Vol 6, 1954 Br J Plast Surg

THE EARLY CIRCULATION IN SKIN GRAFTS WITH A CONSIDERATION OF METHODS TO ENCOURAGE THEIR SURVIVAL

By WILFRED HYNES, F.R.C.S.

Plastic and Jaw Department, The United Sheffield Hospitals

THE successful "take" of skin grafts, on which the plastic surgeon so largely depends for his results, is such an everyday experience that it is apt to be taken for granted. A study of the factors which allow such a graft to be nourished and to survive before the arrival of a true blood circulation from the defect on which it is placed is worthy of consideration. A knowledge of the primitive circulation in a skin graft has important practical applications and, in addition, may throw some light on the problem of wound healing in general.

THE BLOOD-VESSELS OF A FRESHLY CUT SKIN GRAFT

Microscopic examination of a freshly cut skin graft shows that its vessels are collapsed and are either empty or contain only an occasional red blood cell (Fig. 1, A); this finding applies to skin grafts of all thicknesses, from the thin razor graft to the full-thickness Wolfe graft.

That this is not the result of the pressure exerted by the board or dermatome as the graft is being cut is proved by the fact that the vessels remain collapsed and empty in skin grafts which are raised without the use of any pressure appliance whatever. Even if a skin graft is cut from the surface of a limb which is congested with blood by the obstruction of its veins by means of a lightly applied tourniquet, its vessels are still found to be collapsed and empty. It is therefore concluded that, as a skin graft is being cut, its vessels go into spasm which expels their contents through the opened capillary plexus on the deep surface of the graft. A similar temporary spasm of skin vessels as the result of trauma is demonstrated by the delayed onset of bleeding from a superficial cut while shaving, and also from the surface of the dermis exposed on a donor area from which a skin graft has been cut.

The observation that the vessels of a skin graft are collapsed and empty is important, as it enables us to conclude that any red blood cells that are found in the vessels of a skin graft *after* it has been placed on an unhealed wound must have entered the graft from the defect.

THE EXAMINATION OF A SKIN GRAFT AFTER IT HAS BEEN PLACED ON A VASCULAR DEFECT

The subject of the experiment (which has been confirmed on other patients) was a female patient, aged 24 years, with a seventeen-day-old healthy granulating wound of the thigh. A medium split-skin graft was cut from the opposite thigh and divided into nine pieces, each of postage-stamp size. One "postage-stamp" was sent for microscopic examination which showed that its vessels were collapsed and empty (Fig. 1, A). The other eight pieces of skin graft were placed on the granulating thigh defect and the area was left exposed without dressings to allow the following examinations to be made :—

1. *Fifteen minutes after the grafts were applied to the defect*, one " postage-stamp " graft was removed and the underlying granulations were inspected. The granulation tissue, previously almost dry, was seen to be very wet due to the effusion of a clear fluid which had deposited a light fibrin clot. A similar observation has been made on many occasions and it would seem that a skin graft in some way stimulates a vascular defect to exude tissue fluid. It is possible that this is due to the presence of a histamine-like substance on the deep surface of the graft; the application of histamine solution to a granulating wound certainly produces a very similar effect.

2. *Six hours after the grafts were applied to the defect*, another " postage-stamp " was lifted off and sent for section. This graft, though lightly held in place by filaments of fibrin on its deep surface, was easily separated from the defect, the surface of which was wet. Microscopic examination showed that the vessels of the graft were still collapsed and empty.

3. *Twelve hours after the grafts were applied*, another " postage-stamp " was removed and sent for section. The findings were exactly the same as at six hours.

4. *Twenty hours after the grafts were applied*, another " postage-stamp " was removed and sent for section. This graft was slightly pink in colour and was not closely adherent to the surface of the defect which was covered with a copious tissue fluid exudate.

The microscopic examination of this twenty-hour skin graft showed that many of its vessels were now dilated but still contained no red blood cells (Fig. 1, B).

5. *Twenty-four hours after the grafts were applied*, a further " postage-stamp " was lifted off the defect and sent for section. Though the graft was lightly held to the surface of the defect by fibrin filaments, the complete absence of capillary bleeding from the underlying granulations as the graft was removed indicated that capillaries from the surface of the defect had not yet reached the deep aspect of the graft.

