Free Flap Transfer with Microvascular Anastomosis

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SUMMARY

The development of the flap transfer technique in plastic and reconstructive surgery has evolved to the stage where free transplantation of a full-thickness skin flap, by means of microvascular anastomosis, has become possible. For the first time in South Africa, a case is documented where such a free graft was used successfully to reconstruct a severe burn contracture of the neck. Experience with this and subsequent cases has taught valuable lessons about the procedure.

S. Afr. med. J., **50**, 2026 (1976).

An important recent advance in plastic and reconstructive surgery has been the development of the free full-thickness flap graft. The first report of a successful one-stage free transfer of such a flap, by Daniel and Taylor[1] in 1973, was accompanied by an editorial which stated that it represented the birth of a new era in reconstructive surgery.

In this article we propose to trace the development of free flap grafting and to document our experience in this field.

DEVELOPMENT OF THE FREE FLAP GRAFT

The use of skin flaps for the repair of soft tissue defects is as old as reconstructive surgery itself. In the beginning, however, little was known about the anatomy and physiology of the vasculature of the skin and flaps survived by chance rather than through planning. These early flaps usually had a random supply of blood vessels and their design and size were determined only by their length-to-width ratio.

Even the tubed pedicle flap, perfected by Sir Harold Gillies early in this century, had a random blood supply and was not designed to include axial blood vessels. With these tubed flaps large amounts of tissue could be moved in stages from the donor site to a defect elsewhere on the body, and it became possible to perform reconstructions previously considered impossible. This procedure, however, is time-consuming, often stretching over months, and entails uncomfortable body positions for the patient.

In 1946 Shaw and Payne[2] described a single-stage tubed abdominal flap based on the superficial epigastric arteriovenous system. Although it was not fully recognised at the time, this was a major advance. Here, for the first time, a flap was purposely designed according to a specific arteriovenous system supplying the skin. The great advantage of this type of flap was that a block of skin and subcutaneous tissue could be transferred in a very much shorter space of time. During the 1950s William Littler[3] applied the same principle when he pioneered the use of neurovascular island flaps in reconstructive procedures to the hand.

It remained however, for McGregor and Jackson[4] to point out the true value of axial pattern flaps, as they became known. They commented on the safety of the medially based deltopectoral flap developed by Bakanjian and postulated that its success depended on its unique vascular characteristics; 'instead of the usual pattern accepted for tube pedicles, the deltopectoral flap has a virtually closed arteriovenous system deriving from and draining back into the perforating branches of the internal mammary system'. Applying this knowledge, they found similar vascular systems elsewhere on the body. In 1972[5] they described the groin flap, a new, single-stage tubed pedicle flap based on the superficial circumflex iliac vessels, and reported its successful use in 35 patients. This discovery, together with that of the deltopectoral flap, rendered the multi-stage random tubed flaps virtually obsolete.

Despite its versatility the axial pattern flap still has limitations and disadvantages. It is still a staged procedure and usually requires delay before its transfer. Active patient co-operation is required, which limits its use in children. Loose, mobile joints are essential and this precludes its use in the elderly, the arthritic or the immobilised patient.

The stage was set for the next advance in flap reconstruction. Buncke and Schulz,[6] in discussing their experience with total re-implantation of the rabbit ear, stated that 'the successful transplantation of a block of composite tissue by re-anastomosing the microvascular pedicle has untold experimental and clinical possibilities'. As the vessels which supply axial flaps are often less than 1 mm in diameter, anastomosis of these vessels would certainly require an operating microscope. Clinical microsurgery had already been established, with the re-implantation of severed digits, toe-to-hand transfers and the transfer of omental tissue to the cranium. Free skin flap transfer had succeeded in experimental animals, and the clinical application of this procedure was merely a matter of time.

