

Degloving injuries and flap viability assessment

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Abstract Degloving injuries are associated with major morbidity. The management of these injuries is still not resolved. The method of management used by the authors involves the harvesting of split skin from the surface of the flap and assessment of flap viability based on surface dermal capillary bleeding. The skin grafts are then used to cover denuded areas. This technique has proved to be effective, time-saving and morbidity-reducing in the cases reviewed here and in recent publications.

The issue addressed in this trial was the effect of partial de-epithelialisation on the survival length of a flap. Two groups of dorsal rat flaps were compared. In one group, the flaps were raised and restitched after a period of time and in the second group, the surfaces of identical flaps were partially de-epithelialised and then restitched. The survival length of these flaps was compared, as well as the metabolic responses to surgery in the two groups. No statistically significant differences were found in these 2 groups. It was concluded that partial de-epithelialisation did not have a detrimental effect on duration of flap length survival, thus encouraging the continued use of the clinical technique described above in the handling of degloving injuries.

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The inevitable concomitant of technology is injury. Motor vehicle and industrial accidents often result in degloving injuries. These injuries occur when torsional and compressive forces tear the skin and occasionally muscles and neurovascular structures from their underlying beds (Fig. 1). The plane of separation

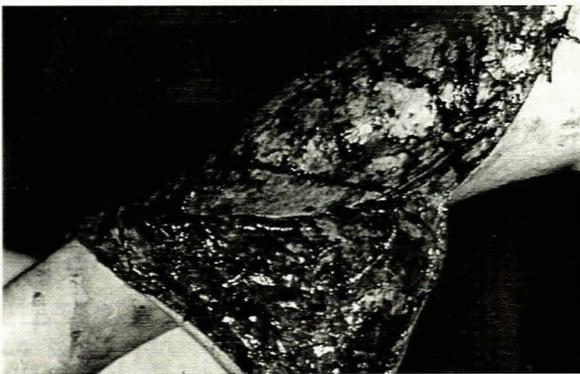


FIG. 1. Degloving injury of the lower limb showing plane of flap separation.

is outside the deep fascia and the perforating musculocutaneous vessels rupture.¹ In the management of these injuries, the following problems arise: (i) the injuries may not be recognised or may be underestimated initially; (ii) assessment of the viability and survival time of the skin flap is difficult; (iii) the denuded areas and associated injuries need to be dealt with.

Numerous methods of viability assessment have been suggested and used, but a foolproof test is still being sought. It is well recognised that clinical judgement of the viability of degloved flaps is very unreliable.

Myers,² McCraw *et al.*³ and McGrouther and Sully,⁴ describe the technique of whole body fluorescence. Although used for many years with varying degrees of success, fluorescein testing does have many limitations. These include: (i) the large doses needed (15 mg/kg); (ii) poor visualisation and unreliability of the test in dark-skinned individuals; (iii) possible anaphylaxis, nausea and vomiting;⁵ (iv) transient hypotension;⁶ (v) a 3 cm gap between the original fluorescein line and the devitalised flap in favour of the latter (i.e. underestimated flap survival time with fluorescein);^{3,4} (vi) mottled areas surrounded by normal fluorescein that may be missed by the inexperienced and may become necrotic islands;⁷ (vii) bruises that can produce poorly fluorescent areas.

The non-invasive techniques currently available include surface fluorometry, ultrasound, laser Doppler, photoplethysmography, temperature monitoring and transcutaneous oxygen monitoring.⁸ More recently, use of the fibre-optic dermofluorometer has been described.⁹ These techniques all involve sophisticated equipment not readily available and not ideal for assessing the viability of an acutely injured flap at the time of initial operation. They are more suited to following flap viability postoperatively.

Since 1987, we have been using a technique of management similar to that later described by Zeligowski and Ziv.¹⁰ The technique has proved particularly useful in assessing flap viability and in determining the amount of flap that needs to be discarded. The method involves:

1. Suturing of the avulsed flaps back in their original positions.
2. The use of split-thickness skin harvested from the flap.
3. Assessment of flap viability according to surface dermal capillary bleeding (Fig. 2). If brisk punctate bleeding occurs within the first 30 seconds of harvesting, it confirms viability, whereas sluggish flow with poor colour indicates non-viability. A grey zone of intermediate bleeding usually exists between the brisk and sluggish flows. This is the cut-off area beyond which the distal flap should be discarded.

