British Journal of Plastic Surgery (1987), **40**, 11–15

A study of the saphenous venous island flap in the dog without arterial inflow using a non-biological conduit across a part of the length of the vein

R. L. THATTE and M. R. THATTE

Department of Plastic and Reconstructive Surgery, Lokmanya Tilak Municipal Medical College and General Hospital, Bombay, India

Summary—This paper includes material which is a follow-up on the work of Se Min Baek *et al.* (1985) who demonstrated that in dogs a saphenous flap could survive without arterial inflow. Here we have repeated part of their work and confirmed it.

In addition, this paper shows that in dogs a saphenous venous flap with only the cephalad venous channel intact can survive even if the vein is cut and replaced by a non-biological conduit (a polyethylene tube). A total of 13 dogs and 19 flaps were studied. The possible reasons for the survival of these flaps are discussed.

Se Min Baek *et al.* (1985) have shown that:

1. An axial pattern island flap like the saphenous flap (Fig. 1) in a dog can survive without arterial inflow (Fig. 2).
2. This flap cannot survive by arterial inflow alone without venous drainage (Fig. 3).
3. The saphenous venous island flap with only the cephalad venous channel intact did not survive (Fig. 4).

In our project we set out to repeat part of Baek's work. In addition, we investigated whether the flap would survive with a gap in the vein bridged by a non-biological conduit (Fig. 5).

Materials and Methods

A total of 13 adult mongrel dogs of either sex, weighing between 12 and 20 kg, were used and 19 saphenous flaps were executed on them. General anaesthesia was administered using sodium pentothal 20 mg/kg intravenously and Gallamine 1 mg/kg. The dogs were put on a ventilator via an endotracheal tube. All the flaps were fasciocutaneous flaps raised from the level of underlying thigh muscles and based on the saphenous artery and vein which arise from the femoral vessels at the level of mid-thigh. In our project we raised a flap as a circular island flap about 10 cm in diameter, the mid-point being about 3 cm above the knee. A circular incision was made down to and through the deep fascia. The proximal and distal ends of the vessels were easily identified at either end of the flap. The flap was then raised from the underlying muscle so that it was attached only by the vessels. For further details of the saphenous flap the reader is referred to the earlier papers by Banis *et al.* (1980) and Baek *et al.* (1985).

The flaps were then divided into four groups:

Group A (Fig. 6). In this group of two flaps, all the four vascular channels (arterial and venous) were ligated after raising the flap which was then resutured.

Group B (Fig. 2). In two flaps both the cephalad and caudal venous channels were kept intact but the arteries were ligated at each end.

Group C (Fig. 4). In four flaps all the vessels to the saphenous flap were ligated except the cephalad vein.

Group D (Fig. 5). In this last group 11 flaps were studied. After raising the flap only the cephalad venous channel was kept intact. The vein was then cut and a polyethylene tube of 1 or 1.5 mm internal diameter (depending on the size of the vein) was introduced as a conduit between the two ends. A ligature was tied on either side to fix the tube in the vein (Fig. 7). The flap was sutured back on to its bed.

In all groups intraoperative heparin was given in the dose of 100 IU/kg and followed by acetyl salicylic acid 300 mg/day postoperatively for 6 days.