This goal was reached in 1973 when Daniel and Taylor[1] reported the successful transfer of an ileofemoral flap containing skin and subcutaneous tissue and based on the superficial circumflex iliac vessels, to a defect on the lower limb of a patient. Articles by Harii *et al.*,[7] O'Brien *et al.*[8] and Rigg[9] soon followed, in which their experiences with this procedure were described. Free flaps have now been used to cover defects all over the body. Donor sites include the forehead (utilising the superficial temporal vessels), the deltopectoral area (internal mammary vessels) and the groin (superficial inferior epigastric and superficial

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Date received: 16 August 1976.

circumflex iliac vessels). Despite its technical difficulties the free flap procedure therefore represents a major advance in flap surgery.

As far as we are aware, the following case report is the first documentation of a successful free flap graft performed in South Africa.

CASE REPORT

History

A 16-year-old Coloured girl was referred to our unit with serious burn contractures of the face, neck, trunk and upper extremities. The contracture of her neck anchored her chin to the sternum, severely limiting extension and rotation. In addition, she had contractures of both elbows and axillae (Figs 1 and 2).

The first priority, especially to facilitate anaesthesia in the future, was the release of the neck contracture and reconstruction with soft, pliable tissue. Split skin grafting is a poor solution, since contraction of the graft usually leads to recurrence of the flexion deformity; a skin flap is always preferable.

The extent and severity of the burns on the patient's anterior chest wall precluded the use of a local deltopectoral flap, but her groin was relatively free of scars and seemed suitable as a donor site. The problem was that neither of her arms could be used to transport the groin flap. The only alternatives were either reconstruction by way of a random tubed flap brought forward from her back (a multi-stage procedure with high incidence of complications) or a free flap transfer with microvascular anastomosis.

Fig. 1. Frontal view of the patient, showing the scarred and contracted areas on the neck, trunk, axillae and arms.

