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SOME EXPERIMENTAL SUCCESSES WITH ACQUIRED TOLERANCE TO HOMOGRAFTS IN POSTEMBRYOGENESIS

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Results obtained in a study of the problem of homoplasty showed clearly that the property of failure to accept a homograft can be of varying degrees. If the relationship between donor and recipient is close, failure by the recipient to accept the homograft is less marked. Inability to accept a homograft increases with age. The degree of rejection of a homograft is also largely dependent on the character of the transplanted tissue. In the author's experiments, comparison of different organs showed that skin possessed the strongest antigenic properties and ovaries the weakest. The peripheral nerves occupied á middle position.

The degree of failure by the recipient to accept a homograft was also evaluated by the way in which it could be overcome.

In groups in which the degree of failure was small, successful transplantation was obtained without special treatment of recipient and graft.

Such results were obtained in the transplantation of ovaries in rats (Efimova 1952, 1954). Transplantation in rats inbred over a long period gave substantially better results than in rats from different breeds. Function of the homograft was studied for over one and a half years and it was found that it could continue to function normally even in a recipient in the menopause.

In intrafamilial transplantation in rats, skin grafts took completely. Transplantation from offspring to mother gave positive results in 75% of the animals (Musina 1956), while transplantation between the young was successful in 30% (Kaipova 1956). These findings in the intrafamilial transplantation of skin grafts basically confirm the results of Gohrbandt (1926) and Schöne (1916).

A moderate degree of failure by the recipient to accept a homograft was also encountered.

In this group successful transplantation was actually observed in a series of experiments in which the recipient's reactivity was inhibited by drug-induced sleep, sometimes supplemented by hypothermia.

On using drug-induced sleep, transplantation of skin homografts was 100 per cent successful in two-month-old rats in cases in which donor and recipient came from a group of animals which had been inbred over a long period (Musina

1953). In this group the monograft was studied for over a year and a half and covered more than half the area of the recipient's body (Fig. 1).

Regeneration of the sciatic nerve was almost always observed in rabbits in a series of experiments in which a nerve from another rabbit was transplanted

Fig. 1. Appearance of skin of rat to whose back the whole skin of a newborn rat was transplanted, 16 months after transplantation. The graft can easily be distinguished from the skin of the recipient by the direction of growth of the fur. The edges are clearly visible. Commencement of formation of the nipples and ears. The dimensions of the graft correspond to about half the body area of the recipient.

to a large defect of the sciatic nerve. An attempt was made to preserve the vitality of the homograft by means of drug-induced sleep (Gudzovskaya 1955).

In further experiments with similar good results, regeneration of the sciatic nerve was obtained in rabbits after it had been almost completely removed (Fig. 2—5). The nerve was removed and was replaced by two homologous nerves from another rabbit, while drug-induced sleep and hypothermia were used to protect the vitality of the homograft (Aimanbetov 1957).

Marked failure by the recipient to accept a homograft was observed in the transplantation of skin grafts in rats of different breeds. In this case the degree of rejection increased with age.

The use of drug-induced sleep, in different variations, was ineffective in these cases. On using foreign protein for temporary inhibition of the recipient's immune activity, a complete take was observed in a few rare cases (Efimov 1953)

Relatively good results, i.e. a true take, were obtained in almost 50 per cent of this group of rats by special pretreatment of the recipient prior to transplan-

tation of the skin graft. This consisted in administering donor protein into the recipient's organism while the reactivity of the latter's immune system was artificially inhibited by drug-induced sleep and hypothermia (Efimov 1959).

Fig. 2. Rabbit in first series of experiments, 222 days after operation. Renewal of movement of left hind limb.

Fig. 3. Dissected experimental limb of rabbit in first series of experiments. Regenerated nerve has been formed at the site of the graft. It has several branches, the longest of which extends down the leg.

The above examples of successful homotransplantation are based on different principles. Where the degree of immunity is weak, tolerance of homografts is formed in a number of cases because the proteins of donor and recipient differ so little that the recipient's immune system does not react to the proteins of the graft.

In moderate and marked immunity, the character of the mechanism of acquired tolerance of homografts is different.

Some explanations of this question have been submitted by Hašek (1953—1956) and Medawar (1953—1956). These authors found that the administration

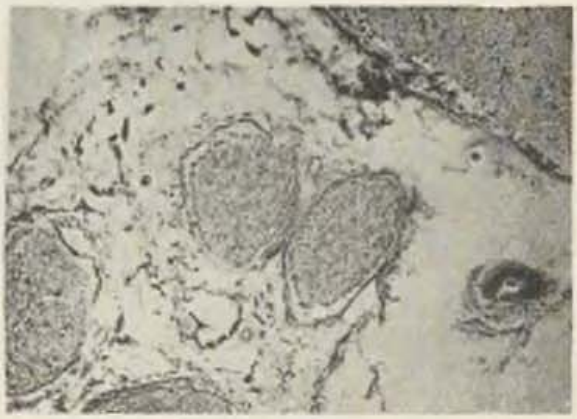

Fig. 4. Fig. 5.

Fig. 4. Longitudinal section of middle of regenerating nerve in rabbit No. 41. Observed 165 days after operation. 330×. Impregnated with silver (Cajal-Buke method). Newly-formed axons visible, some with a large number of branches. — Fig. 5. Cross section of regenerating nerve in rabbit No. 105. Observed 230 days after operation. 80×. Impregnated with silver (Cajal-Buke method). The nerve stem has divided into individual nerve fibres, each with its own sheath. The fibres contain axons of different diameters, separated from one another by Schwann's sheaths.

of tissue of the future homologous donor to an embryo or newborn individual, i.e. at a time when its immune system it still incapable of reacting, induced tolerance to homografts of the donor's tissues transplanted in adult life.

The induction of tolerance to homografts in the presence of moderate immunity in the present experiments can be explained as follows: drug-induced sleep or hypothermia temporarily artificially inhibits the recipient's immune activity during the postoperative period, i.e. its immune system is in a non-reactive state, as during embryogenesis. During this time the proteins of the homograft act on the recipient's immune system and tolerance of the homograft is induced.

The formation of tolerance in the presence of a marked degree of immunity in the present experiments was in principle the same. The reactivity of the recipient's immune system was temporarily inhibited during the preoperative period by means of drug-induced sleep and hypothermia. During this period donor protein was administered, thus inducing tolerance of the donor's tissues.

In the experiments of Hašek and Medawar, tolerance of homografts was obtained through the effect of the donor's tissues on immunogenesis, which is naturally non-reactive during the early stages of ontogenesis. The present author achieved the same effect by administering donor protein to recipients whose immune reaction was temporarily inhibited during the middle and late stages of ontogenesis.

SUMMARY

1. The property of failure by the recipient to accept a homograft can be of varying degrees. This depends on the degree of relationship between donor and recipient, on the age of the recipient and on the type of tissue transplanted.

2. The degree of failure of homotransplantation was evaluated by the way in which it could be overcome.

3. In cases in which this property was not marked, a take was actually obtained without special treatment of recipient and graft. Such results were obtained with the transplantation of ovaries in rats and in the intrafamilial transplantation of skin in rats.

4. In the presence of moderate failure by the recipient to accept a homograft, a true take was observed in a series of experiments in which the recipient's reactivity was inhibited by drug-induced sleep, sometimes supplemented by hypothermia. Similar phenomena were observed in transplantation in rats, in cases in which donor and recipient belonged to animals which had been inbred over a long period, and in transplantation of the sciatic nerve in rabbits.

5. In marked failure by the recipient to accept a homograft, positive results were obtained by artificially inhibiting the recipient's immune reaction by means of drug-induced sleep and hypothermia and by administering donor protein into the recipient's organism before transplanting the homograft. This gave successful results in the transplantation of skin homografts in rats, in cases in which donor and recipient came from different breeds.

6. With a weak degree of immunity, tolerance of homografts is formed because in a number of cases the proteins of donor and recipient differ so little from one another that the recipient's immune system does not react to the protein of the homograft.

7. With a moderate degree of immunity, the formation of tolerance to a homograft can be explained as follows: drug-induced sleep and hypothermia inhibit the recipient's immune reaction during the postoperative period. During this time the proteins of the homograft act on the recipient's immune system, resulting in the formation of tolerance to the homograft.

8. With a marked degree of immunity, the formation of tolerance to homografts is, in principle, the same as for moderate immunity.

ВЫВОДЫ

Некоторые успехи в получении толерантности к гомотрансплантату в постэмбриональном периоде в эксперименте

М. И. Ефимов

1. При гомопластике невосприимчивость реципиента к гомотрансплантату может быть выражена в различной степени и это зависит от родства между донором и реципиентом, от возраста реципиента и от характера пересаживаемой ткани.

2. О силе невосприимчивости реципиента к гомотрансплантату мы судили по тому, какими путями нам удавалось ее преодолеть.

3. При слабой степени невосприимчивости реципиента к гомотрансплантату истинное его приживление нами было получено без специального воздействия на реципиенты и гомотрансплантат. Подобного рода данные были получены при пересадке яичников у крыс и при внутрисемейных пересадках кожи у крыс.

4. При средней степени невосприимчивости реципиента к гомотрансплантату истинное его приживление наблюдалось в тех сериях опытов, в которых у реципиентов была снижена реактивность путем медикаментозного сна, а иногда дополнительно и гипотермией. Так, подобного рода явления мы наблюдали при пересадках кожи у крыс в том случае, когда донор и реципиент относились к крысам, длительно размножающимся в узком кругу, и при пересадке периферического нерва у кроликов.

5. При высокой степени невосприимчивости реципиента к гомотрансплантату положительный результат наступал тогда, когда до пересадки система иммуногенеза реципиента медикаментозным сном и гипотермией переводилась временно в искусственное арективное состояние и в этот период в организм реципиента вводился белок донора. Такой исход опыта мы получили при пересадке кожи у крыс в том случае, когда донор и реципиент были выращены в разных питомниках.

6. При слабой степени иммунитета толерантность к гомотрансплантату возникает как следствие того, что в ряде случаев белки донора и реципиента настолько мало отличаются друг от друга, что система иммунитета реципиента не реагирует на белок гомотрансплантата.

7. При средней степени иммунитета получение толерантности к гомотрансплантату можно объяснить так: медикаментозный сон и гипотермия реципиента в постоперационном периоде переводят его систему иммуногенеза в ареактивное состояние. Белки гомотрансплантата в этот период действуют на иммунную систему реципиента, в результате чего у последнего вырабатывается толерантность по отношению к пересаженному гомотрансплантату.

8. При сильной степени иммунитета возникновение толерантности к гомотрансплантату, в основном, происходит также, как и при средней степени иммунитета.

RÉSUMÉ

Quelques succès expérimentaux pour l'acquisition d'une tolérance envers l'homéogreffon à l'époque post-embryonnaire

M. I. Efimov

1. L'intolérance du porte-greffe envers l'homéoplastie peut se manifester à des dégrés différents et dépend du degré de parenté entre l'accepteur et le donneur, de l'âge de l'accepteur et du caractère du tissu greffé.

2. Nous avons évalué le degré de l'intolérance du portegreffe envers l'homéoplastie d'après les mésures qu'il fallait prendre pour surmonter cette intolérance.

3. Si l'intolérance du porte-greffe envers l'homéoplastie n'était que peu accentuée, nous avons pu réaliser une adhérence parfaite sans aucune intervention spéciale, ni sur le porte-greffe, ni sur l'homéogreffon. Des propriétés semblables ont été observées pour les greffes ovariales sur des rats, ainsi qu'à l'occasion des greffes cutanées intra-familiales, également sur des rats.

4. Si l'intolérance du porte-greffe envers l'homéoplastie se manifeste à un degré moyen, nous n'avons obtenu une adhérence parfaite que dans ces séries d'expériences où la réactivité de l'accepteur avait été abaissée à l'aide du sommeil thérapeutique, renforcé parfois par l'hypothermie. Des faits semblables ont été observés dans les cas où les accepteurs aussi bien que les donneurs faisaient partie de lots d'un élevage dans lequel la consanguinité avait été maintenue pendant une période prolongée, ainsi que lors de la greffe du nerf schiatique du lapin.

5. Si l'intolérance du porte-greffe envers l'homéoplastie était très prononcée, nous avons obtenu des résultats positifs si, avant l'intervention, l'immunogenèse de l'accepteur fut mise artificiellement dans un état de réactivité abaissée, à l'aide du sommeil thérapeutique et l'hypothermie et, à ce moment, des protéines du donneur furent introduites dans l'organisme de l'accepteur. De cette manière, nous avons obtenu des résultats positifs lors des greffes cutanées sur des rats dans le cas où les donneurs et les accepteurs provenaient d'élevages différents.

6. En présence d'un degré d'immunité faible, la tolérance envers l'homéoplastie résulte du fait que, dans beaucoup de cas, les protéines du donneur ne diffèrent que très peu de celles de l'accepteur et l'immuno-système de l'accepteur ne réagit pas sur la protéine de l'homéogreffon.

7. Si l'immunité se manifeste à un degré moyen, on peut s'expliquer l'acquisition d'une tolérance envers l'homéogreffon de la manière suivante: le sommeil thérapeutique et l'hypothermie transportent, pendant la période post-opératoire, l'immunogenèse du porte-greffe dans un état de réactivité diminuée. A ce moment, les protéines de l'homéogreffon agissent sur l'immunité de l'accepteur, ce qui provoque le développement d'une tolérance envers l'homéogreffon implanté.

8. Lors d'un degré fort prononcé d'immunité, la tolérance envers l'homéogreffon se développe, en principe, d'une manière analogue à ce qui se passe dans le cas d'un degré d'immunité moyen.

ZUSAMMENFASSUNG

Einige experimentelle Erfolge bei der Toleranzerwerbung gegenüber dem Homotransplantat im postembrionalen Stadium

M. J. Jefimov

1. Eigenschaften des Empfängers die Aufnahme eines Homotransplantates bei Homoplastik zu verweigern, können einen verschiedenen Grad haben und sind von der Verwandschaft zwischen Spender und Empfänger, Alter des Empfängers, sowie vom Charakter des transplantierten Gewebes abhängig.

2. Den Eigenschaftsgrad des Empfängers die Aufnahme des Homotransplantates zu verweigern, haben wir nach dem Umstand beurteilt, auf welche Weise es uns gelang dieser zu beherrschen.

3. Bei wenig ausgeprägten Eigenschaften des Empfängers die Homotransplantat-Aufnahme zu verweigern, konnten wir eine effektive Zuheilung ohne spezielle Einwirkung auf den Empfänger und das Homotransplantat erreichen. Analoge Angaben wurden auch bei Eierstocktransplantationen bei Ratten und intrafamilliären Hauttransplantationen erworben.

4. Bei Eigenschaften mittleren Grades des Empfängers die Homotransplantataufnahme zu verweigern, konnten wir eine effektive Zuheilung in jenen Versuchsserien beobachten, wo die Reaktivität des Empfängers mittels eines medikamentösen Schlafes gesenkt wurde, der manchmal durch Hypothermie ergänzt wurde. Analoge Erscheinungen konnten wir im Verlaufe von Transplantationen bei Ratten in jenen Fällen beobachten, wo Spender und Empfänger den Ratten angehörten, die sich eine längere Zeit hindurch in einem engen Verwandschaftskreis vermehrten und bei Transplantationen des N. ischiadicus bei Kaninchen.

5. Bei stark ausgeprägten Eigenschaften des Empfängers die Aufnahme des Homotransplantates zu verweigern, konnten wir positive Ergebnisse dann erreichen, als wir vor der Transplantation die Immunogenese des Empfängers mittels medikamentösen

Schlafes und Hypothermie zeitweilig in einen künstlichen areaktiven Zustand versetzten und zu dieser Zeit dem Organismus des Empfängers das Eiweiss des Spenders verabreichten. Derartige Versuchsergebnisse konnten wir im Verlaufe von Hauttransplantationen bei Ratten in dem Fall erreichen, als Spender und Empfänger aus verschiedener Zucht entstammten.

6. Bei einem geringen Immunitätsgrad entsteht die Toleranz gegenüber dem Homotransplantat als Folgeerscheinung der Tatsache, dass in einer Reihe von Fällen sich das Eiweiss des Spenders und Empfängers nur unwesentlich voneinander unterscheidet und das Immunitätssystem des Empfängers auf das Eiweiss des Homotransplantates nicht reagiert.

7. Die Toleranzerwerbung gegenüber dem Homotransplantat kann bei einem mittleren Immunitätsgrad wie folgt erläutert werden: Medikamentöser Schlaf und Hypothermie überführen im postoperativen Stadium die Immunogenese des Empfängers in einen areaktiven Zustand. Das Eiweiss des Homotransplantates wirkt in diesem Zeitabschnitt auf die Immunität des Empfängers. Infolge dessen bildet sich eine Toleranz gegenüber dem übertragenen Homotransplantat.

8. Bei einem hohen Immunitätsgrad verläuft die Toleranzentstehung im Grunde gleich, wie bei einem mittleren Immunitätsgrad.

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TRANSPLANTATION OF RABBIT SKIN CONSERVED BY FREEZING IN LIQUID NITROGEN at-196° C*)

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The transplantation of conserved tissue is becoming of increasing practical importance in plastic surgery. The commonest methods of conserving tissue for transplantation are freezing and lyophilization, but the basic question is still under debate, i.e. whether the cells of conserved tissues and organs remain alive, or whether they die during conservation and the transplanted graft acts merely as a temporary covering or support for growth of the recipient's own regenerating tissue, or whether it stimulates regeneration or acts as a reserve of specific material (e. g. of calcium in bone grafts).

For some tissues, which have a mainly mechanical function as support or stiffening (bone, cartilage, blood vessels, etc.), survival of the graft after conservation and transplantation is of less importance, although these grafts are clinically more effective in autoplasty, as far as they are capable of actually taking. In the transplantation of tissues with active cellular functions, however, such as skin, endocrine glands and particularly whole organs and parts of the body (e.g. limbs) a permanent clinical effect can be expected only if the graft retains its vitality after conservation and transplantation. For this reason, when resolving the question of the survival of tissues in relation to different methods and conditions of conservation, the first essential is research on this material (i.e. skin, whole organs and endocrine glands).

When preparing apparatus for the conservation of organs and tissues for transplantation, it was decided to test the vitality of grafts subjected to deep freezing without drying and to compare it with the survival of lyophilized tissues, which, according to the data in the literature, do not retain their vitality.

The experiments were carried out with rabbit skin, in which, in addition to histological criteria of vitality, clinical signs can be observed dynamically, e.g. changes in the appearance and palpation characteristics of the graft and in its visible functions, such as growth of the fur (biological test of survival).

*) Delivered at the II. International Symposium of Plastic Surgery at Mariánské Lázně, Czechoslovakia, June 1960.

Fig. 1. Fig. 2.

Fig. 1. Removal of two large full-thickness skin grafts from rabbit's back. — Fig. 2. Skin grafts stretched over roll of gauze, with the fur inside.

METHODS

Large full-thickness skin grafts measuring 8×10 cm. were excised from the rabbit's back with a sharp scalpel and were separated from the deeper musculovascular layer by a blunt instrument (Fig. 1).