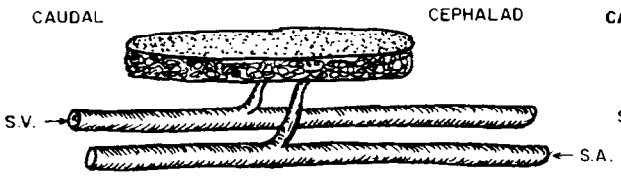

Fig. 1

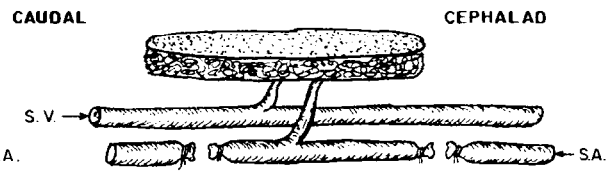

Fig. 2

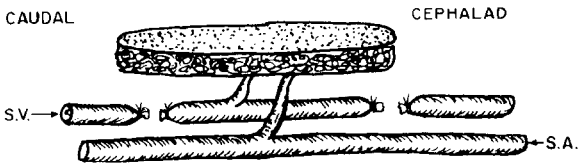

Fig. 3

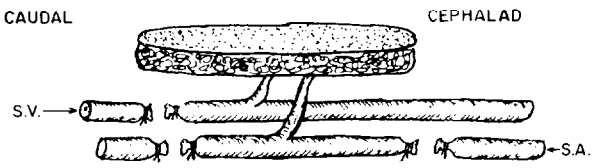

Fig. 4

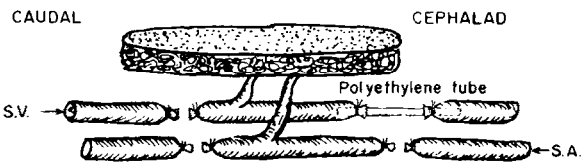

Fig. 5

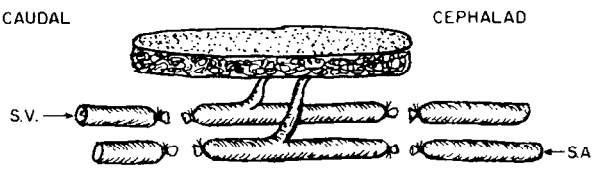

Fig. 6

Figure 1—The saphenous flap in the dog. SA = saphenous artery, SV = saphenous vein. The actual blood vessels supplying and draining the flap are unnamed and small. All manipulations are therefore done at the level of the main saphenous vessels (SA, SV). Figure 2—Flap without any arterial inflow but with its venous drainage intact. Group B in our series. Figure 3—Flap with arterial inflow alone. This is not enough for survival of the flap in the absence of venous drainage (Baek *et al.*, 1985). Figure 4—Flap with only cephalad venous channel intact (Group C). Figure 5—The cephalad venous channel substituted over a part of its length by a polyethylene tube. All the other channels ligated (Group D). Figure 6—Flap devascularised by ligating the artery and the vein both proximally and distally (Group A).

Results

A brief summary of the results is given in the Table.

Both of the flaps deprived of both arterial and venous circulation (Group A) were obviously dead by 24 hours. The flaps in all other groups had only venous circulation. The two in Group B were congested at first (Fig. 8) but both survived. All four flaps in Group C, in which only the cephalad vein was left intact, also survived (Fig. 9).

In Group D a total of 7 out of 11 flaps survived in their entirety. Three flaps were cannibalised in the immediate postoperative period, though even one of these survived (Fig. 10), hanging by its pedicle which contained the polyethylene tube.

One flap necrosed completely in the first 24 hours.

In this group the flaps became purple and oedematous in the first 72 hours. The colour gradually changed to pink by the 6th or 7th day but the oedema took about 10 days to disappear. The flaps were indistinguishable from the surrounding skin at the end of 2 weeks if they survived. Similar colour changes were seen in Groups B and C but to a much lesser extent than in Group D.

The total period of follow-up was three months, showing normal hair growth in all surviving flaps in Group D (Fig. 11). In one dog the polyethylene tube was re-explored after 10 days and was seen to be patent.

Discussion

Adequate venous drainage is very important for composite tissue survival particularly in the context of microvascular anastomosis. Two interesting studies by Smith *et al.* (1983) and Nichter *et al.* (1985), in which venous drainage of composite tissue or flaps was manipulated through creation of abnormal arteriovenous fistulae, succeeded in allowing survival of the tissue. In those two reports

Fig. 7

Figure 7—Polyethylene tube substituting the saphenous vein in its cephalad portion (as in Fig. 5) (Group D). Magnification × 2.

the arterial inflow was intact and only the venous side was manipulated. The results of the experimental work in this paper raise more questions because, in addition to manipulation of the venous outflow, the surviving flaps in Groups B, C and D have no arterial inflow. Firm answers are not available to these questions but some conjectures can be discussed.

Did the flaps in Groups B, C and D survive by picking up nutrients from their beds and sutured edges from the first day? The answer is almost certainly in the negative. Manipulations in the rabbit ear model (Serafin *et al.*, 1977) and the inferior epigastric model in the rat (Tsur *et al.*, 1980) have conclusively proved that a minimum of 4 days is needed before neovascularisation can

Table Fate of flaps

	Group A (Fig. 6) All 4 channels ligated	*Group B (Fig. 2) Both veins intact and both arteries ligated*	*Group C (Fig. 4) Both arteries ligated, caudal vein ligated, cephalad vein intact*	*Group D (Fig. 5) As in Group C but cephalad vein bridged by conduit*
Total flaps	2	2	4	11
Survived	–	2	4	7
Necrosed	2	–	–	1
Others (cannibalised)	–	–	–	3

Fig. 8

Figure 8—Example of a flap with no arterial inflow but intact venous drainage (Group B). There is venous congestion but the flap survived.

support survival of an axial pattern flap raised from its bed, irrespective of the nature of manipulation of its axial supply.

The solitary example of a partly cannibalised flap hanging by its venous pedicle and surviving (Fig. 10) would also support the theory that the solitary cephalad venous pedicle was more important for flap survival than neovascularisation. This question could be resolved in another experiment by the insertion of a non-permeable membrane to separate the flaps from their edges and beds.

How did one cephalad venous channel allow flap survival in Groups C and D in this series when it failed in the study of Baek *et al.* (1985)? This question is difficult to answer. In our experiment we were very careful in not applying any clamps to the cephalad venous channel. In fact, when the polyethylene tube was inserted in the vein, the vein was controlled only with two loops of thread and the tube was inserted through two nicks in the vein as in an old-fashioned venesection, so that blood flow was never interrupted in the channel. This may be relevant.

