

Island flaps with an exclusively venous pedicle. A report of eleven cases and a preliminary haemodynamic study

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Summary—Eleven cases are reported of island flaps containing only venous pedicles. All but two survived completely without arterial input and all the successful cases were on the extremities. The possible reasons for this are discussed.

Skin flaps are normally characterised by arterial inflow and venous outflow. In the case of island flaps, the pedicle may be subcutaneous, muscular, fascial or an isolated artery and vein.

In 1978 we made the chance discovery that an island flap with only a venous pedicle survived with an excellent circulation. This patient is described in detail in Case 1 of our series (see below). Since then we have raised a number of flaps without arterial inflow, particularly on the extremities, and almost all have done well.

Such flaps are interesting, less for their specific surgical advantages than for the understanding of the haemodynamics of their behaviour; a venous pedicle is not only *necessary* to the viability of a skin flap but is *sufficient* under certain conditions.

Materials and methods

The Table summarises 11 clinical cases treated in our Unit over the last few years.

The series is limited for two reasons: firstly, because the improbable nature of such flaps meant that they were considered for some time with disbelief by the members of our team and, secondly, due to the difficulty of finding haemodynamic justification for the first clinical cases.

The venous pedicle (1 or 2 veins) of several flaps was very carefully dissected and the possibility of an arterial axis eliminated.

In two cases (6 and 7) the dorsal metacarpal arteries of Foucher's "kite" flap (Foucher and Braun, 1979) were deliberately clamped and then severed.

In all the cases of flaps taken from the dorsal surface of the first phalanges of the index, long and

ring fingers, the collateral dorsal artery described by Oberlin and Lequang (Tubiana, 1983) was severed (Cases 3, 4, 5, 9, 10 and 11). These were therefore true cutaneous flaps with exclusively venous pedicles.

Clinical results

There were two partial failures among our 11 cases (Cases 2 and 8, described below). In all the other cases it was noteworthy that these venous flaps were *immediately* normally vascularised, with normal colour and capillary return and with no sign of ischaemia or venous stasis. They reacted in the same way as flaps with a conventional pedicle with arterial inflow and venous outflow.

Illustrative case reports

We describe below the most significant clinical cases: the first gave us the initiative to undertake the series, the second concerns a free venous island flap which is of demonstrative value in spite of partial failure, the third shows the limitations of the type of flap and the fourth is an example of the proper indication and successful realisation of venous flaps in the hand.

Case 1.

A male paraplegic patient aged 22 years had a left lateral malleolar pressure sore. After debridement, there was an ulcer 5 cm in diameter, its centre formed by the bony protruberance of the malleolus on a level with the surrounding connective tissue.

We considered how best to close this defect. A thin graft would not have been adequate and a dorsalis pedis island flap would have provided a donor site with potential problems. We opted for a modified full thickness

Table Details of venous flaps

Case	Age	Sex	Aetiology	Site	Venous island flap donor site	Dimensions	No. of veins in pedicle	Result
1	22	M	Pressure sore	Ext. malleolus	Dorsum foot	5 cm ²	1	Successful
2	13	M	Burn alopecia	R. temporo-frontal	Free temporo-frontal	2.5 × 8 cm	1	Dermal necrosis
3	20	M	Electrical burn	1st web hand	Dorsum proximal phalanx index	2 × 3 cm	1	Successful
4	59	M	Trauma	Thumb pad	Dorsum proximal phalanx index	2 × 3 cm	1	Successful
5	30	M	Trauma	Thumb pad	Dorsum proximal phalanx index	2 × 3 cm	1	Successful
6	40	F	Electrical burn	Palmar surface Proximal phalanx Thumb	Dorsum proximal phalanx index	2 × 3 cm	2	Successful
7	70	M	Trauma	Palmar surface IPJ thumb	Dorsum proximal phalanx index	2 × 3 cm	1	Successful
8	68	M	SCC	Dorsum MCPJ index	Dorsum proximal phalanx ring finger	2 × 3 cm	1	Superficial necrosis
9	57	M	SCC	Dorsum 2nd web	Dorsum proximal phalanx ring finger	2 × 3 cm	1	Successful
10	70	M	Radionecrosis + recurrent SCC	Dorsum MCPJ + proximal phalanx middle finger	Dorsum proximal phalanx + PIPJ index	3 × 4 cm	2	Successful
11	22	M	Surgical complication	Volar surface index Proximal phalanx	Dorsum proximal phalanx middle finger	2 × 3 cm	1	Successful