To ensure quicker freezing, the grafts were stretched over a roll of gauze, where they were held in place by means of sutures (Fig. 2) and were plunged into liquid nitrogen at about —196° C (Fig. 3). In some experiments 30% glycerin solution or paraffin oil was used as a protective medium, in which the graft was placed before freezing. The grafts, which froze immediately in the liquid nitrogen, were stored for varying periods, ranging from one hour to 35 days. Before being transplanted they were thawed by placing in warm physiological saline. The graft was always transferred to the recipient's back (Fig. 4), in homoplasty nearer to the head and in autoplasty nearer to the tail, since with homoplasty it was impossible, when the graft failed to take, to determine whether this was due to the conservation method or to immunobiological incompatibility of the homoplastic tissues. Since some of the data in the literature indicate that conserved grafts take better than unconserved grafts (Filatov 1937, Lapchinsky 1941), it was important to study the fate of both types of conserved grafts.

The grafts were marked by turning them 180 degrees, so that the fur grew in the opposite direction from normal. This permitted the dividing line to be determined clearly, not only macroscopically, but also in histological preparations (Fig. 5).

RESULTS

Altogether 60 experiments were carried out with 30 rabbits, which were divided into five series. It was found from the control series that fresh, unconserved, rabbit skin, transplanted in the form of a free full-thickness graft takes. These grafts were observed for a number of months and sometimes years

Fig. 3. The skin graft, on the roll of gauze, is plunged into liquid nitrogen.

after transplantation. During this time the grafts not only do not shrink, but actually increase in size. They grow fur of the same colour and also retain their other functions. The picture of such skin as a whole corresponds to that of normal skin, the only difference being in the direction of growth of the fur, for which the transplantation method is responsible (Fig. 6). In transplantation of unconserved skin homografts, necrosis is always observed after the primary take, followed by regression and replacement of the graft by scar tissue.

In the second series of experiments with rabbit skin frozen at —70° C and lyophilized in an apparatus constructed by the institute by the technique used for blood vessels, the grafts did not take satisfactorily, either in autoplastic or in homoplastic transplantation. This is in agreement with the findings in the literature.

In the third and fifth series of experiments it was found that rabbit skin conserved by freezing at —196° C in liquid nitrogen for one month retains its vitality and autografts are capable of taking satisfactorily. Depigmentation

occurs, however, and the white coloration of the graft contrasts sharply with the normally pigmented surrounding skin (Fig. 7). Fur later grew again on these permanently healed frozen grafts, but it was also unpigmented and softer, like the under-fur, so that it contrasted quite sharply with the surrounding parts (Fig. 8 and 9). The white fur of the grafts later became pigmented; the process

Fig. 4. The thawed skin is transplanted to a rabbit's back (autograft and homograft).

of recovery of pigmentation did not start from the edges, but took place over the whole surface of the graft (Fig. 10). Histological examination of skin conserved by freezing in liquid nitrogen for 23 days and eight months showed that after transplantation its structure was normal (Fig. 11).

Homoplastic grafts of rabbit skin conserved by deep freezing at —196° C, after healing by first intention or apparently taking (during which many homografts are more healthy in appearance than autografts) do not take permanently. They later become necrotic and regress, though they retain their vitality considerably longer than unconserved homografts, as seen from histological preparations removed for biopsy on the 37th day (Fig. 12 and 13; the latter, greatly enlarged, shows mitoses — M) and 65th day (Fig. 14).

Maintenance of the vitality of skin grafts frozen in liquid nitrogen is helped by protecting them with a layer of vaseline oil. This is probably because the

vaseline oil prevents the liquid nitrogen from penetrating deep into the tissue, which might result in its being torn in transition of the nitrogen to the gaseous state when graft is warmed prior to transplantation.

It should also be mentioned that, as shown by the fourth series of experiments, the use of local anaesthesia when removing the skin grafts for freezing is dele-

Fig. 5. Microphotographs. It can be seen that the hair bulbs in the autograft point in a different direction from those in the surrounding normal skin.

Fig. 6. Fur on autograft growing in the opposite direction from normal.

terious to survival of the conserved skin. This may be due to crystallization of the additional water administered into the tissue with the anaesthetic. This should also be borne in mind in clinical practice.

DISCUSSION

Study of the fate of skin grafts frozen at —196° C in liquid nitrogen after autotransplantation showed that with this method rapid deep freezing did not damage living skin from adult rabbits. Rapidly frozen grafts took permanently and their vitality was prolonged in a similar manner to that of skin frozen at only —79° C in a solid carbon dioxide medium (Billingham and Medawar 1952)

Fig. 7. Depigmentation of a frozen skin autograft; the edge of the graft is clearly visible.

Frozen skin autografts apparently remain alive throughout, with clearly discernible oblong contours. When the graft is turned by 180 degrees at transplantation, the fur continues to grow in the opposite direction from normal, as seen clearly both macroscopically and in microscopic specimens. The frozen graft can also be distinguished by the depigmentation of its own skin and fur, which grows again and is sparser and finer than on the surrounding skin. When the fur is shaved off, the dividing line between the depigmented skin of the graft and the normal surrounding skin remains just as sharp and straight for several months after transplantation as at the outset. This indicates that regenerating cells from the normal surrounding skin do not infiltrate into the graft. The partial renewal of pigmentation of the frozen graft observed later is not due to the infiltration of cells from the surrounding tissues, but occurs evenly and simultaneously, not from the edges of the graft, but from individual foci throughout the whole area of the graft. The possibility of regeneration of the skin from the underlying tissues must be excluded if no skin was left below it. As a rule the skin was

removed completely, for its full thickness, down to the underlying musculovascular layer.

In experiments in which skin grafts first frozen and then lyophilized were transplanted, the grafts did not take even in autoplastic transplantation and certainly not in homotransplantation. Lyophilization was carried out in an apparatus used in the conservation of blood vessels, which, according to the findings

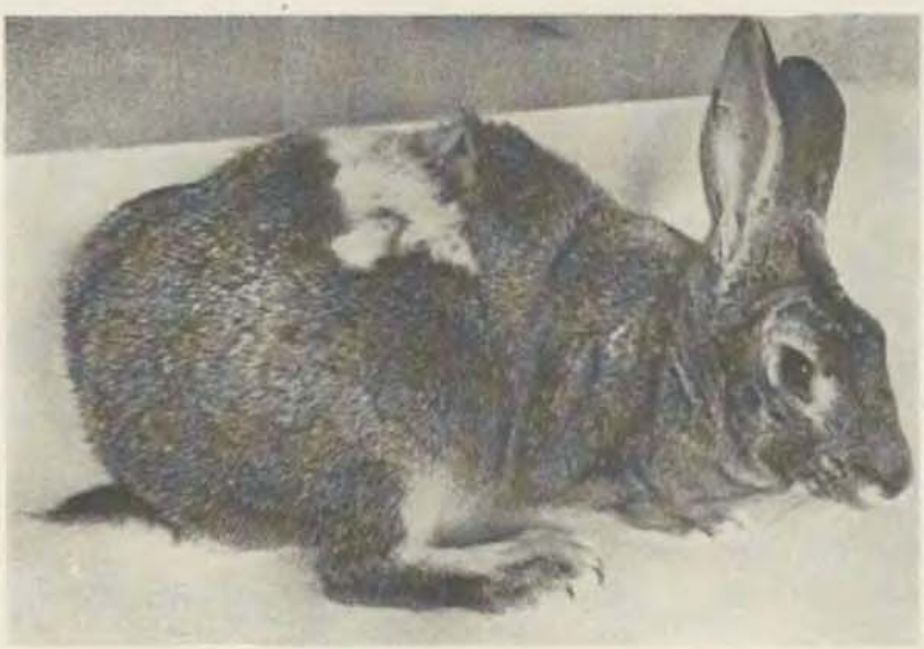


Fig. 8. Depigmented white fur growing on healed depigmented frozen skin.

Fig. 9. The depigmented skin and fur of a frozen graft contrast markedly as regards coloration and the direction of growth of the fur from the surrounding normal skin.

in the literature, do not retain their vitality when conserved in this manner and do not grow in tissue cultures, although when used in operations in human beings they have a positive clinical effect (Deterling, Coleman and Parshley 1950, Hufnagel and Eastcott 1952). According to the literature, a similar picture is obtained with the lyophilization of skin (Billingham 1954). It is not out of the question that conditions of freezing and drying (to a smaller degree) can be elaborated

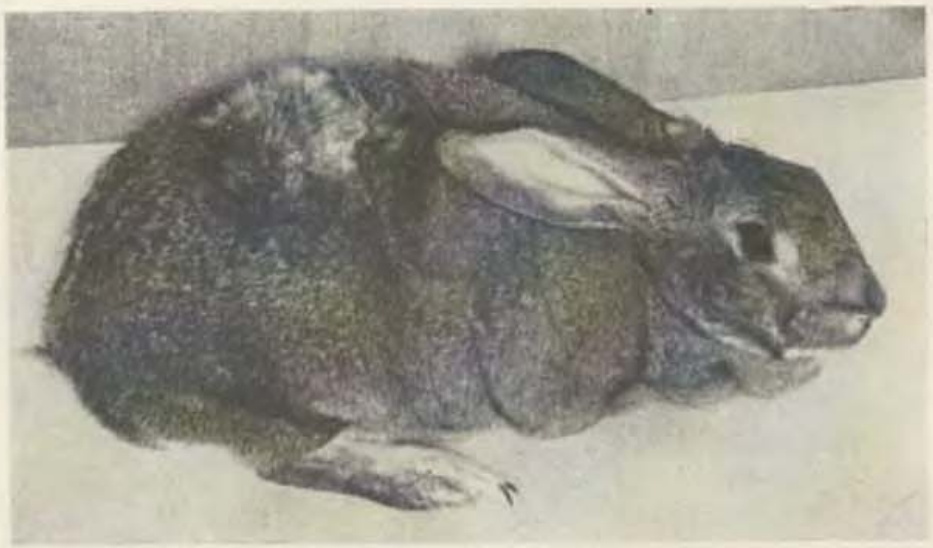
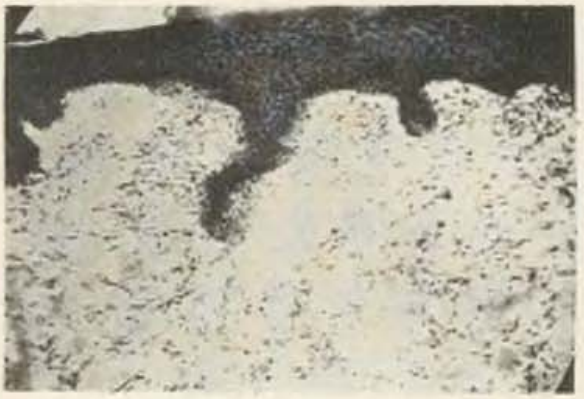


Fig. 10. The pigmentation of the colourless fur of the frozen autograft is partly recovered in time. The process does not take place from the edges, but over the whole surface of the graft.

Fig. 11. Microphotographs of healed skin autograft conserved by freezing in liquid nitrogen for 24 days. Eight months after transplantation (×20).

which will not kill living tissues. Until then, however, precedence should be given to freezing without drying, as a method with which skin retains its vitality.

In the homotransplantation of skin grafts conserved by freezing in liquid nitrogen, the grafts eventually regressed, not as a result of conservation, but because of incompatibility, manifested after a primary take, during which homo-



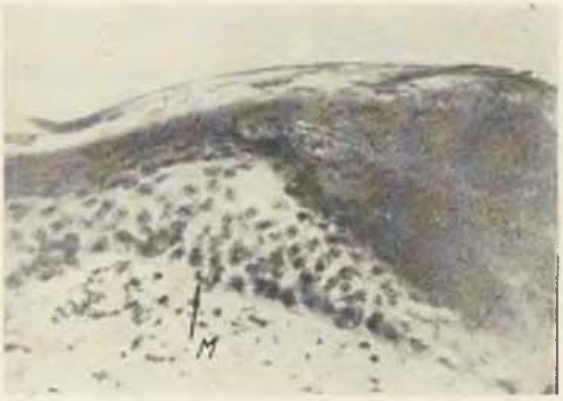


Fig. 12. Fig. 13.

Fig. 12. Microphotographs of skin homograft conserved by freezing for 14 days in liquid nitrogen. Biopsy on the 37th day after transplantation (×280). Mitoses can be seen. — Fig. 13. Microphotographs of skin homograft conserved by freezing for 23 days in liquid nitrogen.

grafts are more healthy in appearance then autografts and are firmly attached to the bed. In a number of cases, prolonged survival of frozen homografts was observed. Immediately after the superficial scab was shed, the white surface of the living epidermis appeared, with desquamation of small flakes characteristic for healing of an autograft. Cases were observed in which the healed homograft, with living epidermis, was isolated from the normal skin on all sides by a strip

Fig. 14. Biopsy on 65th day after homotransplantation.

of wound granulation tissue, which prevented infiltration of the regenerating epidermis from the base. The longest time of survival of a healed frozen skin homograft observed was 65 days. During this time two full-thickness strips were removed from the graft down to the muscles (biopsy for histological examination), followed by suture; this undoubtedly shortened the life of this homograft.

Prolongation of the vitality of frozen skin homografts in rabbits was also found by the Italian workers Pariente and Ayregi (1958), who conserved skin in dry ice at —79° C.

These findings on prolongation of the survival of conserved skin homografts as compared with fresh tissue correspond to the observations of Filatov (1937) and his school, who obtained better results with corneal homografts conserved by cooling at $+2^0$ and $+4^0$ C than with fresh grafts and to findings on the transplantation of tooth germs in dogs, rats and cats (Lapchinsky and Malinovsky 1940, 1941). The reason for this may be that since individual peculiarities in the structure of tissues, which form the basis of incompatibility, are recently formed characteristics, or characteristics weakly fixed during evolution, they must be less important and do not necessarily interfere in the basic molecular structure characteristic for a given species. In the process of necrobiosis of the tissues during conservation, individual peculiarities, being less stable and less firmly rooted in phylogenesis, must be the first to be lost. Individual specificity must go first, while deep species specificity remains (Lapchinsky 1957).

Liquid nitrogen displayed good properties as a conserving agent for deep freezing, being safe and not unpleasant to manipulate, easy to obtain and better than liquid oxygen, since it does not react with the conserved tissues. Vaseline oil is to be preferred to glycerin solutions as a protective medium. It mechanically prevents the liquid nitrogen from penetrating deep into the frozen tissue, the softer parts of which might be injured in the transition from the liquid to the gaseous state during thawing.

The authors refrained from placing skin intended for freezing in various aqueous solutions, so as to prevent water absorption, which would be undesirable from the aspect of subsequent freezing. This was indirectly confirmed by the poor results of experiments in which local anaesthesia was used when removing skin grafts; they showed that the skin ought not to contain any additional water before freezing.

SUMMARY

1. Fresh (unconserved) rabbit skin, when transplanted in the form of a free full-thickness autograft, took permanently and satisfactorily (observed for months and even years after transplantation). In the transplantation of unconserved rabbit skin homografts, after a primary phase of apparent healing necrosis was always observed, followed by regression of the homograft.

2. Rabbit skin conserved for 23 days by freezing at -196^0 C in liquid nitrogen, retained its vitality and as an autograft was capable of taking permanently, although depigmentation occurred. Fur later began to grow on permanently healed grafts; this was at first also depigmented, but pigmentation of the fur was later partly recovered.

3. Homografts of rabbit skin conserved by deep freezing at -196^0 C in liquid nitrogen first took, but later underwent necrosis, regressed or were absorbed, although they survived considerably longer than unconserved homografts.

4. Rabbit skin conserved by freezing at -70^0 C followed by lyophilization in an apparatus for the conservation of blood vessels did not take either in autoplastic or in homoplastic transplantation.

5. Maintenance of the vitality of skin grafts frozen in liquid nitrogen was facilitated by covering them with a protective layer of vaseline. The use of local anaesthesia, by introducing additional water into the tissue, is harmful to the vitality of skin subjected to deep freezing.

ВЫВОДЫ

Пересадки кожи кроликов, консервированной замораживанием до —196° С в жидком азоте

А. Г. Лапчинский, Н. С. Лебедева

1. Свежая (неконсервированная) кожа кроликов после свободной пересадки лоскутов во всю толщу при аутопластике дает истинное и стойкое приживление, наблюдавшееся много месяцев и даже лет после трансплантации. При гомопластике неконсервированных лоскутов кожи кроликов после первоначалького периода мнимого приживления, всегда наблюдается некроз с последующим отторжением гомотрансплантатов.

2. Кожа кроликов, консервированная замораживанием до —196° С в жидком азоте до 23 дней, остается живой и после аутопластической пересадки способна к истинному приживлению: при этом она депигментируется. На стойко прижившихлоскутах впоследствии отрастает выбритая шерсть, сначала депигментированная, а затем пигментация шерсти частично восстанавливается.

3. Гомопластические лоскуты кожи кроликов, консервированные глубоким замораживанием до —196° С в жидком азоте, после периода первоначального приживления омертвевают, отторгаются или рассасываются, однако, сроки их жизни значительно больше, чем при гомотрансплантации неконсервированных лоскутов.

4. Кожу кроликов, консервированную замораживанием до —70° С, с лиофилизацией в аппарате для консервации кровеносных сосудов, не удалось приживить ни при аутопластической, ни при гомопластической пересадке.

5. Сохранению жизнеспособности лоскутов кожи при замораживании с жидком азоте способствует покрытие их слоем вазелиного масла в виде защитной среди. Применение местной анестезии с введением в ткань дополнительной воды, препятствует сохранению жизни в коже, подвергнутой глубокому замораживанию.

RÉSUMÉ

Transplantation de la peau de lapin, conservée par congélation à —196° dans l'azote liquide

A. G. Laptchinsky, N. S. Lebedjeva

1. L'emploi de la peau de lapin fraîche (non-conservée) pour l'autogreffe aboutit, après transplantation libre du greffe dans son épaisseur toute entière, à une adhérence réelle et permanente, observée pendant des mois et même des années après la transplantation. Lors de l'homogreffe des lambeaux non-conservés de la peau de lapin, on observe toujours après l'époque primaire pendant laquelle l'adhérence semble s'effectuer, des nécroses suivies du détachement de l'homogreffe.

2. La peau de lapin conservée pendant 23 jours par congélation dans l'azote liquide à —196° С reste vivante et capable d'adhérence permanente après l'application autoplastique; en même temps, on assiste à une dépigmentation de celle-là. Mais sur les greffes qui se sont incorporés définitivement, les poils rasés vont repousser plus tard,

au début sans pigmentation, mais après un certain temps, la pigmentation se renouvelle partiellement.

3. Les greffes homoeoplastiques de la peau de lapin, conservés par congélation à —196° C dans l'azote liquide vont, après une première période d'adhérence, se nécroser et ou bien se détacher ou bien être résorbés, mais en comparaison avec les applications homoeoplastiques des greffes non-conservés, leur période de survie est nettement prolongée.

4. La peau de lapin conservée par congélation à —70° C et lyophilisation dans l'appareil destiné à la conservation des vaisseaux sanguins, ne montre pas d'adhérence, ni après transplantation autoplastique, ni après transplantation homoeoplastique.