4. Application of these split-skin grafts to denuded areas. This is an added advantage as the skin may be utilised to cover degloved areas without recourse to new donor areas.

The advantages of the above technique have been well documented,¹⁰ and clinical series have proven its worth. Using this technique, operative time and hospitalisation time are reduced and morbidity is decreased. In our series of 14 patients most injuries involved the lower limbs and were the result of motor vehicle or motor-cycle accidents. Elements of closed degloving injuries were present in many cases but no cases of pure closed degloving injuries were assessed. Results of treatment were very similar to those of other published

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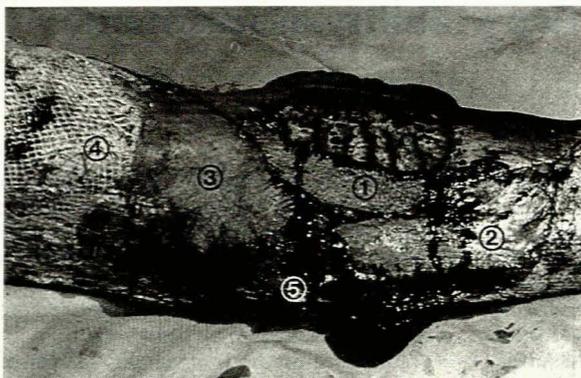


FIG. 2.
 Degloving injury of the lower limb thigh to ankle — area shown is that between knee and ankle; area 1— flap restitched over exposed bone and skin graft harvested from surface with brisk bleeding indicating a viable flap; area 2 — skin graft in test area 1 used to cover degloved leg; areas 3 and 4 — skin grafts from same flap higher up in thigh region; area 5 — remaining denuded area at first operation.

series.¹⁰ Approximately 50% of the avulsed flap was discarded and a maximum of 1 - 2 cm of further flap necrosis took place in some cases. None of these patients needed to be returned to theatre as the small amount of grafting needed was carried out using excess refrigerated skin from the original procedure. Aside from small areas of graft loss, the take was almost 100% in all cases and patients without underlying fractures were ambulant within 10 days. One patient required a gastrocnemius muscle transposition flap to cover an exposed fracture site; the muscle was then skin-grafted at the same time. In most cases the skin grafts were meshed to allow for greater surface area cover but for the smaller wounds where enough skin was available, non-meshed skin was used.

The efficacy of the technique has been well documented.¹⁰ However, two questions have not been addressed — what effect does partial de-epithelialisation have on the viability of the flap, and does this further trauma to the flap have an adverse effect on the viability of the flap? From the clinical cases this does not appear to be the case, but laboratory/experimental confirmation is needed.

Materials and methods

Mature male Sprague-Dawley rats weighing 350 - 500 g were used for the trial. All experimental animals were anaesthetised with thiopentone (30 mg/kg) intraperitoneally.

The rat flap design was that described by McFarlane, i.e. a dorsal cephalically based flap situated between the bony landmarks of the inferior angles of the scapulae and the hip joints.

Two groups were selected for the study. In the control group the dorsal flaps were raised (approximately 8 × 3 cm) including the panniculus carnosus. These were restitched in position after 20 minutes. The partially de-epithelialised group underwent similar flap raising, followed after 15 minutes by de-epithelialisation of the distal 3/4 (approximately 6 cm) of the flap, and resuturing.

The wire bristle dermabrader was used for partial de-epithelialisation (Fig. 3). Fifteen rats were used in each group as sample size aiming at 90 - 95% power of the test. The rats were individually housed, they were monitored daily and weight charts were kept. Any loss of

weight greater than 10% of body weight would have necessitated euthanasia and reassessment of the trial protocol.

Flap viability assessment in both groups was made clinically, histologically and by planimetry.



FIG. 3.
 Flap raised and partially de-epithelialised using wire bristle dermabrader.

Results

Assessment of flap survival (Table I)

Clinical assessment of flap viability was often complicated by eschar formation in the partially de-epithelialised rats. Thus, flaps were submitted for histological analysis of viability. Viable flaps were those where numerous adnexal structures were present in the dermis, allowing epithelial regeneration and flap survival. These histological slides were compared in the two groups and within the same groups to contrast regeneration potentials.