skin graft, hoping that this could be improved by preserving a thin subcutaneous venous layer and venous drainage. We took this from the dorsal surface of the foot and included the dorsal venous arch and two marginal veins draining into the long saphenous vein. When what was really an island flap was isolated on its venous axis, it was passed under the pre-malleolar skin bridge and placed over the lateral malleolus.

We were surprised to observe that a capillary return was present and the appearance of the flap was normal, pink, well vascularised and without ischaemia or stasis, whereas we had thought that it would be "white". After it had been sutured to the edges of the ulcer, capillary return was still present and the flap remained well vascularised with no ischaemia except for very minor venous stasis in the distal part.

The patient has been seen again since the operation in September 1978 and there has been no deterioration or recurrence of an ulcer at the same site (Fig. 1).

Case 2.

A female patient aged 13 years had an area of temporo-frontal alopecia and a decision was made to replace it with a free temporo-parietal scalp flap from the other side.

Doppler testing for the parietal branch of the superficial artery revealed a strong venous bruit thought to conceal the arterial axis, as this branch of the temporal artery is generally located at this site. The flap, together with the epicranial aponeurosis, was dissected from the distal to the proximal part. It was 2.5 cm wide and 8 cm long. At

the end of the dissection we were unpleasantly surprised to find at the origin of the flap only a large vein with no collateral arterial element.

We decided to transplant the free flap with an exclusively venous pedicle which was sutured to the superficial temporal vein at the recipient site. At the end of the operation there was slight venous stasis and a slow capillary return; the flap remained warm, but from the 48th hour it deteriorated and appeared necrotic. Surgical excision was decided upon on the 5th day. When the distal part of the flap was approached it was seen that only the skin was necrotic; the aponeurotic and subcutaneous layers were still well vascularised and dissection of the venous axis showed a well filled vein and patent



Fig. 1

Figure 1—Case 1. Postoperative appearance.

anastomosis (Fig. 2). A postoperative Doppler test confirmed that the vein was functional.

This case was therefore clinically a failure as the superficial necrosis resulted in the loss of the majority of the hair follicles. However, haemodynamically it is interesting since the entire deep part of the flap was nourished by only a microscopically sutured vein, which suggests that a venous pedicle can nourish a flap providing it is below a critical volume.

Case 8.

A male patient aged 68 years had a squamous cell carcinoma of the dorsal surface of the metacarpophalangeal joint of the right index finger.

Excision was performed with a safety margin around and below the lesion, exposing the extensor tendon.

To repair the loss of substance, a venous island flap was taken from the dorsal surface of the first phalanx of the long finger. Two dorsal veins were dissected for 5 cm proximal to the flap, making it possible to transpose the flap to cover the defect, after passage under a skin bridge.

At the end of the operation, which was carried out without a pneumatic tourniquet, the flap was white and capillary return was absent.

Over the next few days cyanosis followed by superficial necrosis appeared, as is commonly observed in full thickness skin grafts. Healing was finally obtained, without exposure of the underlying layers. The blood supply to this flap was inadequate and this was the only case in which the venous pedicle was dissected for several centimetres beyond the metacarpal heads.

Case 10.