5. La conservation de la vitalité des tissues cutanés lors de leur congélation dans l'azote liquide permet de couvrir ces tissues d'une couche en huile de vaseline et de constituer ainsi une couche protectrice. L'application d'une anesthésie locale avec instillation d'eau complémentaire dans les tissus empêche la conservation de la vitalité de la peau exposée à une congélation à température très basse.

ZUSAMMENFASSUNG

Transplantation von Kaninchenhaut, die durch Gefrieren bei minus 196° C in flüssigem Stickstoff konserviert worden war

A. G. Laptschinsky, N. S. Lebedewa

1. Mit frischer (nicht konservierter) Kaninchenhaut wird nach autoplastischer freier Übertragung von Lappen in ganzer Hautdicke eine wirkliche und dauernde Anheilung erzielt, die durch eine Reihe von Monaten und sogar Jahren nach der Transplantation verfolgt worden ist. Bei Homoplastik mit nicht konservierten Kaninchenhaut wird nach Ablauf des primären Stadiums der entzündlichen Anheilung jedesmal Nekrose des Homotransplantats und seine darauf folgende Elimination beobachtet.

2. Kaninchenhaut, die für die Dauer von 23 Tagen durch Gefrieren bei —196° C in flüssigem Stickstoff konserviert worden war, bleibt am Leben und ist nach autoplastischer Übertragung imstande, dauernd anzuheilen. Dabei tritt ein vollständiger Pigmentverlust des Hautlappens auf. Am definitiv angeheilten Lappen wächst später das ausrasierte Fell wieder nach, zuerst ohne Pigment, später jedoch tritt das Pigment des Fells teilweise wieder auf.

3. Homoplastische Kaninchenhaut, die durch Gefrieren bei —196° C in flüssigem Stickstoff konserviert worden waren, verfallen nach dem Stadium des primären Anheilens der Nekrose, werden eliminiert oder resorbiert; ihre Überlebensdauer ist jedoch gegenüber der bei homoplastischer Übertragung nicht konservierter Haut markant verlängert.

4. Kaninchenhaut, die durch Gefrieren bei —70° C konserviert und im Gerät für Blutgefässkonservierung lyophilisiert-worden war, heilte weder bei autoplastischer noch bei homoplastischer Transplantation an.

5. Die Erhaltung der Vitalität der Haut wird bei Gefrieren in flüssigem Stickstoff durch eine Schutzschicht von Vaselinöl ermöglicht. Die Verwendung der Lokalanästhesie, bei der zusätzliche Flüssigkeit ins Gewebe eingeführt wird, verhindert die Erhaltung der Vitalität der Haut bei Konservierung durch Gefrieren bei tiefen Temperaturen.

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REVASCULARIZATION OF A FREE SKIN AUTOGRAFT

J. ŠMAHEL

The way the blood supply to the tissue is restored after transplantation is of first importance. It is, therefore, understandable that most authors, employing skin transplants, particularly free skin grafts, paid great attention to this aspect of the problem. Despite the large knowledge gained and the practical experience accumulated, the problem cannot yet be considered as being solved.

This paper deals with the revascularization of free skin grafts, and the author bases his study on knowledge about the regeneration of the vascular system in the bed of a healing skin wound [Šmahel, Charvát (8)] obtained under identical experimental conditions and with the same method. He thinks the evaluation of the problem from this point of view would be useful.

MATERIAL AND METHODS

The author studied revascularization of a transplant in a total of 120 rats of both sexes, average weight 110 to 150 g. On the depilated dorsal skin two skin wounds of a diameter of 8 mm. and 5 cm. apart, were produced with Luer's forceps. The wound base consisted of sparse subcutaneous connective tissue.

The circular skin discs acquired by this procedure, were used as free grafts. After shaving off the deeper layers, these grafts consisted only of the epidermis and the larger part of the corium, and were then re-implanted into the wounds. The discs were interchanged so that the skin from the caudal wound was implanted into the cranial and vice-versa. Then the transplants and the surrounding area were covered with a layer of gauze soaked in vaseline which was kept in place by a pressure bandage consisting in a number of turns of a wide roller bandage fixed by three circular bands of leucoplast. This formed a tube-like dressing around the trunk which impeded the movement of the animal to a great extent and thus performed the function both of compression and immobilization. The latter proved very important because of the restive behaviour of the animals.

The material for investigation was taken at intervals of one day starting one hour after transplantation. Prior to this, the vascular system was made visible by an intracardial injection of a constrast substance.

Under general ether anaesthesia after the subcutaneous administration of heparin, the thorax of the experimental animal was opened, the left heart ventricle punctured, through the thus produced opening an injection needle was

then introduced into the ascending aorta and fixed there with a ligature. Then a mixture of gelatin and Indian ink with vasodilators added to it and warmed to 50^0 C, was injected. On an average 30 to 50 cc. of this mixture were given. After cooling the substance within the vascular system by submerging the animal in cold water, the skin in the area of the defect was cut out and carefully separated from the underlying dorsal fascia. Thus square pieces of skin measuring 2×2 cm. were obtained in the centre of which was the healing wound previously treated with a skin graft. After fixation in Carnoy's solution, these pieces of skin were cleared by putting them into glycerin, and then investigated *in toto* under a stereoscopic microscope. The above observations were implemented by the study of frozen slides of the injected tissue. The combination of both methods of investigation is considered important, because they are complementary and make up for each other's shortcomings.

Photographs were made under a Lumipan microscope with an Exakta-Varex camera always by small magnification with a Mikrotar objective.

ACTUAL OBSERVATION

In this section only actual observations documented by photographs are referred to. Their interpretation and integration will be carried out later in the discussion.

It needs to be pointed out that experimental transplantion of the skin grafts was carried out immediately after infliction of the wounds so that the time data are identical both for the wound and the transplantation.

The course of revascularization of a free skin autograft may be divided into three stages :

1. the preparatory stage up to the second day after transplantation,
2. the stage between the third and seventh day in which the connections between the vascular systems of the bed and the transplant are formed and the blood circulation in the graft is restored,
3. the stage between the eighth and twelfth day in which transformation and final adjustment of the circulation in the transplant takes place.

Stage I.: In the first hours after transplantation thrombi develop in the severed vessels of the wound, and the transplant, which has a strikingly pale colour, becomes glued on to its bed by fibrin. In the bed itself preserved vessels of the subcutaneous network, but only a relatively small number of capillaries, can be observed (Fig. 1).

From the vessels of the subcutaneus network, whether preserved in the actual bed or in the area surrounding the wound, considerable regenerative processes start already after a few hours. The vessels grow in the shape of interlocked arcades and form a very dense network, the development of which reaches its maximum on the second day after transplantion (Fig. 2). It is characteristic that this network develops not only in the wound bed, but also in the area around the wound.

In this arcade-like vascular network very thin and erect afferent arterioles, typical loops and winding efferent venules can be distinguished (Fig. 3).

Microscopic investigation shows that formation of this network proceeds in the wound bed and its surroundings without any apparent relationship to the transplant (Fig. 4).

Stage II: On the third day we can observe sacculations in the walls of sinusoid arcades from which, in the course of further development blind capillary sprouts are formed. The arcade network thus acquires a "thorny" appearance (Fig. 5). The lumen at the end of these sprouts is conical with a characteristic pointed apex (Fig. 6).

On growing towards the surface, the sprouts penetrate into the wound space, i.e. towards the transplant and its vessels with which they, providing favourable conditions, finally unite. Formation of such links is demonstrated in Fig. 7. Minute extravasations around the vessels of the transplant can be observed almost regularly at this stage. The same situation is demonstrated in the histological slide of Fig. 8.

After the links have formed, the vessels of the transplant gradually fill up (Fig. 9). At the same time reduction of the arcades takes place which, on the fifth day, are reduced to the vessels feeding blood to and draining it from the transplant (Fig. 10). At this time all vessels of the transplant are already filling up, though in the case demonstrated in Fig. 10 they are very sparse. In this connection it is necessary to point out that in the period between the third and fifth day the injecting of the vascular system of the transplant is successful to a varying degree even if carried out by the standard methods. This could be due to some peculiarities in the revascularization of the individual transplant, but the author regards the main cause to be the complicated vascular situation and the inadequacy of the blood circulation in the transplant which is typical for this stage and, of course, is also an obstacle to the infiltration of the contrast substance into the vessels of the transplant. Frequently it is possible to follow the course of vessels in the transplant only, because they are really stuffed with erythrocytes which were pushed forwards as into a blind alley by the surging contrast substance.

On about the seventh day circulation in the vessels of the transplant is restored. The anatomic structure of the vascular network in the transplant has, however, its peculiarities, because this system is not being made use of according to its original structure, either with regard to the direction of the blood flow or to the functional category of the individual vessels (Fig. 11).

Stage III: After the circulation has been restored, the vascular system of the transplant is reformed, i.e. a new architecture develops evidently under the influence of the altered haemodynamic conditions. Fig. 12 also shows the two alternatives of healing at the margin of the transplant. Providing satisfactory apposition of the skin edges of the wound and the graft, direct union takes place so that the border between the transplant and the surrounding skin is indiscernible. If apposition is inadequate, the regenerative blastema grows into the gap between the edges which results in the formation of paler scar tissue with a scantier vascular network.

On the twelfth day there is practically no difference in the arrangement of the vascular systems of the transplant and the skin around it (Fig. 13).

In his experiment the author could also observe cases where revascularization was less satisfactory, i.e. where the vessels of the transplant did not fill up with blood and the circulation was not restored in a smaller (Fig. 14) or larger (Fig. 15) area. Under such an area blood vessel bushes start to grow from the area around the wound. These bushes together with the regenerative blastema developing in close connection with them, either lift the respective non-revascularized portion of the transplant off its bed and cause its elimination, or invade it (Fig. 16). Here it seems necessary to point out an important fact. At the time when the rest of the transplant has been successfully revascularized the affected area has been invaded by the vascular bush only to about half of its thickness; this results in necrosis of the superficial layers in this area of the transplant.

DISCUSSION

The author considers it important to deal with the formulation of the whole problem first. This paper is headed by the title "Revascularization of a Free Skin Autotransplant", i.e. in harmony with the term usually applied to it in the literature. The author considers, however, that such a limitation of the problem does not give a true picture of the whole situation, that is so say, it gives the impression that the transplant was the dominating and the skin wound the accessory feature. It also imputes that the transplant evokes regenerative processes of the vessels in the wound bed in the sense of a "sympathetic response" [Edgerton et al. (6)] and that these processes are specific for the transplant. The results of the above experiments, however, lead to the opposite conclusion which would be better defined by the title "Regeneration of the Vascular System in a Wound Treated with a Transplant". Such a definition of the problem is important from a practical point of view. It shows that the reparative processes of the wound represent the dominating factor which is but modified by the presence of the graft: The vascular system of the graft is "offered" to the regenerating vessels of the healing skin wound. It also shows that wherever the union of the vascular system in the bed and the transplant has not been established, the subsequent development is that of the regenerative vascular process typical for a simple skin wound. The reparative process in the wound constitutes a chain the links of which are regularly interlocked with each other and in the course of which the same preconditions are not always present for the union with the transplant. A few hours after infliction of a skin wound, a rich arcade-like network of vessels develops in and around it which reaches its maximum on the second day after injury (8). During this time, union between the *newly formed* vessels of the bed and the vascular system of the transplant cannot yet be established, because the blind capillary sprouts constituting the mediators between the two systems, have not yet developed. This means, therefore, that not even the most intense vascularization of the wound bed provides for the revascularization of the transplant, if sprouting of the capillaries does not take place.

The author does not consider the immediate union between vascular stumps in the wound bed and in the transplant, resembling that in a stitchless vascular suture, which may be effected during this period [Davis, Traut (5) and others (1, 3, 6)] and which the author could also observe occasionally, to be a pheno-

menon essential for the revascularization of the transplant. He is convinced that it contributes to the revascularization only to a lesser extent. He is of the opinion that these vascular links are rather infrequent and, particularly, that the formation of such links at a time when the preconditions for multiple connections between both vascular systems (by way of capillary sprouts) have not yet been established, can have no great significance for the revascularization of the graft, just because of the functional isolation of this phenomenon.

The optimal conditions for the development of vascular links between the systems of the bed and the transplant are found in the wound on the third day after injury, when the blind capillary projections which are to become the links between both systems, start to sprout from the arcade-like network.

In the following days a great many of these sprouts develop in the wound which become interlinked and thus vessel bushes are formed which constitute the vascular foundation of granulation tissue (8). After the formation of granulation tissue the chance for the take of the transplant becomes worse, although the conditions, i. e. rich vascularization of the bed and the presence of capillary sprouts seem, on the contrary, to favour it. The author believes the explanation should be sought in the biological aspect of the problem : The reparative processes, typical for a wound are, at the time, in a state of full development and can only be influenced with great difficulty. The recommended ablation of granulations, thus also the removal of the vascular bushes actually represents a violent return of the regenerative process to the stage typical for the third day after injury. This explanation, of course, takes into consideration only the vascular aspect of the problem. The author by no means wishes to underrate the unfavourable influence of infection.

If we compare the regenerative process in the bed of a simple wound with that in a wound treated with a transplant, it can be ascertained that there is no essential difference between them up to the beginning of the third day after injury. In both tremendous formation of an arcade-like network takes place, and as from the third day the sprouting of capillary projections can be observed. This process, therefore, is not induced by the presence of the transplant, but is specific for the healing of a skin wound. It is, however, possible that this process is somewhat stimulated by the transplant, but not to a great extent. Since the conditions for the formation of links between the vascular systems of the bed and the transplant are established not earlier than the beginning of the third day, the question arises as to whether it is necessary or suitable to cover a fresh wound with a skin graft or whether it would not be better to apply the transplant only to a three-day "old" wound in whose bed the preparatory processes have already been completed. The answer to this question will require further experiments.

The most relevant process leading to revascularization of the transplant is the sprouting of capillary projections from the newly formed vessels of the wound bed. In the experiment described these sprouts appeared with a certain regularity on the third day after injury. The author believes that, in view of the tremendous regenerative capacity of the endothelium, the initial vascularization of the bed is, on the whole, not of decisive importance. It also seems that the

period up to the third day cannot be regarded as the time necessary for a definite increase in the number of vessels, but that the regularity of this interval has another cause.

The sprouting of the capillary projections is a basic qualitative change in the development of the reparative process of the vessels. Up to the time of their appearance the regenerative vascular processes took place in the tissue of the wound bed. The capillary sprouts, however, grow into the space already filled with fibrin or the transplant. If on growing they meet with the vessels of the transplant, they unite with them and the blood starts to enter the vessels of the transplant.

At this time clinical observation shows that the transplant is turning pink. This colour comes partly from oxygenated blood entering the vessels of the transplant, but mainly from the fine extravasations which are usually observed in the transplant. Their development may be explained by the pathological permeability of the vessels in the transplant enhanced by congestion. The pink colour cannot, therefore, be regarded as a proof of the restoration of circulation in the transplant (which is effected later — see below), but as a prognostically favourable sign of the established union between the vessels of the bed and the graft.

After the formation of the links and evidently due to the altered haemodynamic conditions, the sprouts cease to grow and the arcades of the vascular network in the wound bed are greatly reduced, so that on the fifth day only the vessels feeding the links remain patent. The dynamics of the vascular process are surprising with regard both to the appearance and the disappearance of the arcade network. The formation of vascular links shows a regularity which may be regarded as decisive for the revascularization of the transplant. The blind capillary sprouts show solitary growth only to a certain distance, usually to a maximum of 300 μ as has been reported by Clark et Clark (2). Afterwards they form anastomoses and send out further sprouts thus forming bushes which appear at the same time as the granulation tissue. This, as was stated above, is unsuitable for the formation of links.

It can, therefore, be said in general that any obstacle preventing the growing sprouts from meeting the vessels of the transplant to a distance less than 300 μ, jeopardizes revascularization of the transplant, and this failure is then followed by the regular development of reparative processes in the wound, i. e. of granulation tissue.

The usual obstacles include : haematoma, seroma, air bubbles, pus.

These facts corroborate the generally recognized principle that it is necessary to provide for the closest contact of the transplant with its bed.

Actual revascularization of the transplant starts with the establishment of capillary links, and between the third and sixth day its course becomes very complicated. The vascular and circulatory situation on whose solution depends the fate of the transplant, is complex for the three following reasons :

1. The capillary sprouts growing in the direction of the transplant are of an afferent character. Their joining with the vessels of the transplant provides for the supply of blood to, but not drainage from, the transplant.

2. The capillary sprouts join with the vessels of the transplant both end-to-end and end-to-side. End-to-end junctions can be effected only with vessels of a similar calibre, i. e. with capillaries or other minute vessels. The same applies to the end-to-side junctions, since the wall of larger vessels constitutes an impenetrable barrier to the capillary sprouts. By this a situation arises in which the blood first enters the capillaries and minute vessels of the transplant and from there it flows into the veins and arteries. Thus the importance of the number of links formed and their usefulness stands out clearly.

3. The anatomical and functional condition of the vascular bed of the transplant are very important factors in revascularization. An originally rich vascularization of the graft provides for a dense network and a multitude of anastomoses which are of great help, for the restoration of the circulation. The functional intactness of the vascular bed in the transplant is of particular importance, because it determines the extent and degree to which this vascular system can be utilized. Among the causes which may make the vessels impassable, are the following:

a) Thrombosis; though the author is of the opinion that it is not a frequent cause, since the vessels are practically emptied on taking a graft, particularly a thin one.

b) Collapse of vessels which may persist particularly when considerable pressure is applied to the transplant.

c) Collapse of vessels followed by the sticking together of the endothelium as a result of degenerative processes.

d) Air embolism.

The author thinks c) and d) the most frequent causes.

None of these causes need be permanent. In view of the precarious biological situation of the graft, however, even a short delay in revascularization of only a few hours can have disastrous consequences for the respective section of the transplant because during this time irreversible destructive processes may take place.

At the beginning, therefore, one cannot really speak of blood circulation. The blood actually enters the transplant and shows only a pendulum-like movement with a very sluggish flow or even stasis, as has been described by authors who made observations of the vessels of transplants *in vivo* (2, 4, 6, 9, 10).

The clinical manifestation of this unsatisfactory circulation is the cyanotic discoloration of the transplant.

The decisive factor for the adjustment of these conditions which comes into action between the sixth and eight day, is — according to the author's opinion — the link-up of the capillary sprouts with the vessels of the transplant. These links then become differentiated into afferent (arterial) and efferent (venous) evidently under the influence of the different pressure of the blood they contain. Apart from this, differentiation into main and secondary links according to their usefulness and the amount of blood flowing through them takes place.

As stated above, the original vascular bed of the transplant is made use of to a degree limited by its functional intactness. It is, however, not used with regard to the original architecture and hierarchy of the vessels in the transplant, but rather as a system of tubes. This, too, shows a certain passivity of the graft towards its bed (the wound).

It is necessary to point out that revascularization of the transplant can be influenced favourably by links with vessels from the wound edge, though this always occurs to a lesser degree; provided, of course, apposition of the edges of the wound and the graft is satisfactory and no ischaemization — e.g. by a suture — has been caused.

On the sixth and seventh day the blood circulation in the transplant is restored, but because of some anatomical features and a certain imperfection, the author considers it justified to speak of a "primitive circulation". This circulation is, however, capable of providing the graft with an adequate nutrition and so revascularization may be considered completed from a clinical point of view.