1. Flap length lost in the control group (Table I) varied from 0,8 cm to 5 cm of distal flap length (10 - 62%). The mean percentage flap loss was 39,53% in this group of 15 rats.

2. Flap length lost in the partially de-epithelialised group (Table I) varied from 0 cm to 5 cm (0 - 62%). The mean percentage flap loss was 32,27% in this group of 15 rats.

TABLE I.
 Flap length survival assessment

No.	Length of flap lost (cm)		% flap lost	
	Control	De-epithelialised	Control	De-epithelialised
1	2	4	25	50
2	4	0	50	0
3	2	4	25	50
4	2	0,8	25	10
5	4	0,8	50	10
6	5	5	62	62
7	4	4	50	50
8	4	4	50	50
9	2	0,8	25	10
10	3	0,8	37	10
11	4	4	50	50
12	5	0,8	62	10
13	5	0,8	62	10
14	0,8	4	10	50
15	0,8	5	10	62

Statistical analysis of these results showed that the difference between the means in the two groups in the light of the Wilcoxon test resulted in a P -value of 0,3321 — a non-significant difference.

Assessment of metabolic response to surgery

Metabolic response differences were analysed in the two groups according to weight loss measurements. The timing of the weight loss after surgery, the amount of weight lost, the percentage of weight lost in relation to total body weight, and the time taken to regain pre-surgery weight were measured.

These figures and tables were submitted for statistical analysis and once again the recorded differences between the two groups, in terms of their metabolic responses, proved not to be statistically significant in these sample groups: (i) timing of weight loss after surgery ($P > 0,6458$); (ii) amount of weight loss ($P > 0,3350$); (iii) percentage weight loss to total body weight ($P > 0,9338$).

Discussion

The morbidity associated with degloving injuries can be considerable. The overall treatment and management plan for these injuries has been less than adequate. All the above factors have been discussed in the introduction to this trial, and a new method of treatment and management has been elaborated. Although this treatment technique has proved successful clinically, it was not known to what extent de-epithelialisation would disadvantage the survival and viability of the flap. This study aimed at answering this question and the results of the study warrant further discussion.

With regard to the survival length and viability of the flap, the study demonstrates that partial de-epithelialisation does *not* compromise flap viability. It is important to note that the depth of de-epithelialisation is critical — if too deep, flap length survival is adversely affected (as seen in the first and third rats in the de-epithelialised group). This may be due to interference with the subdermal plexus nourishing the flap. Thus, the first precaution for preventing damage to the flap is to perform superficial de-epithelialisation.

Why does the further trauma of partial de-epithelialisation not have a detrimental effect on rat flap survival? The entire mechanism appears to revolve around critical blood flow and ischaemia. The process of partial de-epithelialisation may cause temporarily improved blood flow in these flaps that would exceed the critical closing pressure and thus enhance flap survival.¹² The improved flow may be a result of neurohumeral or other transmitters, possibly of a prostaglandin E type or prostacyclin.¹³

These transmitters may be released by the partial de-epithelialisation process and result in a decongestive effect and selective vasodilation to the underlying skin flap. The process is self-limiting and short-lived because of the coagulation of the vessels and the rapid formation of an overlying eschar. However, the effect is enough to reverse any adverse effect that de-epithelialisation may have had on flap length survival.

The purpose of this trial was to assess whether de-epithelialisation would negatively affect survival time. This would appear *not* to be the case. One must obviously bear in mind that the rat flap has not undergone the amount of damage that a degloving injury imposes upon a flap. However, we feel that the temporary beneficial effects observed with partial de-epithelialisation would be as beneficial, if not more so, in the damaged flap where increased blood flow and redistribution is critical to counteract the effects of long-standing anoxia.

The overriding impression gained from the trial is that the survival of the de-epithelialised flap appears to be dependent on the depth of the de-epithelialisation and its effect on the subdermal plexus. Thus in the clinical context, partial de-epithelialisation of the flap would appear to have no detrimental effect (and no lasting beneficial effect) on flap survival, provided the de-epithelialisation is carried out at the superficial level clear of the subdermal plexus. We would thus encourage the use of the technique described earlier to assess the viability time of flaps in degloving injuries.

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