A male patient aged 70 years had radionecrosis and recurrence of an epithelioma of the dorsal surface of the

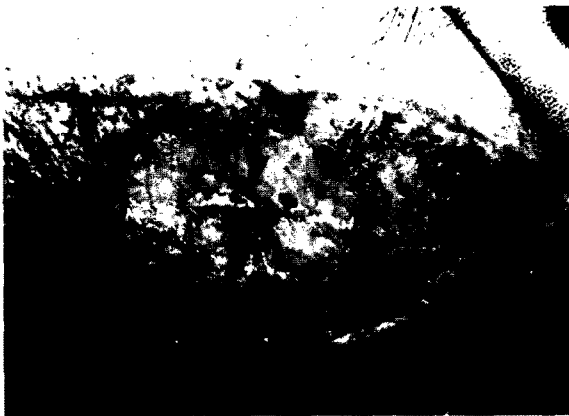


Fig. 2

Figure 2—Case 2. Venous free scalp flap. Superficial necrosis but viable epicranium and subcutaneous tissue and well filled vein (arrow).

first phalanx of the long finger, extending to the metacarpophalangeal joint and the second web.

A wide excision exposing the tendons and joint capsules was performed.

A venous island flap was dissected, taking in the skin over the entire dorsal surface of the first phalanx and the proximal interphalangeal joint of the index finger. Dissection was performed, using a pneumatic tourniquet, between the paratenon and the venous plane. Two veins were isolated. When the tourniquet was removed the veins filled instantly, there was bleeding from the subcutaneous tissue, the flap regained its colour and the capillary return was that of a normal flap (Fig. 3).

There were no complications and full healing was obtained with the exception of slight distal ischaemia.

Preliminary haemodynamic study

We carried out a preliminary haemodynamic study on two venous island flaps of the hand. Using a strict protocol, the cutaneous capillary network and the venous axes were studied.

Cutaneous capillary network: capillary circulation and the exchanges in the capillary and the micro-circulation beyond the meta-arteriole were examined by capillaroscopy. This showed normal capillary loops where the venous portion was not more dilated than the arterial portion, indicating a normal pressure equilibrium between the two sides. It confirmed the clinical appearance of the flaps which seemed normally irrigated without ischaemia or stasis.

Venous axes: on the 1st, 6th and 21st days venous ultrasound echography with compression and the Doppler technique were used in an attempt to determine the direction of blood flow in the flap. Unfortunately these attempts were unsuccessful.

Discussion

Haemodynamic characteristics

In the venous pedicle: According to classic studies, e.g. Levame *et al.* (1967) and Grosshans and Eberst (1980), the superficial and distal veins of the limbs, such as those involved in venous island flaps, differ notably in structure and innervation from deep veins:

- (i) the former have few valves; the ostial valves near venous junctions are present but not those of the venous wall;
- (ii) they are rich in muscular tissue and better innervated due to their thermoregulatory function;