At this time cyanosis is receding and the transplant acquires a colour similar to that of the surrounding skin.

The disorders which may occur in the process of revascularization remain to be mentioned.

The author assumes that even under the most favourable circumstances revascularization cannot make use of a 100% of the original vascular bed in the transplant and, therefore, there are always a few minute areas in which circulation has not been restored. This, however, is not a serious shortcoming, since these microscopic areas can be adequately supplied with nutritives through the intercellular fluid from the surrounding area for quite a considerable time during which their revascularization takes place by the growth of new vessels originating in the graft itself.

It may be considered a more serious event if the circulation of a larger area or part of the transplant has not been renewed. Such an area retains the colour which the whole transplant showed during the first two days, i. e. it is strikingly pale. For causes dealt with above, a vascular bush starts to grow under it from the underlying bed. The author could observe two kinds of reaction of this bush towards the transplant. In the first case the vascular bush invaded the transplant making but negligible use of the original vascular bed. "Secondary" vascularization of the graft took place which, however, required roughly twice the time of the revascularization by way of the vascular system of the transplant. Thus too great a demand is made on the viability of the affected part in consequence of which the superficial layers usually slough off and are eliminated. The author believes that this type of revascularization is known to clinicians as "deep desquamation". In the second case the vascular bush together with the regenerative blastema lifted the affected part of the graft off its bed and caused its elimination. A similar mechanism is employed in the complete failure of transplantation.

From the eight to twelfth day, transformation and final adjustment of the vascular bed takes place evidently under the influence of the new haemodynamic factors. Anatomic readjustment of the architecture of the vascular bed, i. e. the

course of vessels where the blood, up to then, had often flowed through the most bizarre channels is effected, and the vessels undergo differentiation into arteries, veins and capillaries. It may be assumed that these anatomical changes must be accompanied by a radical transformation involving differentiation and de-differentiation of the vascular wall, because many a vessel or its part acquire a functional status different from that which it occupied originally.

Around the twelfth day the difference between the adjusted vascular bed of the transplant and that of the intact skin, has disappeared. This period should, however, be taken as the lower limit, i. e. the shortest possible time required for the transformation of the vascular bed. The vascular bed of the transplant can only be regarded as "definitely" adjusted when reinervation has been completed.

It remains to be considered whether this study could contribute to the solution of the frequently discussed problem in connection with stretching, compression and immobilization of the transplant.

As to the stretching of the graft, the results of the author's experiments corroborate the generally accepted principle according to which the tension in the transplant ought to be the same as that in the donor site. This will also be most favourable for revascularization of the transplant because the vessels are not distorted.

The pressure exerted on the transplant is fully justified, if it is applied in order to provide the closest contact of the graft with its bed and to arrest bleeding. It has, however, no doubt an unfavourable influence on the regenerative process taking place in the vessels of the bed, on the filling of vessels in the transplant, and it also complicates the already difficult situation arising during the restoration of the blood circulation in the transplant. From this point of view, the contact method as recommended by Sano (7) seems justified.

Immobilization appears suitable during the first three days, because it prevents the transplant from being lifted off its bed and provides for undisturbed linkage of the capillary sprouts of the bed with the vessels of the transplant. Later, however, slight movements may assist in the restoration of circulation.

SUMMARY

1. A study was carried out of revascularization of a free skin autotransplant in rats with the aid of injection technique.

2. The principles of regenerative processes of the wound are in the forefront, and are only modified by the presence of the transplant.

3. In the first two days after transplantation tremendous regenerative processes of vessels of the wound bed occur characterized by the development of an arcade-like network from which, on the third day, blind capillary projections start to sprout. During this time interval there is no essential difference between a simple wound and a wound treated with a transplant.

4. The capillary sprouts link up with the vascular system of the transplant which is made use of to an extent limited by its functional intactness. A complicated vascular and circulatory situation develops which is solved between the sixth and the seventh day when the circulation in the transplant is restored.

5. Invasion of the transplant by vessels is regarded as a substitute, as the revascularization of the transplant "per defectum".

6. After restoration of the circulation, transformation and adjustment of the vascular system takes place in the transplant under the influence of new haemodynamic conditions. This is completed on the twelfth day after transplantation at the earliest.

7. In the discussion an attempt is made at interpretation and integration of the observed facts.

A c k n o w l e d g e m e n t. The author wishes to express his thanks to Prof. V. Karfík, M. D., Director of the Clinic of Plastic Surgery in Brno, and his team, for making it possible to aquaint himself with the clinical side of the whole problem.

He also would like to thank the laboratory technicians of his department, E. Matějková, for her cooperation in the technical side of the experiment and O. Vašíř for making the microphotographs.

ВЫВОДЫ

Реваскуляризация свободного кожного автотрансплантата

J. Šmahel

1. Изучалась реваскуляризация свободного кожиого автотрансплантата у крысы при помощи инъекционной техники (введения контрастного вещества в сосуды).

2. Закономерности процессов регенерации сосудов раны являются доминирующими и только модифицируются присутствием трансплантата.

3. В течение первых двух дней после трансплантации в ложе раны происходят бурные процессы регенерации сосудов, характеризующиеся возникновением аркадных сетей, из которых на третий день начинают вырастать тупые капиллярные ростки. В течение этого этапа времени не имеется существенного различия между простой раной и раной обработанной трансплантатом.

4. Сосудистые ростки подключаются к сосудам трансплантата и сосудистое русло трансплантата используется в размерах, в которых сохранена его функция. Возникает сложная сосудистая и циркуляционная ситуация, которая разрешается на шестой — седьмой день, когда восстанавливается кровообращение.

5. Прорастание сосудов в трансплантат автор рассматривает только в качестве возмещающего процесса — реваскуляризации трансплантата per defectum.

6. После восстановления циркуляции происходит перестройка и формирование сосудистого русла трансплантата под влиянием новых гемодинамических факторов, которые заканчиваются не раньше 12-ого дня после трансплантации.

7. В дискуссии производится попытка интерпретации и взаимного согласования наблюдаемых фактов.

RÉSUMÉ

La revascularisation de l'auto-greffon cutané libre

J. Šmahel

1. On a étudié la revascularisation de l'auto-greffon cutané libre, sur des rats, à l'aide de la technique d'injection.

2. Les lois qui règlent le mécanisme de la régénération vasculaire dans la plaie dominent toujours et ne se trouvent que modifiées par la présence du greffon.

3. Au cours de deux premiers jours après la greffe, des processus de régénération vasculaire importants se déroulent à l'intérieur de la plaie, caractérisés par l'apparition des réseaux en arcades, à partir desquels des bourgeons vasculaires en cul-de-sac vont prendre naissance dès le troisième jour. A cette étape, il n'y a aucune différence fondamentale entre une plaie normale et celle où la greffe a été implantée.

4. Les bourgeons vasculaires entrent en communication avec les vaisseaux du greffon et l'utilisation du réseau vasculaire du greffon s'effectue dans une mésure qui permet de conserver son activité fonctionelle. Il en résulte une situation vasculaire et circulatoire très compliquée qui sera résolue entre le 6ème et le 7ème jour a lieu le rétablissement de la circulation.

5. D'après l'avis de l'auteur, la pénétration des vaisseaux dans le greffon ne présente qu'un mécanisme de remplacement, une revascularisation du greffon per defectum.

6. Après le renouvellement de la circulation, il se produit une reconstruction et la formation d'un réseau vasculaire dans le greffon, sous l'influence des facteurs hémodynamiques nouveaux, développement qui ne se terminerait que le 12ème jour après la greffe au plus tôt.

7. Lors de la discussion des faits observés, on essaie de les interpréter et d'expliquer leurs rapports réciproques.

ZUSAMMENFASSUNG

Die Revaskularisation des freien Hauttransplantats

J. Šmahel

1. Es wurde die Revaskularisation des freien Autohauttransplantats bei Ratten mit Hilfe einer Injektionstechnik untersucht.

2. Im Vordergrunde stehen die Gesetzmässigkeiten der regenerativen vaskulären Vorgänge, wie sie bei Wunden üblich sind ; sie werden durch die Anwesenheit des Transplantats bloss modifiziert.

3. In den ersten zwei Tagen nach der Hautübertragung treten in der Wunde kräftige vaskuläre Regenerationserscheinungen auf, die durch die Bildung eines Arkadennetzwerks charakterisiert sind, aus dem am 3. Tage blind endende Kapillaren knospenartig hervorspriessen. Während dieses Zeitabschnitts besteht kein wesentlicher Unterschied zwischen einer gewöhnlichen Wunde und der mit dem Transplantat gedeckten Wunde.

4. Die eindringenden Gefässausläufer treten mit den Gefässen des Transplantats in Verbindung und das Gefässnetz des Transplantats wird in solchem Umfange ausgenützt, welchen die Funktionstüchtigkeit des übertragenen Hautabschnitts ermöglicht. Auf diese Weise entsteht eine komplizierte Situation hinsichtlich der Gefässe und des Kreislaufs, die am 6. bis 7. Tag dadurch geregelt wird, dass zu dieser Zeit sich der Kreislauf wieder hergestellt hat.

5. Im Eindringen der Gefässe in das Transplantat sehen wir bloss einen reparativen Prozess, die Revaskularisation des Transplantats per defectum.

6. Nach Restitution des Kreislaufs spielt sich der Umbau und die Formierung des Gefässnetzes im Transplantat unter dem Einfluss neuer hämodynamischer Faktoren ab, dieser Prozess ist frühestens am 12. Tage nach der Transplantation abgeschlossen.

7. In der Diskussion wurde der Versuch gemacht, die beobachteten Tatsachen zu interpretieren und in gegenseitige Übereinstimmung zu bringen.

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Fig. 8. Frozen slide of injected skin wound with transplant, third day after transplantation. Stained with HE: Left portion marked by the large amount of vessels filled with injected contrast substance and represents the wound bed with arcade-like network. Right, paler portion of picture shows a section through the tissue of transplant with sparse vessels running through the middle. At the border of wound bed and transplant two capillary sprouts connect both vascular systems.

Fig. 9. Total preparation of skin wound with transplant seen from below, fourth day after transplantation: in left third of picture there is undamaged skin surrounding the wound; on the right side — part of the transplant. Above the transplant, arcade-like network and below to the right, filling vessels of the transplant can be seen

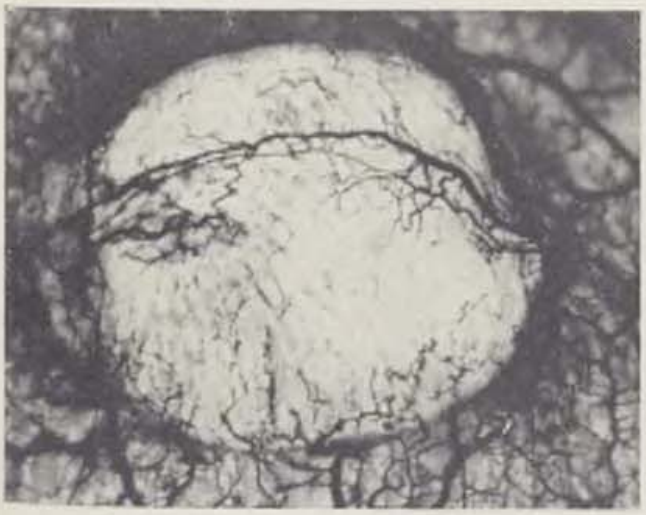

Fig. 10. Total preparation of skin wound with transplant, fifth day after transplantation: Revascularization takes place throughout the whole transplant.

Fig. 4. Frozen slide of injected skin wound with transplant, second day after transplantation. Stained with HE: At the left margin there is intact skin of area around the wound. On the right side of picture are marginal portions of transplant in close apposition with the floor and edge of the wound. In and around the wound bed the arcade-like network can be seen. The vessels are filled with the injected contrast substance.

Fig. 5. Total preparation of part of the wound bed, third day after transplantation: Sprouting of blind projections from arcades.

Fig. 6. Total preparation of part of the wound bed, third day after transplantation: Detail of blind sprouts.

Fig. 7. Total preparation of part of the transplant and bed seen from below, third day after transplantation: Fine vessels in the middle of picture are capillary sprouts from arcades; the rest of the more or less filled vessels lying in the focal plane belong to the transplant. Details of link-ups can be observed.

Fig. 8. Frozen slide of injected skin wound with transplant, third day after transplantation. Stained with HE: Left portion marked by the large amount of vessels filled with injected contrast substance and represents the wound bed with arcade-like network. Right, paler portion of picture shows a section through the tissue of transplant with sparse vessels running through the middle. At the border of wound bed and transplant two capillary sprouts connect both vascular systems.

Fig. 9. Total preparation of skin wound with transplant seen from below, fourth day after transplantation: in left third of picture there is undamaged skin surrounding the wound; on the right side — part of the transplant. Above the transplant, arcade-like network and below to the right, filling vessels of the transplant can be seen

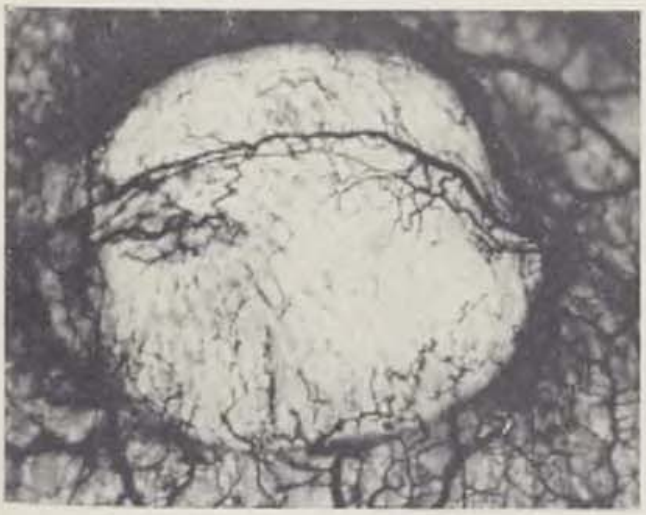

Fig. 10. Total preparation of skin wound with transplant, fifth day after transplantation: Revascularization takes place throughout the whole transplant.

Fig. 11. Total preparation of skin wound with transplant seen from below, seventh day after transplantation: Vessel of transplant clearly consisting of sections which had a different functional status originally. From the right side, a large afferent vessel approaches the transplant followed by a two-branch section (evidently of capillary character) and an S-shaped section (originally probably an artery) which then continues with a section resembling a vein by its course and from this a conspicous vessel stump projects.

Fig. 12. Total preparation of skin wound with transplant seen from below, tenth day after transplantation: Progressing differentiation between afferent and efferent vessels and adjustment of the architecture of vascular system of transplant. Part of periphery of transplant growing pale, caused by presence of scar tissue.

Fig. 13. Total preparation of skin wound with transplant seen from below; twelfth day after transplantation. Final adjustment of vascular system in transplantat. Part of periphery of transplant growing pale caused by presence of scar tissue.

Fig. 14. Total preparation of skin wound with transplant seen from below, seventh day after transplantation: At the lower margin of transplant there is a paler, not revascularized area invaded by vascular tree from area around the wound.

Fig. 15. Total preparation of skin wound with transplant seen from below, seventh day after transplantation: Invasion of a horseshoe-like vascular tree into the pale area of transplant where revascularization has not taken place.

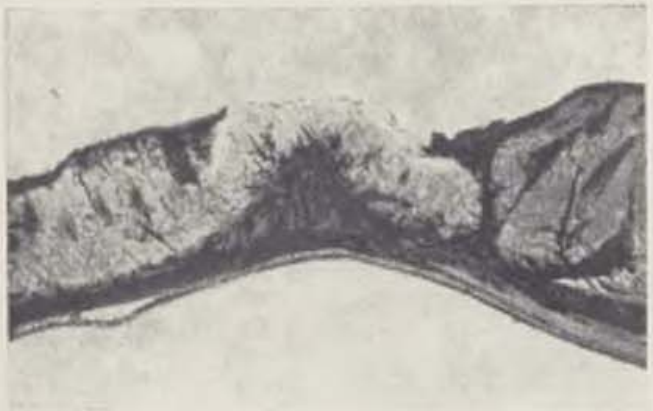

Fig. 16. Frozen slide of injected skin wound with transplant, seventh day after transplantation: In right third of picture there is undamaged skin from area around the wound, in left third, part of transplant where revascularization was effected by employing vessels of the transplant. In middle third a vascular tree is invading the transplant. In this part necrosis of superficial layers can be observed.

V. Novák

THE REGENERATION OF THE VASCULAR BED IN AUTOGRAFTS OF COSTAL CARTILAGE IN THE CAT DOES THE SIZE OF THE GRAFT INFLUENCE REGENERATION?

Fig. 1. The costal cartilage of the 6th rib of the right side, view from above. r — bone rib, s — sternum. On the lateral end the blood vessels enter from the front and from behind, on the sternal end from above and from below.

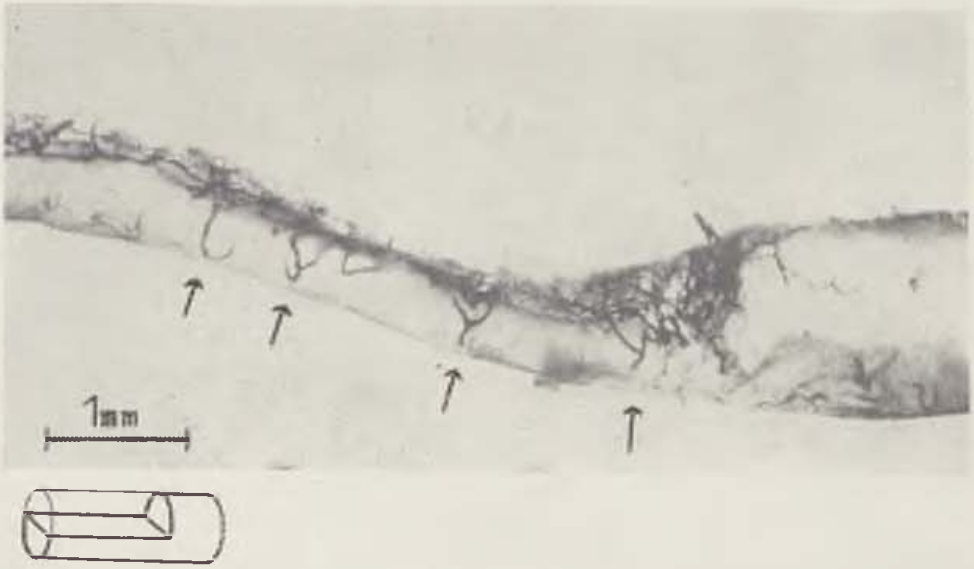

Fig. 2. Autograft of the medial third of the 7th costal cartilage. The cartilage was cut along its long axis, a part of the specimen was left without any change. The arrows indicate the blood vessels that penetrate the whole thickness of the cartilage. There is a rich vascular bed in the connective tissue adjacent to the sectioned surface of the cartilage.