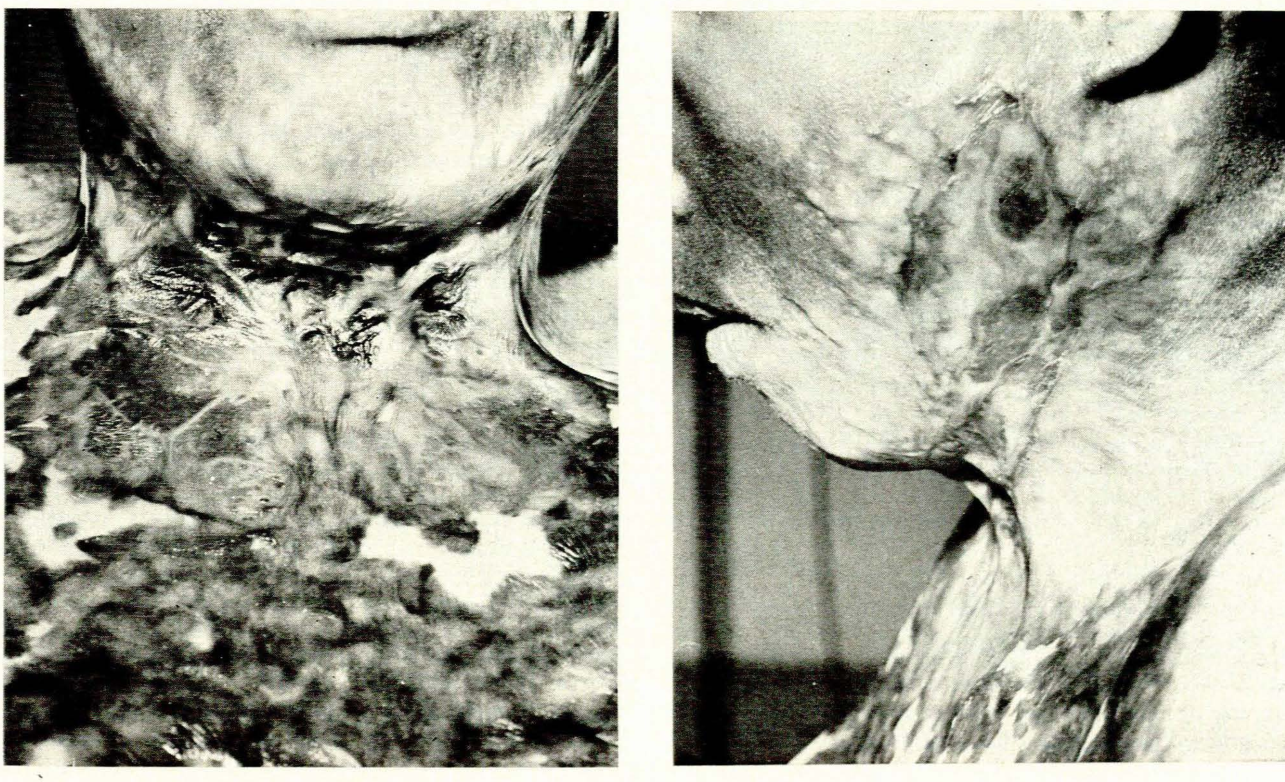

Fig. 2. The severe neck contracture.

As we were prepared for such a procedure (see below) we decided on a free flap graft.

Pre-operative Preparations

Before the operation, experience in microvascular surgery was obtained over many months by the performance of end-to-end anastomosis on the femoral vessels, aortae and inferior venae cavae of rats. The diameters of these vessels correspond well with those in the groin flap.

We also investigated the exact anatomy of the vascular network in the groin. This detailed knowledge is necessary to enable the surgeon to isolate the vessels, while ensuring the least possible trauma to their walls. Dissections were thus carried out on the groins of a number of fresh cadavers, special attention being paid to the vascular network in this area.

To facilitate the demarcation of the flap and the localisation of its vessels, the course of the superficial circumflex iliac and superficial inferior epigastric arteries was marked on the patient's groin pre-operatively with a Doppler apparatus.

Operation

With the patient under hypotensive anaesthesia, a team of four surgeons undertook the procedure on 22 May 1976. Two surgeons excised the scar tissue in the neck and isolated the vessels at the recipient site, while the other two surgeons raised the flap in the left ileofemoral area. In the neck, the right facial artery, the right external jugular vein and a median cervical vein were isolated (Fig. 3). In the groin, those isolated were the superficial circumflex iliac artery, the superficial inferior epigastric artery and a plexus of veins forming two main vessels which drained into the great saphenous and femoral veins (Figs 3 - 6). After the flap had been dissected free of the surrounding tissues, its vascular connections were left intact for a short period in order to prove its viability. During this period the recipient vessels were finally prepared.

Attention was then redirected to the flap vessels. These vessels were ligated and cut — arteries preceding veins. They were made as long as possible on the flap end to facilitate anastomosis. No clamping was performed on the flap vessels in order to limit damage to their walls. In the recipient area the facial artery was lightly clamped proximally with a stainless steel Ligaclip. After it had been ligated distally, it was transsected. The two veins were treated in a similar way, except that here the clips were applied distally. The steel clips were applied lightly, so that they could be slipped up and down the length of the vessels, yet not permitting any bleeding from the cut ends.

The outer diameters of the vessels were as follows: superficial circumflex iliac artery — 1,2 mm, superficial inferior epigastric artery — 1,0 mm, draining flap veins — 3,8 mm and 2 mm, facial artery — 2 mm, external jugular vein — 4 mm, median cervical vein — 2,2 mm.

It was decided that one artery and two veins would be anastomosed, and since the superficial circumflex iliac artery was the larger of the two in the flap, this was chosen for anastomosis with the facial artery. With the use of a double binocular operating microscope and microsurgical instruments, the veins were anastomosed first, followed by the artery. Suture material consisted of 10/0 black monofilament nylon on a GS.9 needle, and 6 - 8 interrupted sutures were placed for every anastomosis.

For colour contrast, a sterile strip of green plastic sheeting was placed under the vessels which were being anastomosed. This also protected the anastomotic site from the direct influence of tissue thromboplastins. Further protection against clotting in these small vessels was ensured by washing their cut ends with a heparin-saline solution and continuous gentle lavage of the operative field with a 2% solution of $MgSO_4$. The flap itself was not perfused prior to anastomosis. An intravenous infusion of low molecular weight Dextran was instituted intra-operatively with the aim of improving peripheral blood flow and reducing platelet adhesion and aggregation.