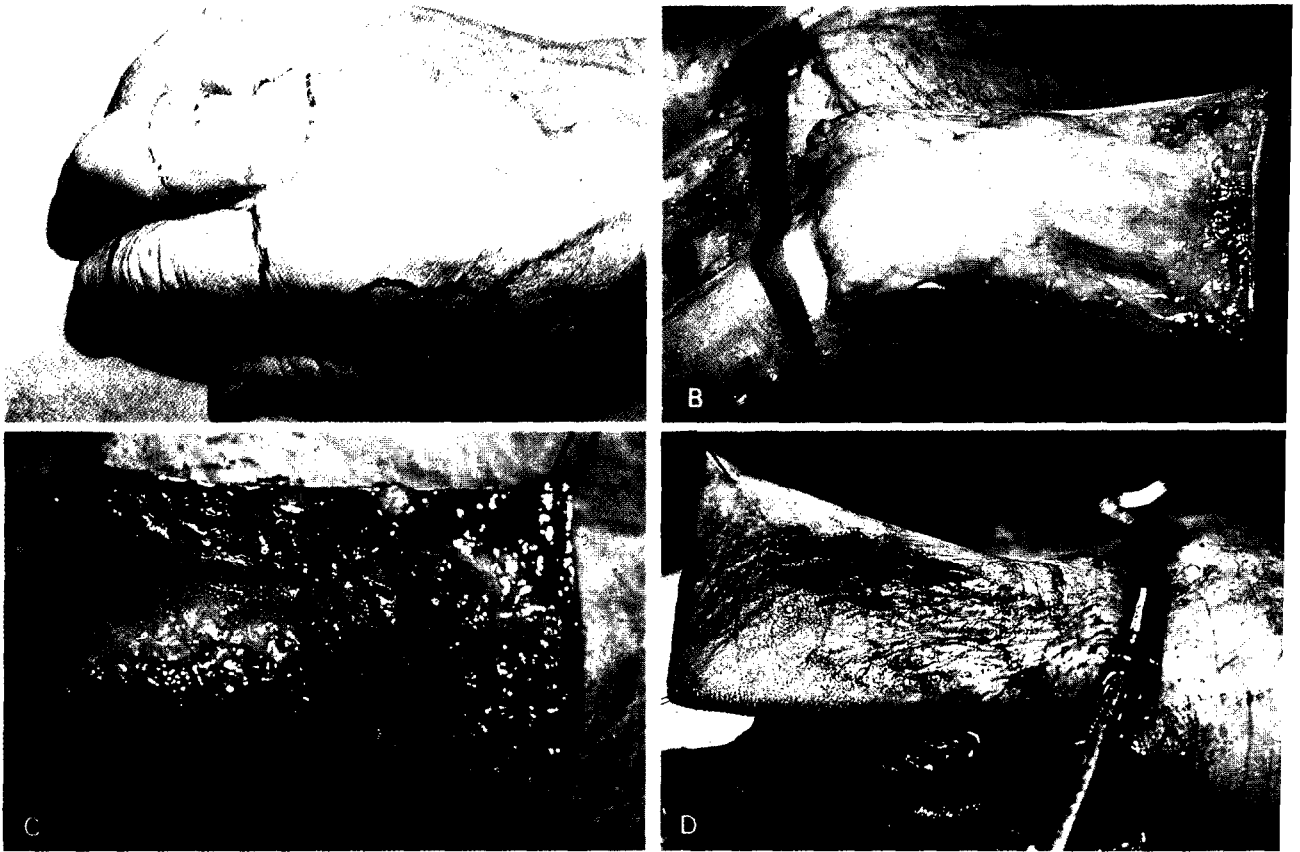


Fig. 3

Figure 3—Case 10. (A) Radionecrosis of dorsal surface of proximal phalanx of the long finger. Venous island flap marked over proximal phalanx of index finger with two draining veins. (B) Venous flap raised under tourniquet. (C) After releasing the tourniquet; the flap's vascularity is normal. (D) Venous pedicle isolated; no arterial connection to flap. Note the pink flap.

they thus dilate by vasoparalysis in regional anaesthetic blocks, and even more so after surgical denervation;

(iii) the fact that there are few valves or perhaps none at all distal to the venous junctions of the dorsal metacarpal area, together with surgical vasoparalysis, accounts for valve failure and venous backflow. The failure in Case 8 can be attributed to the length of the venous pedicle which almost certainly contained patent valves.

Echography, using compression and the Doppler technique, did not enable us to determine the direction or the speed of blood flow. However, it may be deduced from the experiments of Baeck *et al.* (1985) on dogs that the venous flow is intermittent.

Further, more detailed investigations are being carried out using miniprobes for echography and the laser Doppler.

In the cutaneous microcirculation. Capillary haemodynamics are simple: circulation is quasi-laminar and flow at the capillary level depends on the dynamics higher in the system. In normal conditions, the arteriolar-capillary pressure gradient allows gas exchanges between the capillary and the tissues. Capillaroscopy of the flaps showed quasi-normal capillary loops, where the venous portion was not more dilated than the arterial portion, suggesting a normal pressure gradient.