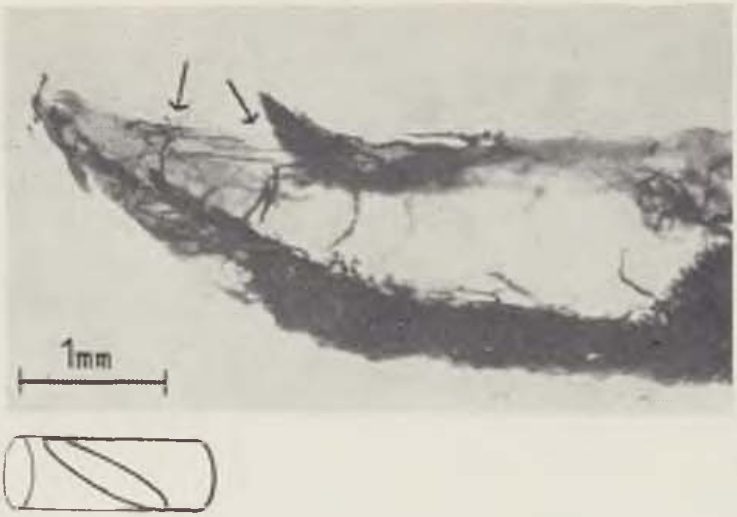

Fig. 3. Autograft of the medial third of the 6th costal cartilage. The cartilage was cut wedge-like. The arrows indicate the blood vessels that penetrate the whole thickness of the cartilage.

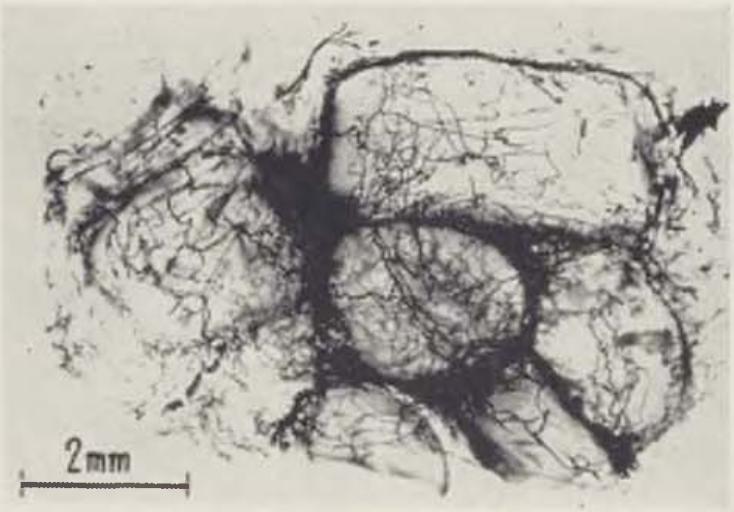

Fig. 4. A group of low disc-like grafts with a longer one. The vascular bed in the connective tissue surrounding the cartilages.

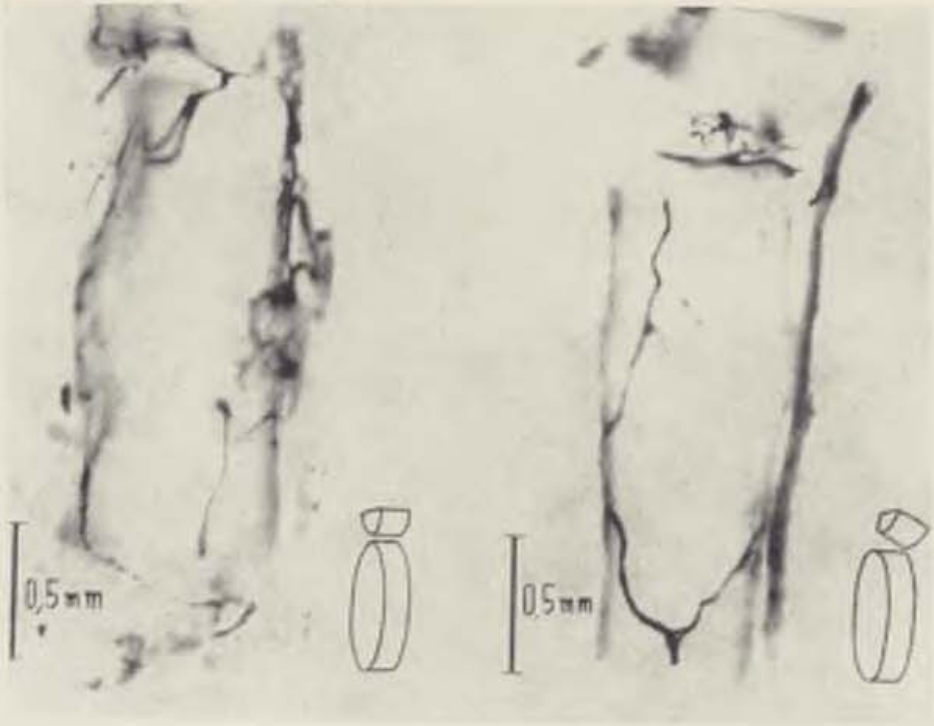

Fig. 5. Fig. 6.

Fig. 5. Disc-like graft with two regenerated vascular loops. They are situated in the neighbourhood of the sectioned surface and anastomose with the blood vessels adjacent to the sectioned surface. — Fig. 6. Disc-like graft with two regenerated vascular loops. Two branches of one loop unite with the blood vessels on both the opposite sectioned surfaces.

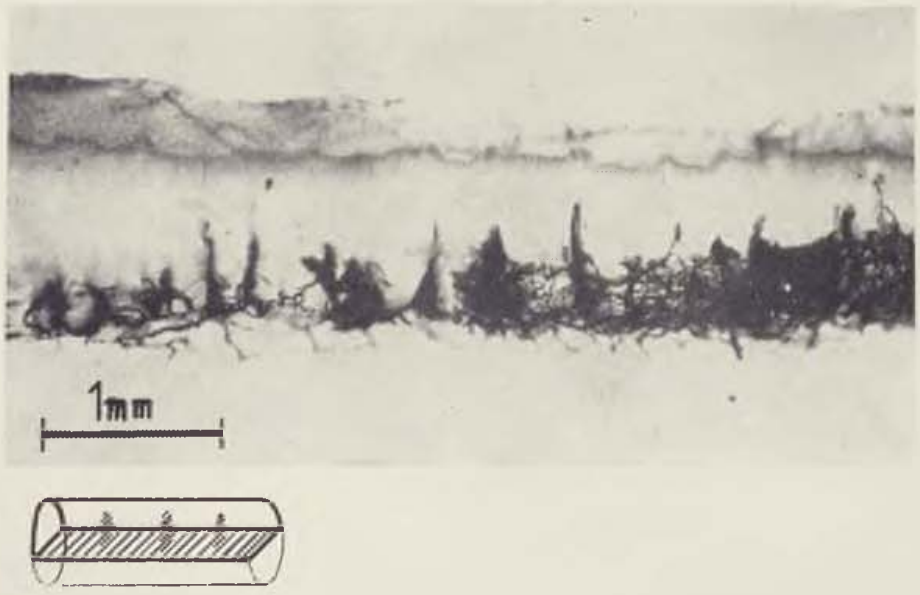

Fig. 7. Autograft of the medial third of the 7th costal cartilage, cut in its long axis. Connective tissue projections with blood vessels penetrate into the cartilage from the sectioned surface.

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THE REGENERATION OF THE VASCULAR BED IN AUTOGRAFTS OF COSTAL CARTILAGE IN THE CAT. DOES THE SIZE OF THE GRAFT INFLUENCE REGENERATION?

V. NOVÁK

Cartilage has a very low rate of metabolism and its metabolism is chiefly anaerobic, so that its requirements from the blood supply are only slight. Some cartilaginous organs are so small that they get sufficient nutrition by the diffusion of substances from the perichondrial blood vessels, and there are no blood vessels in the cartilage proper. This fact must certainly be the source of the wrong assertion that the cartilage is an avascular tissue and that avascularity is its constant feature. The conception of avascularity of the cartilage has been obstinately handed down, in spite of the fact that many authors refer to the occurrence of blood vessels in the cartilage of many organs. Blood vessels appear at a given stage of development of the foetus, i.e. when the cartilage has attained a certain size, in cartilaginous epiphyses and in other cartilaginous parts of the skeleton. The blood vessels, however, are also present in permanent cartilages. The causes of the ingrowing of blood vessels into the cartilage are metabolic. Hintzsche (1928) investigated the mechanism of the ingrowing of blood vessels. He ascertained that the increasing size of the cartilage during its growth evoked degenerative changes in the central parts of the cartilage, which caused the ingrowing of blood vessels by chemotaxis. The size of the cartilage is thus of considerable importance for its vascularisation during development. We wanted to find out whether the size of the cartilage is also of importance in the regeneration of the vascular bed, in other words, whether the number of blood vessels are proportional with the metabolic requirements in cartilage graft.

As far as we are aware, there is no report of similar experiments in the literature. Authors concerned with cartilage grafts consider the cartilage as an avascular tissue. Thus Sarnat and Laskin (1954) in an extensive review dealing with cartilage and cartilage implants on the basis of 200 publications state repeatedly that cartilage has no blood vessels.

In his monograph "Transplantation of Tissues" 1955, Peer also states that cartilage usually contains no blood vessels. It is interesting that this author remarks that he found blood vessels in fresh autogenous and homogenous cartilage grafts. He regards them, however, as new formations and contributes to them

a primary task other than the nutrition of cartilage. He is thereby dependent on the widespread dogma of the avascularity of cartilage.

Gibson and Davis (1958) in their study of the distortion of autogenous rib-cartilage grafts do not mention whether there are any blood vessels in the costal cartilages or not. It is, however, probable that the topography of blood vessel penetration into costal cartilages might explain several cases, where a distortion occurs even of grafts that had been completely freed of their surface layers. When dehydrating the costal cartilages of infants we have noted that they bend in such a way that the surface from which the vessels enter the cartilage becomes convex.

Most recently, Betzel and Schilling (1960) declared that the cartilage has neither nerves, blood vessels nor lymphatics.

It is necessary to note that Burian and Soraluce (1937) in their study on changes in transplanted costal cartilage mention that they found blood vessels in the costal cartilages, even in individuals younger than 20 years.

Unfortunately even textbooks of anatomy and histology often state that the cartilage is avascular. This is in contradiction to tens of papers describing the occurrence of blood vessels in the cartilages and even analysing some common problems of the vascularisation of cartilage. Schaffer summed up most of these papers in 1930. Hintzsche 1927—1933 investigated the vascularisation of cartilaginous epiphyses in detail, later on Haines 1933, 1937 and Hurrell 1934 dealt with the same subject. Prives 1938 and Anserov 1939 also investigated the question of the blood supply of cartilaginous epiphyses of all bones; the important proximal epiphysis of the femur was investigated e.g. by Hladíková 1960.

In permanent cartilage, too, blood vessels were found in all organs with the exception of articular cartilages. We have investigated the blood supply of the costal cartilages in man (1961) and in the cat (1962), of the elastic cartilage of the auricle of ear and of the fibrocartilage of the pubic symphysis (not yet published).

The blood supply of the costal cartilages in the cat is in basic structure the same as in man. The vascular bed consists of isolated structural elements (capillary loops, simple vascular loops, ramified vascular loops and two-branched vascular loops) which do not anastomose with one another. Only in old subjects with a calcified centre of the cartilage, are there extensive vascular layers, but not even here do we find a single anastomosing vascular bed in the whole cartilage. The costal cartilages are oval in cross-section and the blood vessels enter them only at the broader surfaces (Fig. 1). With regard to the torsion of the cartilages the broader surfaces are turned roughly forward and backward at their lateral end, and upwards and downwards at their sternal end.

MATERIAL AND METHODS

The experiments which form the basis to this report were performed in 15 adult cats that survived the necessary period of time. The 5th, 6th or 7th costal cartilage were removed without perichondrium and transplanted subcutaneously. In 11 cats a piece of cartilage of a length of 8—10 mm., cut along its long axis, was transplanted subcutaneously

into the thorax. In 4 cats two blocks 5 mm. in length were cut from the cartilage, each sliced diagonally and the four wedges obtained in this manner were implanted subcutaneously into the thorax. In 6 cats one cartilage was cut into short discs (most of the discs had a height of less than 1 mm.) and these were implanted subcutaneously into the thigh.

On the 20th—29th day following operation, the vascular system of the cats was injected with Indian ink in gelatin under narcosis (80 g. gelatin, 620 ml. water, 300 ml. Indian ink; the technique of injection is described in detail in other publications of our Institute). After fixation of the preparations in formalin, part of the material was treated by the method of serial 500 micra thick section mounted in glycerin, and part was clarified by the method of Spalteholz. Several preparations were studied histologically.

RESULTS AND THEIR EVALUATION

We grafted part of the cartilage cut along its long axis in 11 cats. The cartilage survived in all cases. The specimens that were investigated histologically displayed normal structure and normal staining features of the cartilage. The grafts were surrounded by connective tissue, the blood vessels of which had the picture of a normal quiescent vascular bed of fibrous connective tissue. Only blood vessels that were adjacent to the cut axis centre of the costal cartilages were, as a rule, larger and denser.

In the cartilage proper the vascular system was completely regenerated. In the parts of the grafts, where the original thickness of the cartilage had been left, the vascular bed had the same appearance as in unoperated cartilage. In the halved portions of the grafts the blood vessels had regenerated to their original size. This resulted in some of the vascular loops penetrating the whole thickness of the cartilage (Fig. 2) and uniting with the vascular network in the connective tissue on the opposite side of the graft. In a normal undisturbed cartilage of the cat no blood vessel can ever be found penetrating the whole thickness of the cartilage. This results from the fact that the blood vessels grow into the cartilage on the basis of metabolic changes in the very centre of the cartilage. The penetration of blood vessels throughout the whole thickness of the cartilage cannot be explained by metabolic changes, nor by the needs of the tissue. On the contrary, it is one of the proofs that the vascular bed actually r e g e n e r a t e s in cartilage grafts and that no new active ingrowing of blood vessels occurs.

The same results were obtained by the experiments with the transplantation of rib-cartilage cut in wedges. We transplanted a total of 16 such grafts. At the broader portions of the wedges, where the original thickness of the cartilage had been preserved, the vascular loops regenerated along the whole circumference of the cartilage, in so far as they had originally been present. At the thin end of the graft there were only vascular loops originating from the perichondrial side of the graft. Even here some blood vessels penetrated the whole thickness of the cartilage (Fig. 3). This proves once again that the blood vessels present in the graft are a regeneration of the original bed and not newly ingrown blood vessels as a result of direct metabolic influences.

Finally, we grafted cartilages cut in short discs transversely to the long axis. In the cat the thickness of the costal cartilages is usually less than 2 mm.

The height of our discs was not greater than 1 mm., although to each of the discs we added a block of about 3 mm. The vascular bed in the connective tissue surrounding such groups of grafts is demonstrated in Fig. 4. The blood vessels lie on the surface of the cartilages both the sectioned surfaces and the surfaces from which the perichondrium had been removed. The blood vessels that belong to the connective tissue dividing the single grafts from each other are directly connected with these vessels. In some places the grafts press against one another so closely that there is no connective tissue between them and consequently no blood vessels. The avascular field usually has an oval form and is bordered by capillary arcades.

In the cartilage tissue proper the vascular system regenerates to its original extent regardless of the thickness of the graft. The vascular loops have the same form as in an intact cartilage. Many vessels enter the disc-shaped grafts unsymmetrically, near one of the sectioned surfaces (Fig. 5). Some vascular loops anastomose with the blood vessels on the sectioned surfaces. There are even vascular loops whose branches unite with the blood vessels of both parallel sectioned surfaces (Fig. 6). These facts could not be explained, if we assume that the blood vessels grow into the grafts as during the growth of the cartilage, because of direct metabolic causes originating in the parts of the cartilage that are most remote from the surface. In a normal costal cartilage of the cat, for example, blood vessels never appear in the layer immediately neighbouring the bony portion of the rib, where diffusion from bone marrow can be assumed (as in articular cartilages — Holmdahl and Ingelmark 1950, 1951). This layer can be roughly compared with our disc grafts with regard to its nutritional possibilities and its size. The fact that there are blood vessels in the disc grafts, that they enter the very proximity of the sectioned surface of the grafts and that they anastomose with blood vessels on the sectioned surface, can satisfactorily be explained only by assuming that the vascular bed really regenerates and that the regeneration is not controlled directly by the metabolic needs of the cartilage graft.

The problem to be solved in the title of our paper can consequently be answered by asserting that the regenerating of the vascular bed in cartilage grafts is not influenced by the size of the graft.

In some cases vascular loops appear which penetrate into the cartilage from the sectioned surfaces of the grafts. This fact is apparently against our assertion that no new blood vessels grow into the cartilage. In all cases, where we had an adequately prepared second half of the graft or a neighbouring disc at our disposal, we could prove that such a blood vessel entering from the sectioned surface is a regenerated branch cut from its trunk.

In some cats, the blood vessels in the connective tissue adjacent to the sectioned surface of the graft were found markedly increased in number and thickness. Connective tissue projections, in the form of flat wedges with blood vessels, enter the cartilages, whose central parts are calcified to various degrees in adult cats (Fig. 7). These projections and their blood vessels are new formations growing into the cartilage during the healing of the graft, and certainly

not regenerated vessels. We believe that the connective tissue enters the clefts which arise in the calcified centre of the cartilage when it is cut. The picture of rapid active resorption of cartilage looks altogether different. In spite of this, it is probable that the sectioned surface is less resistant and that this endangers the long-term survival of the graft.

SUMMARY

1. In 15 cats, parts of the costal cartilages without any perichondrium were transplanted subcutaneously into the thorax and thigh. Some cartilages were cut along the long axis in two halves, wedge-like blocks were cut from others, some cartilages were cut transversely in thin discs. The animals were killed between the 20th—29th day after the operation.

2. In all cases the grafts survived and in all cases blood vessels could be demonstrated in transplanted cartilages.

3. The blood vessels in the grafts are not newly grown structures, but are regenerated from the original blood vessels. The vascular bed regenerates quantitatively in its original size, the regeneration is not influenced by the size of the graft. The blood vessels appear, for example, in cartilage blocks whose thickness is not greater than the usual distance between neighbouring blood vessels in intact cartilage.

4. The following points support the assertion that real regeneration of the original vascular bed occurs and not a new growth of blood vessels:

a) The same structure of the vascular bed of the graft in comparison with the unoperated cartilage.
b) The fact that the blood vessels penetrate the whole thickness of the cartilage in some grafts, which can never be observed in a normal cartilage.
c) In thin discs blood vessels can be found unsymmetrically, near one sectioned surface, which could not be explained from the point of view of the usual causes of cartilage vascularisation.
d) The typical vascular loops do not originate from the surfaces where the cartilage was cut. If a vascular loop appears in these areas, it is a regenerated branch whose trunk has been cut.

ВЫВОДЫ

Регенерация сосудистого русла в аутотрансплантате реберного хряща у кошки — Оказывает-ли влияние на регенерацию величина трансплантата?

V. Novák

1. У 15 кошек производилась пересадка частей реберных хрящей без надхрящницы в подкожную клетчатку грудной клетки и бедра. Некоторые хрящи разрезывались в длину на две половины, из других были нарезаны клиновидные блоки, из некоторых же были поперек нарезаны тонкие диски. Животные умерщвлялись через 20—29 дней после операции.