After the microvascular anastomosis had been completed, the clips on the vessels were removed, those on the veins before those on the artery. Immediately thereafter the flap edges turned a healthy pink and arterial bleeding was observed from the distal end of the flap. This indicated a patent arterial anastomosis. Slight bleeding from the anastomosed sites was easily controlled by the application of light pressure. After a few minutes, it was noted that the flap edges had stopped bleeding and that the tissues had again become pale. Inspection of the artery showed no evidence of thrombosis, but an area of vasoconstriction was evident proximal and distal to the anastomotic site. The veins appeared to be empty. The arterial spasm lasted for approximately 40 minutes. Lignocaine was dripped onto the spastic segment in an attempt to alleviate the spasm, but had little apparent effect. Manipulation of the artery between thumb and forefinger produced a temporary flush, however, and this determined the decision not to re-anastomose.

The flap was then sutured into place with 4/0 black silk over a corrugated drain. No dressing was applied. A small remaining defect on the right cheek was covered with a split skin graft, as was the donor site of the flap, after the exposed femoral vessels had been covered by transpositioning of the gracilis muscle. Total operating time was 6 hours 40 minutes, while the actual anastomosis took 1 hour 50 minutes.

Postoperative Course

During the immediate postoperative period the flap temperature proceeded to improve distally and after about 2 hours it was uniformly warm. Because of the darkly pigmented skin in this patient, estimation of its viability according to the colour of the flap was impossible. A small area of depigmentation due to burn scarring, however, served as a testing site for capillary refill. It soon became clear that, for a while at least, the flap was holding its own — it was uniformly warm, had a good capillary refill on release of pressure, and did not appear congested (Fig. 7). Dextran infusion was continued for 72 hours and Persantin and aspirin were given by mouth in an attempt to prevent thrombosis. No systemic heparin was administered.

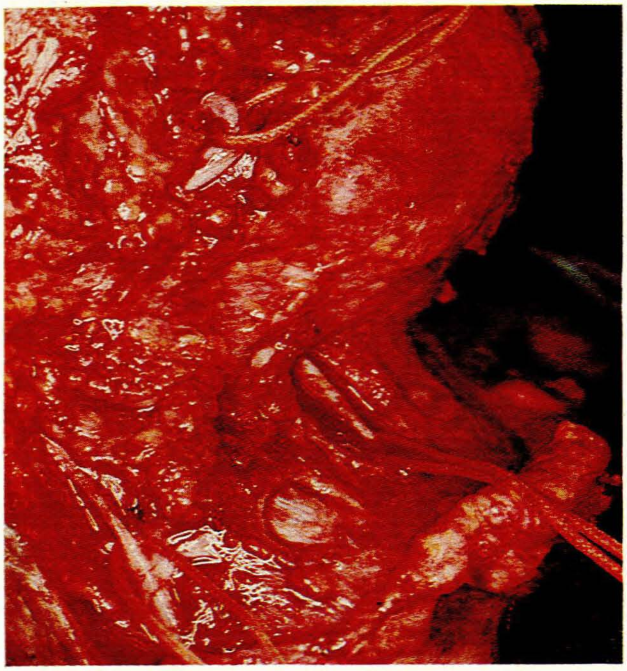

Fig. 3. Defect over chin and anterior neck after excision of scar tissue. Tapes mark (from above downwards) **the right facial artery, a median cervical vein and the right external jugular vein.**

Fig. 4. Pre-operative markings of the flap donor site in the left ileofemoral region (see also Fig. 1), depicting the anatomical landmarks and the course of the vessels in the flap.