Timmons (1984), in trying to explain the survival of distally based radial artery flaps, has postulated three preconditions for reversal of flow in veins even in the presence of valves:

1. Denervation of the vein by a local anaesthetic or surgical elevation.
2. Presence of blood in the vein both proximal and distal to the valve.
3. Venous blood pressure higher proximal (cephalad) to the valve than distally (caudal).

All these three prerequisites were inadvertently met with in our experiment (Groups C and D), probably allowing for an ebb and flow in the solitary venous channel. The addition of intraoperative anticoagulants and postoperative aspirin may have played a role in sustaining a "low flow rate state"

Fig. 9

Fig. 10

Fig. 11

Figure 9—A surviving flap where both arteries and the caudal venous channel have been ligated leaving only a cephalad venous channel to drain the flap (Group C). Figure 10—Flap from Group D, partly cannibalised by dog and hanging from its pedicle. Survival of residual flap seen (arrow). Figure 11—Survival of a Group D saphenous flap with hair growth at 2 months.

in the closed one vein system, and though there might have been some slowing of blood, in the absence of clotting the system might have survived through the ebb and flow that Baek *et al.* postulated, with just enough *vis à fronte* and *vis à tergo* (Best and Taylor, 1979) to allow for tissue perfusion.

The long term survival of the flaps in which a synthetic conduit was used to bridge a gap in the vein perhaps has implications for the future. It seems likely that neovascularisation in most fasciocutaneous flaps from the edges or bed takes about 1 week to 10 days (Furnas *et al.*, 1985; Thatte *et al.*, 1986) so the effort to maintain blood supply to a free axial flap may not need to be of a permanent nature. If a non-biological conduit in the vein alone can replace the complicated manoeuvre of microvascular anastomosis, then free tissue transfer could become simpler in the years to come.

Acknowledgements

The authors wish to thank the Dean of the King Edward VIIth Memorial Hospital, Parel, Bombay and specifically Dr R. A. Bhalerao and Dr A. B. Samsi, successive Heads of the Department of Surgery at the King Edward VIIth Memorial Hospital, for allowing the use of the experimental laboratory in the Department of Surgery. Dr Anil Gangadhar Tendolkar, Reader, Department of Cardio-vascular and Thoracic Surgery of the same hospital, was also helpful in setting up the experiment. Thanks are also due to Parshuram Pangerkar and Shrikant Valavate for illustrations and Shilpa Shirsat who helped with typing the manuscript.

References

Baek, S. M., Weinberg, H., Song, Y., Park, C. G. and Biller, H. F. (1985). Experimental studies in the survival of venous island flaps without arterial inflow. *Plastic and Reconstructive Surgery*, **75**, 88.

Banis, J. C. Jr., Schwartz, K. S. and Acland, R. D. (1980). Electromagnetic flowmetry—An experimental method for continuous blood flow measurement using a new island flap model. *Plastic and Reconstructive Surgery*, **66**, 534.

Best, C. H. and Taylor, N. B. (1979). In J. R. Brobeck (Ed.) *Physiological Basis of Medical Practice*. 10th Edition, Baltimore: Williams and Wilkins. 3rd Asian Edition, Tokyo: Igaku Shoin Ltd.

Furnas, D. W., Lamb, R. C., Achauer, B. M., Turpin, I. M. and Black, K. S. (1985). A pair of five day flaps: Early division of distal pedicles after serial cross clamping and observation with oximetry and fluorometry. *Annals of Plastic Surgery*, **15**, 262.

Nichter, L. S., Haines, P. C. and Edgerton, M. T. (1985). Successful replantation in the face of absent venous drainage: an experimental study. *Plastic and Reconstructive Surgery*, **75**, 686.

Serafin, D., Sharin, J. C. and Georgiade, N. G. (1977). Vascularisation of free flaps. *Plastic and Reconstructive Surgery*, **60**, 233.

Smith, A. R., Sonneveld, G. J. and Van der Meulen, J. C. (1983). AV anastomosis as a solution for absent venous drainage in replantation surgery. *Plastic and Reconstructive Surgery*, **71**, 525.

Thatte, R. L., Yellikar, A. D., Chhajlani, P. C. and Thatte, M. R. (1986). Successful detachment of cross-leg fasciocutaneous flaps on the 10th day: a report of ten cases. *British Journal of Plastic Surgery*, **39**, 491.

Timmons, M. J. (1984). William Harvey revisited: Reverse flow through the valves of forearm veins. *Lancet*, **2**, 394.

Tsur, H., Daniller, A. and Strauch, B. (1980). Neovascularisation of skin flaps: route and timing. *Plastic and Reconstructive Surgery*, **66**, 85.

The Authors

Ravin L. Thatte, MS, Hon. Professor and Head, Department of Plastic and Reconstructive Surgery, Lokmanya Tilak Municipal Medical College and General Hospital, Sion, Bombay.

Mukund R. Thatte, MS, Registrar, Department of Plastic and Reconstructive Surgery, Lokmanya Tilak Municipal Medical College and General Hospital, Sion, Bombay.

Requests for reprints to: Dr Ravin L. Thatte, Apt. 46 "Shireesh," 187, Veer Savarkar Marg, Bombay—400 016, India.