The granulation tissue thus exposed was covered with a copious fluid exudate some of which was picked up on a platinum loop without actually touching the surface of the defect. When spread on a glass slide and treated with Leishman's stain, the exudate showed the presence of many red blood cells together with a smaller number of polymorphonuclear leucocytes (Fig. 1, C).

Microscopic examination of the twenty-four-hour skin graft showed that many of its vessels were now of normal size and contained red blood cells (Fig. 1, D), while occasional polymorphonuclear leucocytes could be seen both inside and outside these vessels.

6. *Further " postage-stamps " were removed from the surface of the defect thirty-three, forty-two, and forty-eight hours after they were first applied.* The findings were similar to those of the twenty-four-hour graft except that the vessels became progressively distended with red blood cells until, in the forty-eight-hour graft, they were grossly dilated and were packed with these cells (Fig. 1, E); the appearance resembled that seen in the vessels of an infarct.

Five conclusions have been drawn from the above observations :—

1. The vessels of a freshly cut skin graft are collapsed and empty. When the graft is placed on a suitable defect, its vessels are not obliterated but are used to receive and transmit a tissue fluid and, later, a blood circulation.

2. The empty, collapsed vessels of a skin graft become dilated about twenty hours after it has been placed on a healthy defect.

3. A fluid exudate is produced at the surface of a vascular defect; it accumulates under an overlying skin graft within fifteen minutes of the application of the graft and increases rapidly in amount during the next two days. The exudate

E

FIG I

Illustrates the changes which occur in the vessels of a skin graft before, and at various intervals after, placing it on a healthy granulating defect.

E, Capillary which is grossly distended and packed with red blood cells in a skin graft which has been applied to the defect for forty-eight hours. × 240.

contains numerous red blood cells and some polymorphonuclear leucocytes; the presence of fibrinogen in the exudate can be inferred from the fact that it clots on standing.

4. Red blood cells from the vessels of a healthy defect appear in the capillaries of an overlying skin graft within twenty-four hours of its application to that defect, *i.e.*, before capillaries have bridged the space between defect and graft. The fluid which accompanies these red blood cells into the vessels of the graft must be fibrinogen-free as the vessels of the graft would otherwise become permanently occluded by the deposit of fibrin in them. It follows, therefore, that the fluid exudate which accumulates on the surface of a healthy defect deposits its fibrinogen in the form of fibrin on the surface of that defect; the fibrinogen-free suspension of erythrocytes which results then enters the capillaries of the overlying skin graft.

5. The fact that the small vessels of a twenty-four to forty-eight hour skin graft contain red blood cells with little, if any, accompanying fluid (Fig. 1, D and E) suggests that the fibrinogen-free fluid, which entered the vessels of the graft with the red cells, has passed through the capillary walls into the substance of the graft. It would appear, therefore, that within twenty-four hours of placing a skin graft

on a vascular defect, a primitive circulation of fibrinogen-free fluid takes place between the surface of the defect and the substance of the overlying graft through the medium of the vessels of the graft.

The Blood-vessels of a Free Graft

The blood-vessels of a free piece of tissue of any kind, whether it be a skin graft, a bone graft, or a massive piece of skin with its underlying fat, are living structures which survive for a certain length of time. The changes which occur in these living vessels once the tissue is cut from the body can be surmised from our knowledge of the reactions of blood-vessels to known stimuli. Thus it can be assumed that, when any piece of tissue is separated from the body, its vessels, after first going into spasm, dilate widely as the result of anoxia and also of the fact that they are divorced from the nervous system of the host and are therefore sympathectomised. In this way they are converted into wide channels which, in the case of a skin graft, are empty and are therefore able to accept any tissue fluid which may be presented to them.

Tissue fluid is exuded at the surface of a defect at a pressure which must approximate to that at the arterial ends of the capillaries in that situation and, with a highly vascular defect, this may be of the order of 20 mm. Hg. The fluid exudate which collects between such a defect and an overlying skin graft will, therefore, readily enter the dilating vessels of the graft in which the pressure must be zero. This provides a possible explanation of the easy survival and " take " of skin grafts.