2. Во всех случаях произошло приживление трансплантатов и во всех случаях можно было доказать в пересаженных хрящах сосуды.

3. Сосуды в трансплантатах не являются нововросшими структурами, но регенератом раньше существовавших сосудов. Сосудистое русло регенерирует также в количественном отношении в прежних размерах, а величина трансплантата не оказывает влияиия на регенерацию. Сосуды, например, встречаются в блоках хряща, толщина которых не превышает обычное расстояние между соседними сосудами в неповрежденном хряще.

4. Об утверждении, что речь идет о регенерации ранее существовавшего сосудистого русла, а не о новом врастании сосудов, свидетельствует следующее:

а) Одинаковая структура сосудистого русла трансплантата в сравнении с неоперированным хрящем.

б) Факт, что в некоторых трансплантатах сосуды проникают сквозь всю толщу хряща, что абсолютно никогда не наблюдается в нормальном реберном хряще.

в) В тонких дисках можно найти сосуды несимметрично расположенные вблизи одной плоскости разреза, что было бы с точки зрения общих причин васкуляризации хряща необъяснимым.

г) Типичные петли сосудов не возникают в плоскости, где хрящ был пересечен или разрезан. Если здесь появится петля сосуда, то это регенерат ветви, ствол которой был отрезан.

RÉSUMÉ

Régénération du réseau vasculaire de l'auto-greffon du cartilage costal du chat Est-ce que l'étendu de la greffe influence la régénération?

V. Novák

1. Sur 15 chats, on a greffé une partie du cartilage costal exempt de périchondre dans la couche sous-cutanée du thorax et du fémur. Quelques uns des cartilages ont été coupés longitudinalement en deux moitiés, de quelques autres on a taillé des blocks en coin, respectivement des plaques transversales minces. Les animaux ont été sacrifiés entre le 20ème et le 29ème jour après l'opération.

2. Dans toutes ces modifications, il y avait adhérence du greffon et dans tous les cas, la présence de vaisseaux a pu être mise en évidence dans le cartilage greffé.

3. Les vaisseaux de ces greffons ne présentent pas des structures nouvellement formées, mais des résultats de régénération des vaisseaux primitifs. Le réseau vasculaire régénère aussi bien du point de vue quantitatif, de façon à atteindre les dimensions primitives, sans que cette régénération se trouve influencée par la taille du greffon. On trouve par exemple des vaisseaux dans des blocs cartilagineux dont l'épaisseur ne dépasse pas la distance habituelle entre les vaisseaux voisins dans le cartilage intact.

4. L'hypothèse qu'il s'agit bien d'une régénération du réseau vasculaire primitif et non d'une formation nouvelle, se trouve confirmée par les faits que voici:

a) Structure identique du réseau vasculaire du greffon et du cartilage non-opéré.

b) Le fait que dans certains greffons les vaisseaux pénètrent l'épaisseur toute entière du cartilage, ce que l'on n'a jamais pu observer dans le cartilage intact.

c) Dans les disques minces, les vaisseaux ont localisés de manière asymmétrique près de l'une des surfaces de coupure, ce qui serait inexplicable du point de vue des causes générales de la vascularisation du cartilage.

d) Les petites anses vasculaires typiques ne prennent jamais naissance à partir des endroits où le cartilage avait été coupé ou détaché. Si jamais une anse y fait apparition, il s'agit toujours d'un bourgeon de régénération d'une branche dont le tronc avait été coupé.

ZUSAMMENFASSUNG

Die Regeneration des Gefässnetzes im autoplastisch transplantierten Rippenknorpel bei der Katze. Hat die Grösse des Transplantats Einfluss auf die Regeneration?

V. Novák

1. Bei 15 Katzen wurden Rippenknorpelstückchen ohne Perichondrium in die Subkutis am Brustkorb und am Oberschenkel übertragen. Manche Knorpelstücke wurden durch einen Längschnitt in zwei Teile zerschnitten, andere wurden keilförmig zugeschnitten, andere wiederum stellten dünne Querschnittscheibchen der Rippenknorpel dar. Die Tiere wurden zwischen dem 20. und 29. Tag nach der Operation getötet.

2. In allen Fällen heilten die Transplantate ein und in einem jeden Falle liessen sich Blutgefässe im implantierten Knorpel nachweisen.

3. Die Gefässe in den Transplantaten stellen keine von aussen eingedrungenen Strukturen, sondern das Produkt der Regeneration der ursprünglichen Blutgefässe dar. Das Gefässnetz regeneriert auch in quantitativer Hinsicht im ursprünglichen Umfang, die Regeneration wird durch die Grösse des Transplantats nicht beeinflusst. So treten z. B. Blutgefässe in Knorpelstückchen auf, deren Dicke die im unversehrten Knorpel übliche Distanz zweier benachbarter Gefässe nicht überschreitet.

4. Für die Ansicht, dass hier eine Regeneration des ursprünglichen Gefässbettes und nicht ein Eindringen von Gefässen vorliegt, zeugt folgendes:

a) Das Gefässbett des Transplantats weist im Vergleich mit dem von unversehrtem Knorpel die gleiche Struktur auf.

b) Die Tatsache, dass in manchen Transplantaten die Gefässe die ganze Schichtdicke des Knorpels, durchdringen, was bei normalem Rippenknorpel ausnahmslos nicht zu sehen ist.

c) In dünnen Knorpelscheibchen findet man die Blutgefässe oft unsymmetrisch etwas näher zu einer Schnittfläche, was vom Standpunkt der allgemeinen Ursachen der Knorpelvaskularisierung nicht zu erklären wäre.

d) Die typischen Schlingen der Blutgefässe gehen nicht von den Schnittflächen der Knorpelstückchen aus. Tritt hier eine Gefäßschlinge auf, handelt es sich um einen regenerierten Gefässast, dessen Stamm abgeschnitten worden war.

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CLINICAL USE OF PLASMA AND BLOOD OF CONVALESCENTS

L. N. PUSHKAR

The pathogenesis of toxaemia in burns is explained in various ways. The majority of authors Ishchenko, Pushkar and Lebedyeva) explain toxaemia by the presence of toxic products derived from the decomposition of denatured proteins. Some authors draw attention to the specificity of burns toxaemia. This was proved by the paper of Segal who has used the blood of convalescents with success in the treatment of patients immediately after injury. At the 24th Congress of Surgeons Dzhanelidze also spoke of the existence of a burns toxin in the blood of patients who have sustained burns.

Fedorov and Skurkovich explain the pathogenesis of acute burns toxaemia by the toxic component circulating in the blood and having antigenic properties. Based on this, these authors have elaborated an effective method of experimental immunotherapy.

The following report is based on observations made at the Surgical Clinic of the Central Institute of Haematology and Blood Transfusion, Holder of the Lenin Order. A total of 950 patients suffering from burns were treated. In 114 with signs of toxaemia immunotherapy was used.

The principle of this method is the prevention and treatment of toxaemia in burns injuries with the blood of patients who have suffered from burns sickness. This is being carried out simultaneuosly with the usual comprehensive methods of treatment. The immune blood in amounts of 250 to 450 ml. is taken from convalescents or patients recovered from burns of at least seven percent of the body surface. This blood must be taken at the latest six months after recovery. Selection of the donor-convalescents is carried out in accordance with regulations for blood donors. In cases, where the blood was taken up to 30 days after recovery the donor received a re-infusion of half the amount of blood or blood substitutes after bleeding. Blood from 194 donors was obtained in this manner. Only in three percent of them could a decrease of haemoglobin by 1 to 1.5 g% be observed. No other adverse effects on the organism of the donor-convalescent have been observed.

The blood thus obtained was administerad to patients with burns affecting 10 to 96% of the body surface. The single dose and the duration of the trans-

fusion depended on the course of the illness. In most cases 250 ml. were administered during 2 to 3 days. A total of 211 transfusions were given, 187 of which were administered intravenously, 24 intramuscularly.

Observations showed that the phase of acute burns toxaemia is characterized mainly by its clinical picture. Therefore, the clinical picture of the illness was

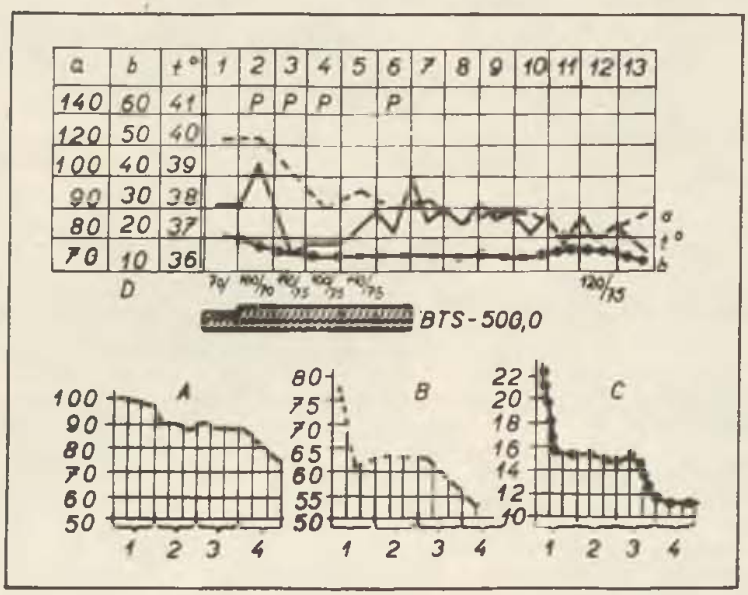

Fig. 1. Patient D. V.; burns of second and third degree, 46% body surface. Explanations: BTS — Belenky's therapeutic serum, ———— temperature, — — — — — pulse, ... respiration, A = Haemoglobin, B = Erythrocytes, C = Leucocytes, P = Convalescent serum, D = arterial pressure, 1—4 = days of illness. Changes in t^0, leucocyte count and other haematological indicators on transfusion of convalescent serum (P).

taken into first consideration on evaluating the success of the treatment. Apart from that laboratory tests were also used: the study of oxidizing processes, instability of the protein systems, renal function, urine toxicity, etc.

The result of this therapeutic method is a marked change in the clinical picture of the toxaemia. The patients, who received this treatment always became more active in spite of quite extensive burns. Soon dyspeptic disorders disappeared, leucocytosis rapidly decreased and the temperature decreased, vomiting ceased, the renal function returned to normal, and the metabolic processes became normalized. The changes in values on using immunotherapy as compared with other methods of treatment are demonstrated.

Apart from the removal of the signs of toxaemia in individual patients suffering from burns of 2nd and 3rd degree with up to 50% of the body surface, immunotherapy also made it possible to carry out skin grafting without preliminary removal of the necrotic tissue already on the 21st day, whereas prior to the introduction of this method of treatment only elimination of necrotic scabs from the wound could be observed at that period. In a series of patients a more rapid epithelization of the 2nd degree burns could be observed. Immunotherapy also contributes to a more favourable course of the septic stage.

Tab. 1.

Indicators		No. of pat.	Using Immunotherapy			No. of pat.	Without immunotherapy			
			decrease	increase	no change		decrease	increase	no change	
Leucocytes		105	95	2	7	50	19	24	27	
Temperature		105	87	8	10	50	11	16	23	
Dyspeptic complaints		105	abating			50	abating			
			1st day 99	2nd day 6	3rd day —		1st day 2	2nd day 27	4rd day 18	5th day 3
Coefficient of oxygen debt		30	readjusted			30	readjusted			
			10th day 7	20th day 18	30th day 5		10th day —	20th day 3	30th day 11	40th day 15	above 21
Diuresis		105	normalized			105	normalized			
			2nd day 44	3rd day 37	4th day 19		2nd day 2	3rd day 17	4th day 28	5th day 3
Renal function according to Skurkevich	Glomerular filtration	4	decrease to 16-20 %	—	—	4	decrease to 60%	—		—
	Renal blood flow	4	20—28	—	—	4	52—64	—		—
	Maximum urine excretion	4	N	—	—	4	decrease to 85 %	—		—

Notwithstanding the successful application of immunotherapy, in 9 percent of the cases the expected effect of the treatment could not be registered. An analysis of these cases showed that a number of failures was connected with the initial period when this new method was just introduced and an insufficient amount of blood was used. On the other hand, in a number of cases blood was used which probably had little immunizing activity because it was obtained from donors with burns up to 5 percent of the body surface. In two patients no effect of immunotherapy could be registered although all the rules of the method had been observed. These require further study.

As a result of immunotherapy 111 patients out of a total of 114 with burns of 2nd, 3rd, 4th degree and affecting 10—96 percent of the body surface survived the phase of toxaemia, 84 of whom had burns of 10—40 percent, 26, 41 to 50 percent, and one woman 70 percent of the body surface. Three patients died, one with burns predominantly of 3rd degree on 72 percent of the body surface, two aged over 65, with 30—42 percent of the body surface. Nine severe cases with 50—96 percent of the body surface with burns of 2nd, 3rd and 4th degree survived the phase of shock and toxaemia but died from sepsis.

In order to make a better evaluation of the method of immunotherapy, a comparison of the results of the treatment in these patients with the results obtained by other authors (Dzhanelidze, Postnikov), who were using the current methods of treatment without immunotherapy, was carried out.

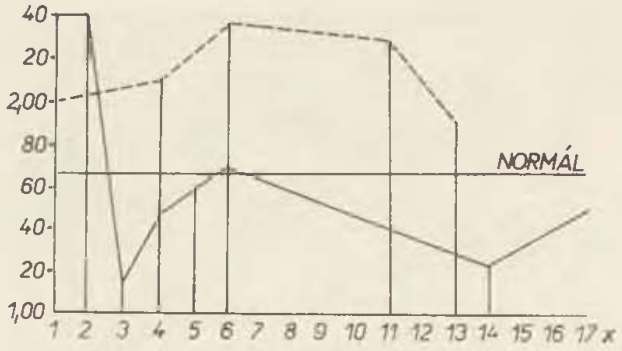

Fig. 2. Changes in oxydation coefficient in patients after using convalescent serum (————) and without serum (— — — — —) with the same area and degree of burns, x = days after injury.

On comparing data from foreign and Soviet sources, particularly concerning the death rate from burns, it was striking that the figures ranged from double-figures, e. g. 50 percent, to 5 percent, 2 percent and even almost to zero.

These diversities are mainly caused by the different conditions of the patients treated by the respective authors. It would be correct, therefore, to compare both methods not by the total death rate but in dependence on the severity of the condition, with regard mainly to the area of the damaged surface, the depth of the burn and the age of the patient.

An analysis of the death rate in this way, in dependence on the percentage of the damaged skin surface was made and the authors' results of the generally applied treatment without immunotherapy were compared.

From a comparison of the death rate it becomes evident that in the group treated with immunotherapy it exceeds that of the usual therapeutic methods only where a maximum of 10 percent of the body surface was affected. This was essentially not caused by the burns sickness but by concommitant diseases affecting patients at the age or 65 or more.

In all other groups the authors of the Surgical Clinic of the Central Institute of Haemotology and Blood Transfusion attained better results although they treated more severe cases.

Tab. 2.

Author	Percentage of burn	Up to					Above
		10	20	30	50	70	
Dzhanelidze		0.2	3.9	27.3	70.0	100.0	100.0
Postnikov		0.3	2.2	16.3	51.9	63.9	94.1
Surg. dept. CIHBT		1.3	1.2	—	38.4	40.0	85.0

The properties of immunized plasma, the duration and quality of immunity have not yet been sufficiently studied, but the data obtained so far make it possible to appraise immunotherapy very positively and to recommend it for clinical practise.

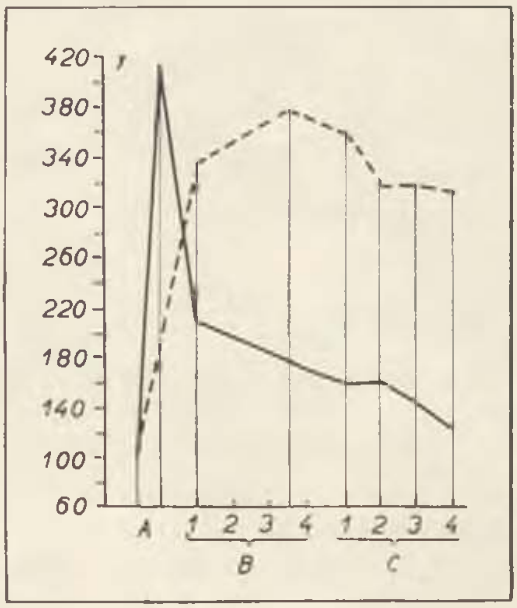

Fig. 3. Changes in total organic acids in patients after using convalescent serum (full black line) and without serum (dotted line), y = total organic acids in %, A = burns, B = hours, C = days.

Because of certain limitations in obtaining immunized blood plasma, and the great significance in the treatment of the burns sickness, ways are being sought for obtaining an unlimited amount.

On the basis of research carried out previously by Fedorov and Skurkovich, who pointed out the possibility of obtaining active heterogenous anti-burn plasma, work has now been started which is concerned with providing considerable amounts of an anti-burn preparation.

As a result of the comprehensive work of the Central Institute of Blood Transfusion (Fedorov, Skurkovich) and the Mechnikov Institute (Muzychenko and Frayman) a series of heterogenous immunized anti-burn plasmas was obtained recently and is being investigated at the Clinic.

SUMMARY

1. Immunotherapy is effective in the phase of acute toxaemia.

2. Immunotherapy must be combined with the currently used complex of anti-shock and sedative preparations.

3. The blood transfusion administered to the donor-convalescent after bleeding in order to obtain immunized blood, has no essentially adverse effect on the organism.

ВЫВОДЫ

Применение сыворотки и крови реконвалесцентов в клинике

Л. Н. Пушкарь

1. Иммунотерапия является эффективной в стадии острой токсемии.

2. Иммунотерапию необходимо сочетать с уже принятым комплексом противошоковых и седативных средств.

3. Обменные переливания при заготовке иммунной крови не оказывают существенного влияния на организм донора-реконвалесцента.

RÉSUMÉ

L'emploi du plasme sanguin et du sang des réconvalescents

L. N. Pouchkar

1. L'immunothérapie s'avère effective dans les cas de toxémie aigüe.

2. L'immunothérapie doit s'accompagner d'une thérapie par des complexes anti-choc courants et des sédatifs.

3. La transfusion sanguine d'échange lors de la préparation du sang immunisant est sans influence essentielle sur l'organisme du donateur.

ZUSAMMENFASSUNG

Die klinische Verwendung von Rekonvaleszentenblutplasma und Rekonvaleszentenblut

L. N. Puškar

1. Die Immunotherapie ist im Stadium der akuten Toxämie wirksam.

2. Die Immunotherapie ist mit der üblicherweise verwendeten Kombination sedativer Präparate und schockbekämpfender Mittel zu verbinden.

3. Bei der Herstellung der Immunblutkonserven haben die Austauschtransfusionen keinen wesentlichen Einfluss auf den Organismus des Spender-Rekonvaleszenten.