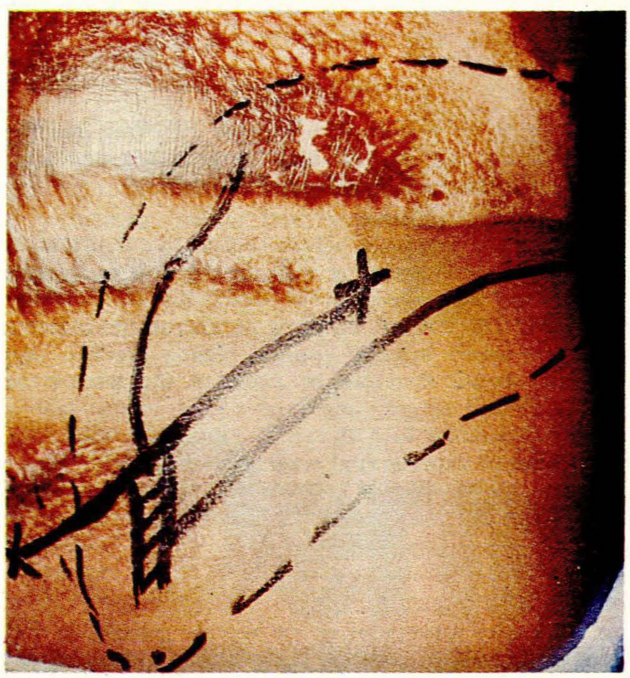

Fig. 5. View of flap prior to isolation of the vascular pedicle.

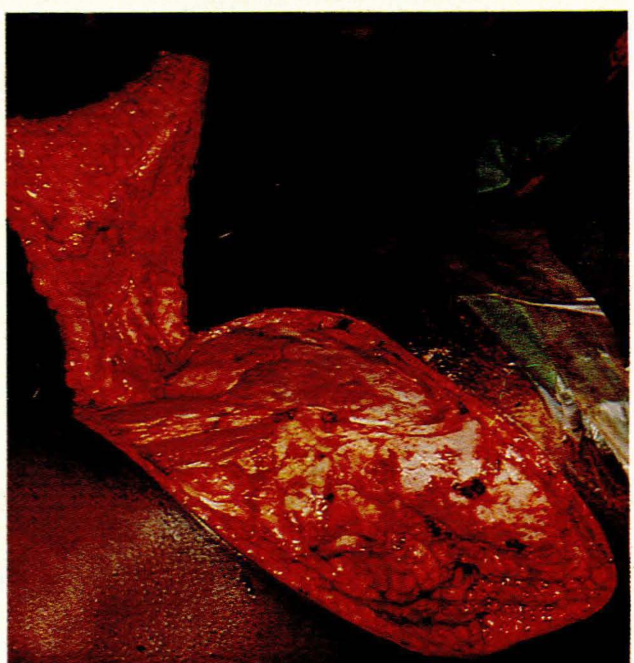

Fig. 6. Detail of the vascular pedicle: (a) **superficial circumflex iliac artery and venae comitantes;** (b) **superficial inferior epigastric artery;** (c) **central axial venous complex.**