In the case of massive free grafts of (say) skin together with its underlying subcutaneous fat, however, conditions are different. When such a piece of tissue is cut from the body the initial spasm of its vessels cannot empty them as, unlike a skin graft, it has no extensive open capillary plexus on its raw surface through which the blood can escape. The blood, imprisoned in the vessels, coagulates and the vessels are therefore no longer available for the reception and transmission of nutrient fluid from the surface of any defect on which the graft is placed. The massive graft, therefore, dies before it can be nourished by the ingrowth of new capillaries from the defect.

Practical Applications

As described above, the early survival of a skin graft depends on two main factors: (1) The amount and pressure of the nutrient fluid exuded from the surface of the defect on which it is placed; and (2) the vessels of the graft itself, which are first emptied and then dilate, thereby encouraging the nutrient fluid to enter them.

In order to ensure the " take " of a skin graft on a defect with a poor blood supply we can try to influence both these factors.

(1) We can encourage the flow of nutrient fluid from the surface of the wound at the highest possible pressure and in the greatest amount, using the lightest of pressure dressings over the grafted defect in the post-operative period; or, if possible, by avoiding pressure dressings altogether. Skin grafts " take " readily under these conditions.

(2) *The "loaded" skin graft.* As already described, a freshly cut skin graft is bloodless; when placed on a defect it has, therefore, to live on its own resources until such time as nutrient tissue fluid can be supplied to it in adequate amounts from the surface of the defect. If the defect is a healthy one, tissue fluid reaches the graft quickly and in quantity. If, on the other hand, the defect is of poor vascularity, the effusion of tissue fluid from its surface appears late and in limited amount; a skin graft placed on such a defect may, therefore, perish from lack of

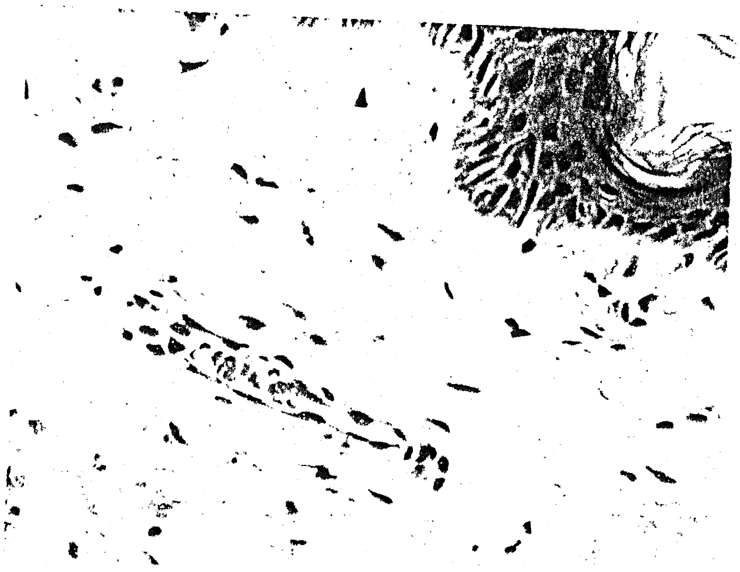

FIG. 2

A "loaded" skin graft showing a capillary which is of normal size and contains red blood cells. ×385.

nutrition. If such an ischæmic defect, however, is covered by a skin graft whose vessels are first filled (or "loaded") with tissue fluid, the graft may well survive on these resources until such time as the defect is capable of producing enough tissue fluid to support it.

The "loading" of a skin graft with nutrient fluid prior to its application to a defect is carried out as follows: The day before the defect is due to be covered, a skin graft is cut under local anæsthesia and is then sutured back on the exposed dermis of its donor area. On the next day the graft, now "loaded" with tissue fluid which it has picked up from the underlying healthy dermis (Fig. 2), is lifted off its donor area and is placed on the defect to be covered. The grafted area is then dressed with a very light pressure dressing.

These two methods of covering ischæmic defects whose blood supply is unlikely to support an ordinary skin graft, though still under trial, are producing promising results.