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CONTRIBUTION ON METABOLISM OF GLYCOPROTEIN IN BURNS

J. MUSIL, F. BARTOŠ

We have been studying the metabolism of blood glycoproteins already for some time in our laboratories. Hitherto, we have directed our attention mainly to the problem of their origin which is fundamental for any further study. Basically, there are two theories as to how they originate. The first considers the blood glycoproteins as products of decomposing tissue due to the depolymerization of the basic substance of connective tissue (1—4). This is particularly so because an increase in their blood concentration occurs in chronic conditions which are accompanied by tissue destruction (carcinomatous processes, TB, inflammations) (1) followed by the release of the soluble components into the blood. Further, in experimental animals with scurvy produced by an insufficient supply of ascorbic acid (5) or to which high doses of parathyroid hormone (4) had been administered, a metabolic disorder of the connective tissue occurred together with an increase in the seromucoid fraction of the blood and an increased excretion of glycoproteins in the urine.

This theory, however, has some grave shortcomings which, up to now, could not been explained by experiment. Whilst the basic substance of connective tissue contains a considerable amount of hexuronic acid, this acid could not be found among the components of any of the hitherto isolated glycoprotein fractions of the blood proteins. Small amounts of this substance, as found in the blood by Stary and Yuvanidis (something around 10 mg%), do not by far correspond to the extensive tissue destruction found in some pathological conditions. In experiments, where the concentration of glycoproteins in the lymph of experimental animals which had received sublethal doses of X-ray irradiation (Zícha) was determined, no increase in the concentration of hexuronic acid which should theoretically have taken place as a result of the increased tissue destruction, could be ascertained. In addition this theory considers only one side of the phenomenon and takes no account of the reparative processes which take place in the organism at the same time and with at least the same intensity.

In contradistinction to tissue destruction, other authors (Shetlar) (8, 9), take processes in connection with tissue proliferation as the source of blood glycoproteins, e. g. hyperplasia of the prostate, pregnancy, during the growth of foetus in the foetal blood (10), after severe loss of blood, etc. In a number of cases, however, it is impossible to distinguish exactly between destructive and

Tab. 1.

Determinations	Number of examinations	Mean Values ± standard deviation	Normal range
GOT activity	20	21.5± 7.9 u.	28.0— 35.0 u.
Thymol turbidity test	20	3.2± 1.1 u.	1.8— 5.4 u.
Total Protein	25	6.4± 0.3 u.	6.0— 7.2 g.%
Hexoses bound	20	130.0±12.0 mg.%	124.0—148.0 mg%
Hexosamine bound	12	76.1± 7.5 mg.%	68.0— 85.0 mg.%
Sialic acid	10	33.5± 3.7 mg.%	25.0— 40.0 mg.%
Filtr. reaction of Brd.	20	10.0± 0.8 mm.	9.0— 12.0 mm.
alpha-1 globulin	13	6.6± 5.0 rel.%	4.0— 8.0 rel.%
alpha-2 globulin	20	10.0± 1.9 rel.%	6.0— 12.0 rel.%
alpha-1 glycoprotein	18	18.0± 4.4 rel.%	16.0— 23.0 rel.%
alpha-2 glycoprotein	23	22.0± 4.5 rel.%	17.0— 27.0 rel.%

proliferative processes (11, 12), the latter usually following the former quite closely (e. g. in inflammations).

In order to solve this problem we tried to make a separate characterization of the processes of destruction and regeneration which proceed simultaneously. As a measure for the intensity of destructive processes we chose serum transaminase GOT activity (13—19). This we did because serum transaminase is an intracellular enzyme (20—22). Where cells and tissues are destroyed, it appears in the circulating blood already within a few hours after the tissue damage and, according both to experimental studies and clinical observations, its activity is proportional to the extent of the tissue necrosis (13—19). It may, therefore, be expected that by a parallel registration at given intervals of transaminase GOT activity and the fractions of blood glycoproteins, it would be possible to ascertain whether the time course of the changes in blood glycoprotein concentration, does or does not correspond to the time course of changes in transaminase GOT activity. In the first instance (i.e. coincident course) it would follow that it was a product of tissue destruction. If the blood glycoprotein levels started to rise only after GOT activity had decreased to normal values, this would rather testify in favour of the glycoproteins taking part in the regenerative processes.

On this basis we carried out a detailed study in patients with myocardial infarction and with infectious hepatitis. From the results, which were already published earlier (23—25), it followed that blood glycoproteins show an increase only after transaminase GOT activity had decreased to normal values. This phe-

Tab. 2.

532/59	day									
	1	1	2	2	3	5	7	9	13	15
GOT in units	29	43	46	—	—	—	29	34	26	23
Hexoses in mg.%	112	80	112	124	124	136	—	—	136	144
Hexosamine in mg%	70	—	70	75	92.5	95	—	—	95	80
Sialic acid in mg.%	29	21	40	37	37	61	—	—	67	71
Brdička's filtrate reaction in mm.	16	14	22	24	34	68	70	71	—	29
Total protein in g.%	8.3	9.2	6.7	8.0	7.0	6.9	6.9	6.1	7.4	8.0
α1-globulin in rel.%	4.0	5.3	5.7	8.3	7.6	10.3	12.5	12.9	8.8	4.8

Patient, aged 26, 20% II—III°

nomenon was evaluated as proof of the blood glycoproteins taking part in the processes of regeneration.

In order to generalize these results and to explain the changes in blood glycoprotein levels, particularly of Brdička's filtrate reaction in the acute stage of burns sickness, we carried out a similar study in a group of four patients who were victims of a mass accident and sustained scalds. This group was chosen, because the persons sustained the same type of damage and were of the same sex and approximately the same age. The burns were of 2nd and 3rd degree, i.e. not only the skin but also the subcutaneous tissue was affected. Only the changes in the initial stage of the sickness were registered, because in the subsequent stages the original causes is usually masked by additional complications such as secondary infection, toxic cachexia, etc.

As a measure of damage to striated muscle we chose the values of transaminase GOT, a low-molecular enzyme whose content in this tissue amounts to 135,000 u./g. of the homogenate (Dubach) (26). At the same time the fractions of blood glycoproteins: hexoses (27), hexosamine (Elson-Morgan) (28), sialic

Tab. 3.

533/59	day								
	1	1	2	3	5	7	9	13	15
GOT in units	—	57	34	51	—	37	31	26	23
Hexoses in mg.%	128	104	—	—	—	—	132	136	136
Hexosamine in mg.%	50	—	—	—	—	—	95	85	80
Sialic acid in mg%	37	29	—	—	—	—	71	62	57
Brdička's filtrate reaction in mm.	9	11	18	19	31	40	38	15	38
Total protein in g.%	9.5	8.1	6.8	6.9	5.4	6.0	7.4	7.1	7.6
α1-globulin in rel.%	5.4	6.2		7.3	14.3	13.3	5.7	9.3	9.0
α2-globulin in rel.%	5.7	9.0	15.3	8.3	8.2	16.7	13,3	16.5	12.7

Patient, aged 40, 15% II—III°

Tab. 4.

534/59	day								
	1	1	2	3	7	9	13	15	17
GOT in units	—	—	37	40	49	26	17	23	23
Hexoses in mg.%	124	76	128	—	—	136	144	132	—
Hexosamine in mg.%	60	—	75	—	—	95	70	95	—
Sialic acid in mg.%	41	29	37	—	—	49	61	57	—
Brdička's filtrate reaction in mm.	18	15	24	—	37	43	47	43	44
Total protein in g.%	8.9	7.4	4.3		5.6	6.7	6.9	7.7	7.6
α1-globulin in rel.%	4.8	7,3	8.1		8.6	7.2	7.7	6.8	5.1
α2-globulin in rel.%	10.5	9.3	4.9		13.9	18	16.9	12.7	19.6

Patient, aged 28, 39% II—III°

acid (Bial) (29), the total protein (biuret) (19), Brdička's filtrate reaction (30, 31) and the electrophoretic separation of the protein fractions on paper (32, 33), were ascertained.

The results are given in tables 1, 2, 3, 4, 5, because of the difference in size of the affected surface in each patient.

The first results vary greatly due to the disordered water metabolism caused mainly be dehydration immediately after injury followed by rehydration effected by one of the first therapeutic measures. After water metabolism had been balanced it was possible to observe that the maximum rise in GOT occurred one or two days after injury. This increase, however, never reaches such high values as in the two diseases (myocardial infarction and infectious hepatitis) studied previously (23—25), evidently because the amount of damaged tissue is relatively smaller (with regard to the total size of the organ). At the same time the readings of bound hexoses, hexosamine and sialic acid remain at normal levels, a definite increase occurring only four to six days after injury. The values of Brdička's filtrate reaction show a much quicker response; on an average already on the second day an increased concentration, can be observed which reaches its maximum on the seventh day. During this rise the normal

Tab. 5.

540/59	day								
	1	2	3	5	7	9	13	15	17
GOT in units	45	32	50	—	31	31	29	—	—
Hexoses in mg.%	—	—	185	—	—	—	195	—	125
Hexosamine in mg.%	—	—	105	—	—	—	115	—	85
Sialic acid in mg.%	—	—	53	—	—	—	42	—	37
Brdička's filtrate reaction in mm.	13	24	—	43	45	42	20	—	37
α1-globulin in rel.%	4	6	6	8	12	10	8	—	—
α2-globulin in rel.%	5	5	12	11	14	13	12	—	—
Total protein in g.%	9.2	9.0	10.0	6.3	6.2	6.5	8.0	—	—

Patient, aged 23, 15% II—III°

values are exceeded by more than 200%. At this stage the thought occurs as to whether this does not represent a functional synthesis of α-1-glycoprotein which we consider to be the main component of the sulphosalicylic filtrate (34—36), being the most stable one in the organism. It is denatured neither by high temperature nor by sulphosalicylic or perchloric acid, both acids having particularly high denaturing properties. This evidently has the purpose of contributing to a higher total concentration of proteins in the circulating blood. Because of its short biological half-life and its useful physical properties this might — at least in the first period — replace albumin the content of which decreases rapidly in the blood serum (37, 38) either through considerable oozing from the wound surface or by insufficient synthesis.

In conclusion it can be summed up that the changes in the blood glycoprotein level in the acute stage of the sickness in burns may be taken rather as a manifestation of the regenerative properties of the organism than as the consequence of tissue destruction. The results of Brdička's filtrate and other non-specific reactions, in which blood glycoproteins, take part, should be considered as the resultant of reparative processes.

SUMMARY

The time changes of blood glycoprotein levels (expressed as protein-bound hexoses, hexosamine, sialic acid and Brdička's filtrate reaction) were followed during the acute stage of burns. From the results we presume that increased levels do not occur immediately after the accident. These findings and those of the GOT transaminase activity indicate that the changed levels of blood glycoproteins are not a result of destruction processes but of regeneration.

ВЫВОДЫ

К вопросу обмена глюкопротеинов у пострадавших от ожога

J. Musil, F. Bartoš

Во время острой стадии ожоговой болезни происходят изменения уровня глюкопротеинов крови. Было произведено исследование уровня гексоз, гексозамина, сиаловой кислоты, фильтратной реакции Брдички, общего белка и электрофоретическое разделение протеинов и глюкопротеинов при помощи электрофореза на бумаге.

На основании результатов исследования создается впечатление, что изменения уровня глюкопротеинов крови являются скорее равнодействующей процессов восстановления, чем процессов деструкции.

RÉSUMÉ

Contribution à l'étude du métabolisme des glycoprotéides chez les brûlés

J. Musil, F. Bartoš

Au cours de la forme aigue de la maladie des brûlés, il y a des changements du niveau de glycoprotéides dans le sérum. Les auteurs ont tiré attention au niveau des hexoses, des hexosamines, de l'acide sialique à la réaction du filtrage de Brdička, au

niveau des protéides totales du sérum, à la electrophorèse des protéides et des glycoprotéides.

En somme ,il est bien probable que les changements des niveaux des glycoprotéides du sérum sont dues à la régénération plutôt qu'à la déstruction.

ZUSAMMENFASSUNG

Beitrag zum Stoffwechsel der Glykoproteine bei Verbrennungen

J. Musil, F. Bartoš

Es wurden die Veränderungen des Blutspiegels der Glykoproteine im Verlaufe eines bestimmten Zeitabschnittes (untersucht wurde eiweissgebundene Hexosen, Hexosamin, Sialinsäure und die Filtratreaktion nach Brdička) im akuten Stadium der Verbrennungskrankheit verfolgt. Die Ergebnisse lassen vermuten, dass erhöhte Glykoproteinkonzentrationen nicht sofort nach der Vebrennung auftreten. Die angeführten Befunde und die Werte der GO-Transaminase weisen darauf hin, dass der veränderte Blutspiegel der Glykoproteine nicht die Folgeerscheinung eines destruktiven Prozesses, sondern Anzeichen einer Regeneration ist.

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CLINICAL FEATURES OF EXTENSIVE AND COMBINED DEFECTS IN THE FACE AND THEIR SURGICAL REPAIR IN STAGES

F. M. KHITROV

Extensive and combined defects in the face are frequently found in war wounds. But not less severe and complicated disfigurement results from peace time injuries, inflammatory processes and after the excision of malignant tumours. Though different as to their aetiology, these deformities have the partial or complete loss of organs and adjacent parts of the face in common. The extent of the defect together with scar formation and an incessant flow of copious secretion from the remnants of mucosa in the exposed paranasal sinuses, from the nasal and oral cavities and the glands cause severe functional disorders. The revolting appearance excludes these patients from the workshop and society as a whole.

Since these conditions mainly occur in patients in their prime of life with otherwise preserved working capacity, the elaboration of methods for repair becomes a very serious task.

The aetiological factors leading to extensive defects in the face may be divided into two groups according to the clinical symptomatology: factors destroying the tissues and organs of the face suddenly and those causing gradual destruction. The first group comprises projectiles of firearms (in war and peace), electric current, agents causing domestic and occupational injuries, acids and alkali inflicting corrosions and high temperatures causing thermic burns. The second group is composed of inflammatory processes leading to acute or chronic break-down of tissue such as noma, irradiation, tuberculosis, syphilis and also of tumours.

The sequelae of suddenly developing facial defects give better results in reconstructive surgery. In these cases both the traumatizing agent and the subsequent reparatory process take place in a healthy organism. Only the severity of the actual trauma together with loss of blood and loss of strength in combating the subsequent inflammatory processes, effect a temporary deterioration of the patient's previously normal condition. This, however, lasts a relatively short time.

In slowly developing inflammatory processes, when the organism gradually becomes weakened by toxins acting for many months and even years, it is another

matter. In these patients the central nervous system is not traumatized by mechanical agents as in acute facial injuries, but by a permanent state of mental distress due to their witnessing the gradually increasing destruction of organs and tissues in their own face. This produces a deep psychological effect and alters the patient's personality.

In these patients surgical treatment much more often leads to unsatisfactory results.

The anatomical basis of the various sequelae in the destruction of tissues and organs of the face is usually different. A suddenly acting factor causes much deeper damage to the tissue and the edges of the defect contract due to scar formation in the tissue remnants of the skin and the mucosa. As a result of the cicatrizing processes considerable displacement of the remnants of organs and tissues from their normal topographical position takes place. In addition, secondary deformities develop from the constant pull of scars at the edges of the defect, even if the organs have retained their anatomical entity.

In the depth of the tissue chronic inflammatory processes around foreign bodies, remnants of paranasal sinuses, deep inside the nasal and lacrymal ducts, etc. may be maintained, particularly in shotgun injuries. In this type of trauma many projectiles penetrate into the tissue simultaneously, but in non-parallel, rather divergent directions. Most pellets get stuck, and each has its own very narrow and winding canal. The inflammatory process developing afterwards is charazterized by its persistence and the frequent appearance of multiple infiltrates leading either to abscesses or fibrous capsules around each infiltrate. This type of injury, therefore, is characterized by a multitude of scars so that the plan for reconstructive operations must be made with regard to the hidden inflammatory processes proceeding in the depth around the many embedded foreign bodies.

Electric current causes deep and extensive necrosis of soft tissue and bone after whose elimination large and slowly healing wound surfaces with easily bleeding granulations are layed bare. The scars resulting from such an injury are flat and lead to considerable contractures.

Similar necrosis is found in noma. Since noma occurs mainly in children, the healing by scars of large granulating surfaces is followed by deformation and contracture of the jaws and by irregular growth of the teeth. The contracture often depends not only on the rigid scar filling the buccal recesses and the retromolar space, but also on periosteal exostoses of the anterior margin of the ramus mandibulae and the coronoid process. The latter sometimes hypertrophies to such an extent that it impedes the movement of the lower jaw mechanically and must be resected together with the scars which limit opening of the mouth. If the necrotic process extends to the bone of the maxilla, reactive hypertrophy of the periosteum can become so great that it leads to synostosis between the coronoid process and the maxilla. Therefore, prior to the resection of scars contracting the jaws, a radiogram of the ramus mandibulae both in a lateral and axial projection must be taken in order to ascertain the exact cause of the jaw contracture.

A special feature of chemical and thermic burns is the formation of large keloid scars as a result of the healing of granulating surfaces. Only radical ex-

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 1, 2. Patient M. F. before operation. — Fig. 3. Completed reconstruction of the upper lip; both ends of tube healed at margins of the defect.

cision and the covering of the resulting defects with tissue of full value prevent the recurrence of keloids and give satisfactory cosmetic and functional results.

Syphilitic affections of the face with the gummous process centered in the maxilla, mandible or the anterior aspect of the neck, cause characteristic deformities. Often this type of inflammatory process is combined with tuberculosis of the face leading to further severe disfigurement. The syphilitic scars are radiating, show depressions and are adherent to the underlying tissues.

Lupus scars are more superficial.

The author never saw keloid formations in scars following lupus or gumma although they, too, cause tissue tension. It seems, therefore, that tension does not lead to the development of keloids.

In large facial defects, particularly in those where the patient has lost both eyes, the question frequently arises whether the surgeon's effort and the patient's sufferings in carrying out reconstructive operations are justified, since the patient will never be able to see the results. Would it not be better to supply the patient with an ectoprothesis?

The author's opinion is the following: In a patient who has lost his eyesight as a result of trauma or an inflammatory process, very fine tactile perception develops, so that he is able to distinguish quite precisely both the limit and depth of his defect and what the surgeon has done for him. The above question, therefore, does not apply in indicating reconstructive surgery in these patients. In the end, the patient who has lost his eyes becomes reconciled, learns to be independent, trains for a new profession, and learns to read and write.

He suffers, however, from tantalizing pain in the contracted scars, from constant and copious secretion of the remnants of mucous membranes in the nasal cavity and paranasal sinuses, from their desiccation and the formation of scabs on their surfaces, but mainly, however, from the thought that the extensive defect which he is well able to describe in words from tactile perception, is repulsive to the people around him.

These facts have to be taken into consideration by the surgeon and constitute the actual indication for surgical treatment.

The plan of repair of combined facial deformities must be made with the intention of relieving the patient of his main functional disorders in the shortest possible way. These disorders are: constant flow of saliva due to defects communicating with the oral cavity or to missing lips, ankylosis or contracture of the jaws, defects in the palate, etc.

If these defects can be repaired by using local tissue, this should be done without delay. The operation, of course, must never lead to further disfigurement. If local tissue does not suffice for the repair of functional disorders and a Filatov flap is required, this should be planned so that each stage of the migration of the pedicles would provide the necessary preconditions for the next stage of operation, thus necessitating a minimum number of surgical performances.