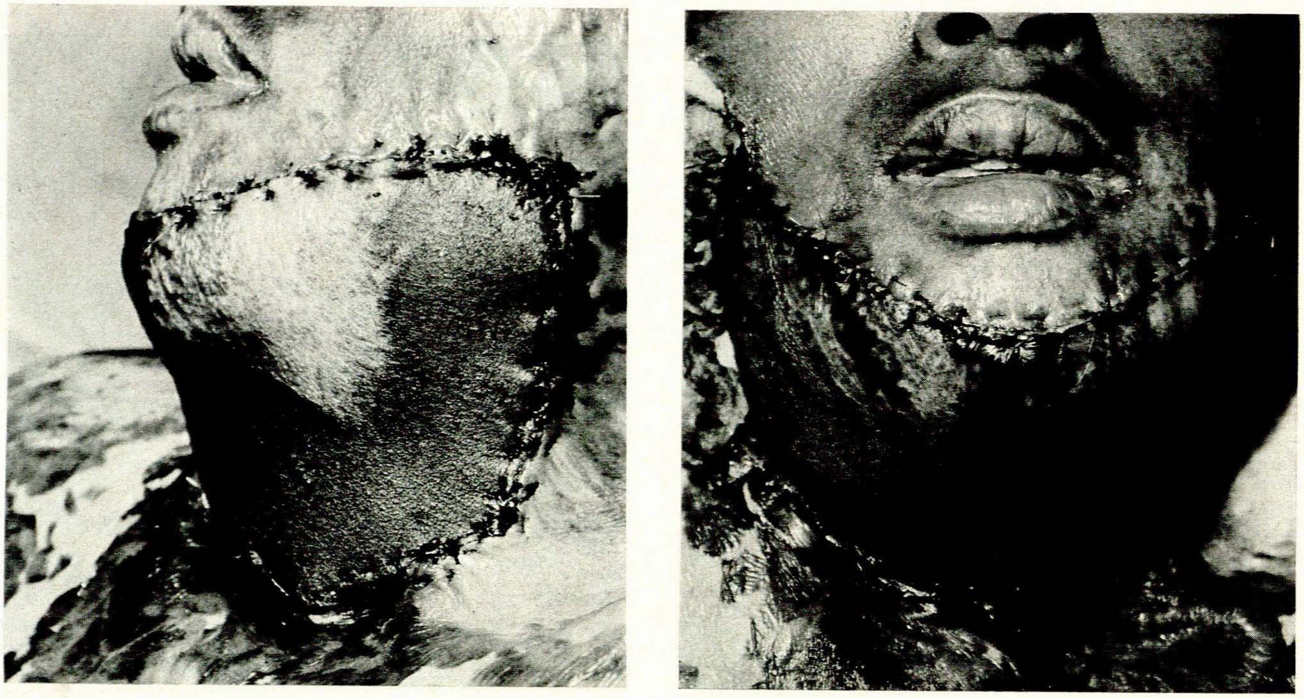

Fig. 7. Appearance of the flap on the first postoperative day.

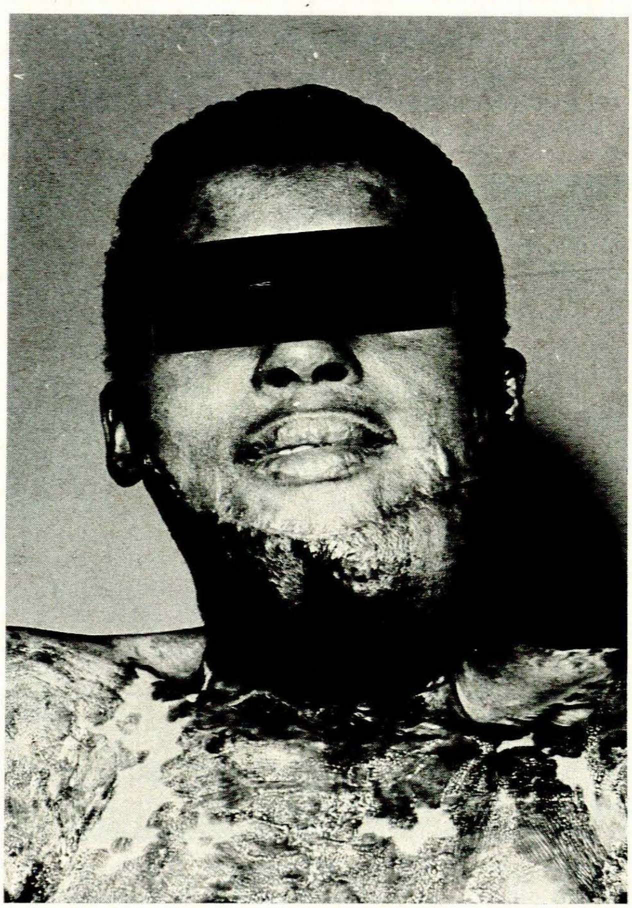

Fig. 8. The flap 4 weeks after its transfer.

Antibiotic prophylaxis was maintained for a week. From the 3rd to the 5th postoperative day the flap gradually became oedematous, but its circulation continued to be excellent. When the stitches were removed on the 10th postoperative day the oedema had subsided and there was no evidence of necrosis. The patient was discharged after an uneventful postoperative course (Fig. 8).

DISCUSSION

Subsequently we performed a number of other free flap reconstructions and we feel that the following points are essential for success with this type of grafting:

1. Extensive experimental and clinical experience in microsurgery is necessary before clinical free flap transfer can be attempted. Operating with the aid of a microscope transfers the uninitiated into an unaccustomed dimension of surgery. The efficient handling of microsurgical instruments and suture material requires regular practice; constant use should therefore be made of the microscope, both in clinical surgery and in the experimental laboratory. Small animals such as rats or rabbits are well suited to this kind of experimental surgery as their larger vessels correspond closely in size to those in the human skin flap. Both end-to-end and end-to-side anastomoses should be practised, the former by re-anastomosis of transsected femoral vessels or rat aortae, the latter by portacaval anastomoses.

