Masson's silver stain—hence the name "argentaffinoma." The most striking feature of these tumours is the bright yellow colour on section. Usually the growth projects into the lumen of the bowel as a smooth polypoidal mass, and obviously this may lead to attacks of intussusception. Occasionally the tumour takes an annular form, giving rise to a typical ring constriction of the affected bowel.

It is obvious from personal experience that these tumours are rare. Raiford (1933) recorded 29 carcinoid tumours—9 of the ileum—as occurring in 62,000 necropsy and surgical specimens examined at the Johns Hopkins Hospital. Ariel (1939) examined 47,045 specimens at the Mount Sinai Hospital, and found 31 carcinoids.

The appendix and the terminal ileum are the two most frequently affected sites in the gastro-intestinal tract, but, as mentioned above, there is a striking difference in the malignancy of the two types. All commentators are agreed that carcinoids of the appendix are innocent. But in the ileum there is no doubt that the tumour is almost as malignant as an adenocarcinoma. Quarry Wood (1936), quoting Humphreys, points out that the incidence of metastases in carcinoids of the ileum is 24.4%, whereas the frequency of metastases in adenocarcinoma is given as 38% by Schleips. In Quarry Wood's case a lymph node 2.5 cm. from the growth was the seat of a metastasis. McLeod cites one case in which the wall of the caecum was invaded, and a second case in which a mass of tumour cells was found in a large blood vessel of the mesentery. In the case under discussion the tumour cells had infiltrated the muscular and subserous layers. Ariel sums up the question of metastases thus:

"Metastases usually occur in the regional lymph nodes, the mesenteric fat, and, to a lesser degree, the liver. . . . Metastases have been recorded as follows: 29 in regional lymph nodes, 10 in the liver, 9 in the mesentery, 2 in the peritoneum, 1 in the inguinal lymph nodes, 1 in the peripancreatic and retroperitoneal lymph nodes, 1 in the testis, and 1 in the dura mater with compression of the spinal cord."

From the clinical viewpoint, the most common picture is one of recurring attacks of intestinal obstruction. The diagnosis arrived at on clinical grounds is most likely to be carcinoma of the colon, but the barium enema *x*-ray will negative this. It may be possible on *x*-ray examination to diagnose an obstruction of the terminal ileum, as in Quarry Wood's case, but many of the cases in the literature were not accurately diagnosed before laparotomy. In the case under review the presence of a gross congenital abnormality of the colon added to the difficulties, and, as mentioned, volvulus of the caecum was considered as a possible explanation of the symptoms.

In view of the evidence as to the malignancy of the tumour treatment must be radical, and as many of the growths are very close to the caecum an extensive resection of gut is necessary. The prognosis depends on the presence or otherwise of irremovable metastases. In the literature, only one reference to