The most plausible hypothesis to account for these findings is that of diversion of the blood flow by the neuromyoarterial glomus (Fig. 4); it may be

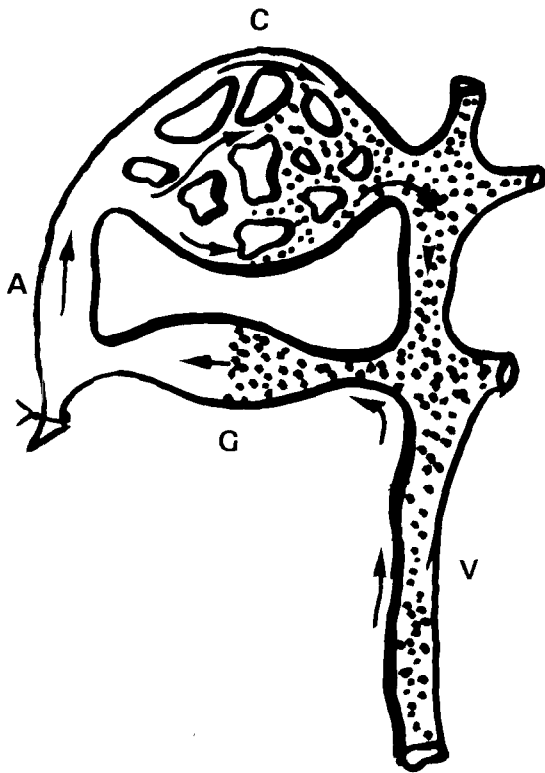


Fig. 4

Figure 4—Haemodynamic hypothesis; diversion of blood flow through neuromyoarterial glomus. A = arteriole; V = venule; C = capillary; G = glomus.

postulated that peripheral sympathectomy when the cutaneous arterioles are severed causes venous vasodilatation, reversal of the arteriovenous pressure gradient, opening of the arteriovenous shunts of the glomus and, lastly, opening of the precapillary sphincters. In the absence of arteriolar circulation, the blood would pass from the venule to the arteriole by the open arteriovenous shunt and capillary circulation would thus follow the normal direction. This hypothesis is compatible with the presence of the normal capillary loops seen under capillaroscopy and the numerous arteriovenous anastomoses and particularly the many glomera (200–500 per cm^2 of skin) found in the extremities.

Further more precise studies of capillary circulation are under way: analysis of transcutaneous oxygen pressure, and in particular fluorescein microcine-angiography will make it possible to compare tissue oxygen consumption and capillary

haemodynamics in normal skin and in the skin of island flaps.

Site restrictions and critical volume

Site restrictions. All the successful clinical cases presented here concern the extremities distal to the ankle and the wrist. In such sites arteriovenous anastomoses are very numerous and this may be indispensable for the survival of venous island flaps.

In the more proximal parts of limbs, the valves and the decreased importance of vasomotor tone in the large venous branches might prevent the venous flow from irrigating the flap.

Critical volume. The interesting partial failure of the free temporal flap (Case 2) suggests that the skin was too thick to be adequately nourished by the pedicle; all the other cases involved the thin dorsal skin of the fingers and foot.

Case 10 is also interesting. The flap took in a larger area than the dorsal surface of the first phalanx and involved the skin of the interphalangeal joint. The slight ischaemia which occurred suggests that the flap surface should be limited to one phalanx in order not to exceed the critical volume.

The flag flap, as originally described by Vilain in 1952, had a venous and arterial pedicle in its stem. Levame *et al.* (1967) considered that there was no artery and that the dermal arteriolar network provided the arterial supply. However, the artery reappeared in the work of Oberlin and Lequang (Tubiana, 1983). In our opinion, as Levame *et al.* anticipated, the flag flap can be haemodynamically considered as a venous island flap since the presence of an artery in the pedicle is highly doubtful.

Conclusion

From the purely practical and surgical point of view, the island flap with an exclusively venous pedicle is a new simplification of the haemodynamic concept of small skin flaps of the extremities, in particular the dorsal surface of the first phalanges of the fingers. Its mobility is comparable with that of the flag flap or Foucher's kite flap. It may be used for the dorsal surfaces of the foot and the four fingers of the hand.

The interesting haemodynamics of this new type of flap will be studied in more detail using modern methods of microcirculation analysis.

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