2. A detailed knowledge of the vascular pattern in both donor and recipient sites is of prime importance, and dissections done on fresh cadavers have proved to be of great benefit in this regard. Pre-operative mapping of the course of the arteries with the aid of the Doppler apparatus is also helpful.

3. In our experience, the thicker the subcutaneous layer, the more difficult the procedure. There is apparently also no direct relationship between the flap thickness and the diameter of the vessels serving that area. Obese patients should therefore not be considered for this type of procedure, when other forms of flap reconstruction are possible.

4. Teamwork is essential and a group of four surgeons seems to be optimal — two to prepare the recipient site while the other two raise the flap. The anastomosis should be done by two surgeons who are both proficient in microsurgery. The remaining two can then proceed to close the donor defect, either directly or by skin grafting.

5. Detailed electron microscopic studies have proved that too-tight clamping of the vessels causes medial necrosis and intimal sloughing.[10] Although this damage appears not to be severe enough to cause thrombosis, it does lead to a fusiform dilatation of the vessel. This dilated segment is incapable of vasoconstriction and causes turbulent blood flow and stasis which probably contribute to late, unexplained arterial thrombosis after an episode of trauma or vasoconstriction. The utmost care should therefore be exercised when clamps are applied to these vessels.

6. Much controversy still exists in respect of prevention of intra-operative thrombosis. The local application of both heparin and $MgSO_4$ has been shown to have no effect on its occurrence or otherwise.[11]

7. Clinical evaluation of the viability of the flap in the early postoperative period presents a special problem in dark-skinned people, since flap colour and capillary refill cannot be assessed as readily as in those with light skins. The Doppler apparatus and plethysmography may, however, prove to be of value in determining postoperative arterial patency.

CONCLUSION

Since its birth more than 3 years ago, clinical free flap surgery is now coming of age. Whereas initially this procedure was limited to those patients in whom no other means of flap reconstruction was considered possible, it can now be implemented as an alternative to the older methods. Its great advantage lies in the fact that an entire reconstructive programme can now be completed in a single procedure, thereby greatly reducing the duration of hospitalisation. It is still a technically difficult procedure, however, limited to those institutions where adequate laboratory and operating room facilities are available.

We gratefully acknowledge the assistance given us by Optical Instruments, distributors of Zeiss operating microscopes, for our experimental work and for the colour photographs reproduced in this article.

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HAEMOGLOBINS WITH ALTERED OXYGEN AFFINITY

The abnormal haemoglobins with altered oxygen affinity have provided a means of relating the structure of haemoglobin to its prime function — oxygen transport. They have also enabled physiological studies of the compensatory mechanisms of oxygen transport to be made, showing that red cell oxygen delivery is a determinant of erythropoietin release and hence of bone marrow activity.

Clinically, they represent an interesting albeit rare diagnostic challenge, particularly in the differential diagnosis of polycythaemia. The importance of establishing the diagnosis rests largely on protecting the patient from unnecessary and potentially harmful treatment and enables genetic counselling to be given when an abnormality is found.

Brit. med. Bull., **32**, 234 (1976).

TRADITIONAL MEDICAL BELIEFS AND PRACTICES IN THE CITY OF TIMBUCTOO

Timbuctoo is a multi-ethnic Moslem town situated in northern Mali. Serious illness is attributed to such causes as genii, sorcerers, and witches. The prevention and treatment of illness is managed at the traditional level by the *marabouts* (Moslem clerics) and by magician-healers. The modern hospital in the town, while providing medical care of relatively good quality, is not utilised fully by large segments of the population. Many people use both medical care systems simultaneously or successively. Only a few use modern medical services exclusively. The enduring power of the traditional practitioners lies in their ability to provide patients with what they urgently desire, to know why they are ill.

Bull. N.Y. Acad. Med., **52**, 241 (1976).