A serious problem also arises on deciding where, near the defect, it would be best first to implant the pedicle of the Filatov flap so that it can be made use of to full effect in the subsequent stages. Here the general principle should be

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 4, 5. Reconstruction of fronto-orbito-maxillary relief. — Fig. 6. View of the patient while the second tubed flap is taking to the base of upper lip.

the following: Since the first stage of implantation near the edge of the defect is but a precondition for the realization of the daring intention to reconstruct various organs and reliefs, the site should be chosen with regard to the best blood supply and the least number of scars, i. e. to the best possible conditions for a smooth take of the flap.

For illustration of the above principle, the following short case history is given below:

F. V. M., a man aged 37 (casepaper 2043), sustained injuries to his face by contact with an electric wire. On admission to CITO, on October 7th, 1954, the condition was as follows: loss of the entire nose, the greater part of the upper lip, the anterior section of the hard palate, both eyes, eyelids and eyebrows, both maxillary and zygomatic bones together with the overlying soft tissue, and loss of a large section of the frontal bone (Fig. 1, 2). The patient was exhausted from drawing pains in the middle zone of the face, headache and copious secretion of mucus. The dressing which he used for covering the defect, increased the secretion of mucus which rapidly filled the nasal ducts making breathing impossible. The removal of the mucus from the nasal cavity required the assistance of another person and caused bleeding from the vulnerable mucosa.

The patient urgently asked for relief from the drawing pains and the irritating secretion from his nasal cavity.

The plan for reconstruction of this large and combined defect had to comprise the following: reconstruction of the upper lip and the anterior part of the hard palate, excision of the contracting scars encircling the gaping defect in the face, reconstruction of the relief of the frontal, orbital and maxillary regions, the nose, eyebrows, eyelids and of the conjunctival sacs for the retention of the eye prosthesis.

After detailed analysis of the defect and calculation of the amount of tissue lost, a plan of the following stages of surgical treatment was elaborated: To start with, two Filatov flaps measuring 10×30 cm. and 8×24 cm. respectively, were to be formed on either side of the anterolateral aspect of the abdomen for the reconstruction of the relief of the forehead and the orbital regions, the eyelids, the nose and the anterior part of the hard palate. The upper lip was to be reconstructed from the remnants of the right half and with a full-thickness section of the cheek adjacent to the left margin of the defect. The eyebrows were planned to be formed with pedicle grafts taken from the temporoparietal region of the hair-bearing tegumen of the head on either side.

Then, as soon as the flaps were ready for migration, one pedicle of the bigger flap was to be implanted first into the wrist, and later the other pedicle transferred to the wound in the left cheek produced when forming the pedicle flap for the reconstruction of the left half of the upper lip. This preparation of the wound for the implantation of the pedicle of one Filatov flap was planned to coincide with the reconstruction of the upper lip.

After discission of the scars which pulled the remnants of the right half of the upper lip in an upward and outward direction, this part was returned to its original position. Then a full-thickness flap of the cheek adjacent to the left margin of the defect was excised for the reconstruction of the left half of the

Fig. 7. Fig. 8.

Fig. 7. Other pedicle of tubed flap taken in the region of nasal root. — Fig. 8. Pedicle of tubed flap separated from base of upper lip and left hanging down.

Fig. 9. Fig. 10.

Fig. 9, 10. Patient M. F. after completion of plasty.

upper lip. The sheet of mucosa thus obtained sufficed not only for covering the oral surface but also for the reconstruction of the reflection of the mucous membrane of the upper lip. Part of the mucosa covering the defect in the hard palate and retracted by scars to one side of the nasal floor, was mobilized, replaced forward to be joined with the reflection of the mucosa of both halves of the reconstructed upper lip.

It was also found that after its broad mobilization, the palatal mucosa even sufficed for covering the defect in the anterior part of the hard palate. By suturing the mucosa of both halves to the upper lip with the mobilized edges of the palatal mucosa and joining the edges of mucosa with those of the skin on the nasal floor, both the upper lip and the anterior part of the hard palate were reconstructed. One pedicle of the Filatov flap was then sutured to the wound left from the excision of the flap taken to reconstruct the left half of the upper lip, and to part of this flap.

The other pedicle of the Filatov flap was sutured under the semicircular skin flap taken from the right cheek above the right half of the upper lip 16 days after the latter operation. After this, the tubed flap took on the shape of an arch with both ends inserted into either cheek just above the reconstructured upper lip (Fig. 3).

In the following stage the tubed flap was divided transversely into equal halves which were then flattened and, after excision of all scars, used for the reconstruction of the relief of the fronto-orbito-maxillary region on either side and of the foundation of the nasal walls (Fig. 4, 5).

A week after this operation one pedicle of the other Filatov flap was transferred to the left forearm. This flap was planned for reconstruction of the nose. The transfer of the other pedicle to the nasal root in the usual way was, however, too risky, because immediately under the skin of the previously taken first flap lay the dura mater, and if one suture of the pedicle, transferred there with the forearm, had cut through, an inflammatory process could have developed which might easily have spread to the dura mater. Therefore, it was decided to transfer the pedicle first to the reconstructed base of the upper lip, because the blood supply there was best. It was, however, necessary to bring this part forward, because the scars from the previous operation had retracted it deep into the nasal cavity (Fig. 6).

In the following stage the other pedicle was separated from the forearm and sutured to the region of the nasal root (Fig. 7).

The implantation of the pedicle to the forearm must be made so that the longitudinal scar of the flap will face backwards when the forearm is placed across the forehead and the flap hanging down from it. Then, when suturing both ends of the tubed flap into the respective site in the face, the flap would be in the proper position for the subsequent flattening and application to the wound surfaces in the face.

After completion of both stages, the tubed flap took on the shape of an arch with one end based at the upper lip and the other at the nasal root.

Reconstruction of the nose from such a flap necessitated taking into consideration various conditions connected with the take of its pedicles and their

blood supply. The lower pedicle received a much better blood supply from the well-supplied tissues at the base of the upper lip, than the upper pedicle united with the flattened-out first Filatov flap forming the relief of the forehead. It was also necessary to carry out particularly careful and systematic "training" of the flap consisting in compression for 10 to 15 minutes every half hour for three weeks. Afterwards the pedicle was separated from the upper lip and the wound closed at this end leaving the long flap hanging down freely from its forehead insertion in order to promote the development of new blood vessels (Fig. 8).

During this interval the patient underwent, according to the plan, yet another operation, i. e. that of the reconstruction of the eyebrows. This was done with narrow, long pedicle flaps based on the temporoparietal region including the temporal artery on either side.

In the meantime the hanging tubed flap became soft and pliable, and a rich capillary network had developed in its skin. This could be demonstrated by the immediate return of normal colour to a certain area of skin after release of pressure exerted by the fingers to squeeze out the blood.

The total rhinoplasty was performed according to the author's basic method supplemented by important details (also described by the author previously) providing for a better blood supply to the inner lining of the nose reconstructed from a Filatov flap. These details consist in flattening of the flap not to its full length but only from its free end up to the level of the bony skeleton of the nose. The upper section then receives its inner lining from the remaining dorsal surface of the tube forming a flap with a nutritive pedicle attached to the nasal root. This procedure permits the use of shorter skin duplications and facilitates reconstruction of the cartilaginous skeleton of the nose (Fig. 9, 10).

As a result of the operations performed up to then, considerable changes in the general condition of the patient had taken place. The headache ceased, the drawing sensation in the head and cheeks disappeared and the superfluous secretion from the nasal mucosa, which had worried the patient so much, stopped. It only remained to perform the reconstruction of the conjunctival sacs for the retention of the eye prosthesis, reconstruction of the eyebrows and here and there correction of some contractures which had appeared at junctions of locally transferred flaps of facial skin.

All this, with the exception of the reconstruction of the eye sockets, was completed in this patient.

Reconstruction of eye sockets had been performed and described by the author previously. The main cosmetic shortcoming of this operation, however, is the fact that the eyelids cannot be closed which is more conspicuous when the other eye and its lids have remained intact. The lively moving sound eye greatly contrasts with the immobile artificial eye with its permanently gaping eyelids.

May be, this would not have been so conspicuous in a case with both eyes lost, and the author was prepared to carry out the operation in this patient. After overall consideration and a detailed discussion of the principle and the outcome of this operation, the patient, however, temporarily refrained from submitting to further surgical treatment and was discharged supplied with a pair of dark glasses.

SUMMARY

1. Filatov's tubed flap has proved an extremely useful material for reconstruction in the face of the most complicated, extensive and combined defects.

2. The principle of the successful application of a Filatov flap for the speedier reconstruction of extensive and combined defects in the face, depends on the correct planning of each individual stage of migration and on the "training" of the flap in the intervals between the stages.

3. A perfect take even in areas with unfavourable conditions, particularly with regard to possible infection, depends on a rich blood supply to the flap.

ВЫВОДЫ

Клинические особенности обширных комбинированных дефектов лица и последовательность их оперативного устранения

Ф. М. Хитров

1. Стебельчатый лоскут Филатова является прекрасным пластическим материалом для устранения самых сложных, обширных, комбинированных дефектов лица.

2. В основе успешного применения филатовского стебля для более быстрого устранения обширных комбинированных дефектов лица, лежит правильное планирование этапности миграции стебля и своевременная тренировка его между отдельными этапами операций.

3. Обильное кровоснабжение стебля обеспечивает безукоризненное его приживление в неблагоприятных в смысле инфицирования областях.

RÉSUMÉ

Particularités cliniques des défectuosités combinées importantes de la figure et le procédé à suivre lors de leur réparation chirurgicale

F. M. Khitrov

1. Le lambeau tubulé de Filatov représente le matériel plastique de choix pour la réparation des défectuosités combinées importantes les plus compliquées de la figure.

2. Pour se servir avec succès du lambeau de Filatov dans le but de réaliser au plus vite la réparation des défectuosités combinées importantes de la figure, il est essentiel de fixer d'avance un plan approprié des différentes étapes de la greffe du lambeau et d'assurer en même temps le training du lambeau, pendant les intervalles entre les différentes étapes de l'opération.

3. L'approvisionnement abondant en sang du lambeau assure l'incorporation parfaite de celui-ci dans des régions défavorables à cause des possibilités d'une infection.

ZUSAMMENFASSUNG

Klinische Eigenheiten ausgedehnter kombinierter Gesichtsdefekte und Vorgang deren operativen Beseitigung

F. M. Chitroff

1. Der Filatovsche Stiellapen ist ein ausgezeichnetes plastisches Material zur Beseitigung von kompliziertesten ausgedehnten Gesichtsdefekten.

2. Grundlage für eine erfolgreiche Verwendung des Filatovschen Lappens zwecks rascherer Beseitigung von ausgedehnten Gesichtsdefekten bildet die richtige Planung

der einzelnen Etappen der Lappenübertragung und gleichzeitiges Lappentraining zwischen den einzelnen Operationsetappen.

3. Eine reichliche Blutversorgung des Lappens sichert dessen tadellose Anheilung in Gebieten, die für das Auffangen einer Infektion ungünstig liegen.

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SURGICAL TREATMENT OF SCAR CONTRACTURES OF THE HAND AND FINGERS FOLLOWING BURNS

Y. HOLEVICH, I. MATEV

The authors' experience with the surgical treatment of scar contractures of the hand and fingers following burns is based on 150 patients (180 hands). A total of 120 patients had flexion contractures (146 hands) and 30 extension contractures (34 hands). The age limit of these patients ranged between one and 49 years. The period of observation was up to six years.

Flexion contractures: These are most frequently caused by domestic accidents (fire, boiling water or other fluids, red-hot metal objects, etc.). Children comprise more than 50% of these cases. As to the degree of the burns the authors have elaborated the following four-degree classification of contractures:

First degree (slight): permitting active extension of the fingers up to physiological position. Second degree (medium severity): permitting extension to a functional position.

Third degree (severe): contractures ranging between a functional position and a position where the tips of the fingers just touch the palm. In these patients definite trophic changes in the distal parts of the finger can often be observed.

Fourth degree (only stump of the hand left): In these patients the fingers and palm are fused and the capacity for grasping is lost. The patient cannot make better use of the affected had than of an amputation stump. Apart from severe atrophic changes, not infrequently partial loss of fingers can be observed.

Half the cases were third degree and only a few fourth degree contractures.

The authors consider the radical removal of the scars to be the only solution for correcting the deformity, and of obtaining permanent results. They always tried to get beyond the neutral line of the fingers, because this is an important technical point preventing recurrence of the contracture. At the level of the proximal interphalangeal joint it is often necessary to make a discission of the lateral portions of the dorsal aponeurosis pulled in a volar direction and also to carry out lateral capsulotomy of the interphalangeal joints.

After excision of the scar and depending on the degree of the contracture and the conditions of the individual case the defect was covered by one of the following methods.

1. Local skin plasty using exchange of opposing triangular flaps according to Limberg: This ideal method always gives good late results. It can, however, only be used in cases where the scar is more or less linear, and if there is enough

Fig. 1a.

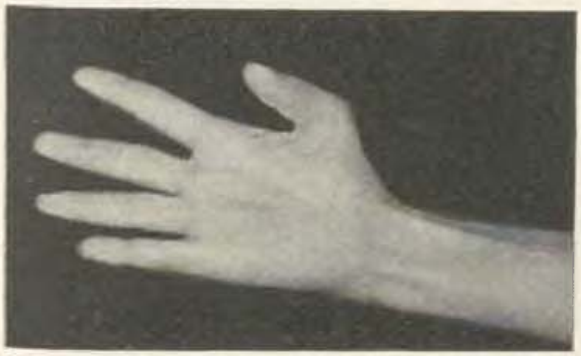

Fig. 1b.

Fig. 1c.

Fig. 1a, b, c. Patient A. K. N., aged 12. Second-degree flexion contracture of fifth finger (a) after local plasty with opposing triangular flaps. The photographs (b, c) show the position of the hand two years after operation.

skin of normal elasticity available for local transfer on the lateral aspect of the finger. The method was used by the authors in 21 hands. Both the early and late results proved to be good (Fig. 1).

2. Free skin graft of ¾ and full thickness, the latter being suitable for small children: This method was used for severe contractures and broad scars. In this way 42 hands were treated. In 90% the grafts took to their full extent, and only in some cases did necrosis occur in small areas or on the surface of thick transplants. The late results are fully satisfactory. A number of patients do heavy manual work (Fig. 2).

Fig. 2a.

Fig. 2b.

Fig. 2c.

Fig. 2d.

Fig. 2a, b, c, d. Patient T. M. N., aged 17, sustained burn 16 years previously. Third-degree flexion contracture (a). The extent to which the fingers were mobilized after excision of scars (b). Free skin grafting has been performed. Control examination six years after the operation shows a good functional result (c, d).

3. Combined local tissue transfer and free skin graft: Based on their own experience the authors regard this method as the most efficient in the treatment of severe flexion scar contractures of the hand and fingers. Local plasty is most useful for the repair of important areas of the fingers, such as the webs and the volar aspect in the region of the flexion creases of the metacarpo- and interphalangeal joints. In these cases the transplant shows less tendency for secondary shrinkage. This combined method of treatment was performed in 65 hands. The results proved to be good.

4. Filatov flaps were used in severe injuries when fibrosis involved tendons, bones and joints. Eighteen patients were operated on by this method; the results are satisfactory (Fig. 4).

In this connection it appears necessary to point out some peculiarities in the treatment of flexion contractures in small children. In children the deformities are usually severe and become worse with further growth of the hand and fingers. Nevertheless, the normal hyperextension of the fingers can be attained without much effort after removal of the scars, because in

these cases contractures of tendons and joints are not usually found. In contradistinction to adults, where, after the operation, the hand is immobilized in a physiological position, in children it is fixed with fingers fully extended. The authors have never observed joint stiffness in small children after this type of immobilization. The defect was usually covered by a skin graft of 3/4 or full thickness, the size of the graft exceeding that of the defect by 1/5.

Fig. 3a.

Fig. 3b.

Fig. 3c.

Fig. 3a, b, c. Patient Z. A. Sh., aged 15, sustained burns 14 years previously. Third-degree contracture of fifth, second-degree contracture of fourth and first-degree contracture of third finger. Free skin grafting was performed in the fifth and combined with local skin plasty in the fourth and third finger. Control examination five years after operation shows a good functional result (b, c).

Fig. 4a.

Fig. 4b.

Fig. 4a, b. Patient D. I. M., aged 15, sustained burns 14 years previously. Severe contracture of the thumb. Fibrosis involves the tendons and joints (a). Plasty with abdominal flap was performed. Control examination three years later shows satisfactory functional result (b).

Extension Contractures

Unlike flexion contractures, the authors found extension contractures more frequently in adults. Most patients were injured while working with petrol or other inflammables. Some cases were sequelae of war injuries (Napalm burns), others of domestic burns, usually in epileptics.

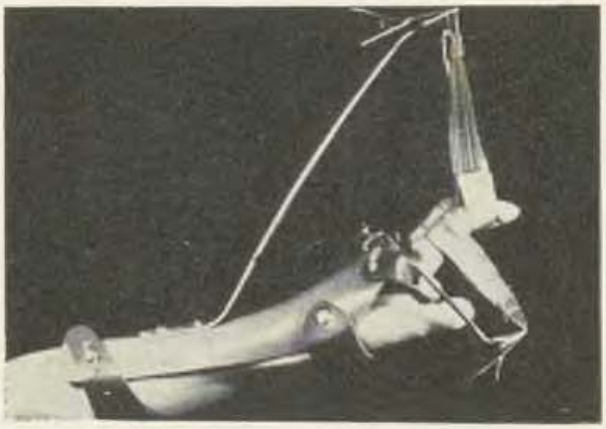

Fig. 5. Splint of plastic material with elastic bands pulling in two directions.

This group is characterized by severe, frequently mutilating deformities with destruction of the extensor tendons, pathological dislocations, ankylotic joints, etc.

The surgical treatment of these patients is one of the most difficult problems of reconstructive surgery. Only in five patients, whose scars did not penetrate into the depth, was it possible to cover the defect, left after excision of the scars, by a free ¾ or full thickness skin graft. Twice, however, this graft had to be replaced by a pedicle flap. In the remaining three patients the functional and cosmetic results were good.

In all other patients pedicle flap grafts were used. Simultaneously with the skin plasty or in a second-stage operation reconstruction of the damaged tendons, bones and joints was undertaken (Fig. 6).

The methods of surgical treatment of this group of patients, as elaborated by the authors, is described below:

1. Complete excision of scars both into width and depth together with the removal of all obstacles impeding full flexion of the hand and fingers: Frequently all soft tissue including tendons and sections of extensor muscle had to be removed and several times capsulotomy, osteotomy, etc. performed.

2. Coverage of the defect with normal skin: Here the authors used their own modification of the Italian flap.

3. Reconstruction of the extensor tendons: Here, more than elsewhere the following special problems are met with:

a) Reconstruction of the gliding apparatus: For this purpose the loose epifascial tissue of the abdominal wall, transplanted on a pedicle of the authors' modification, was used with good effect.

b) Lengthening of the extensor tendons: This was performed in old contractures, frequently dating from early childhood. Lengthening of the extensor tendons has to be carried out at the same time as the transplantation of skin, since only in this way can the graft be placed with hypercorrection of the deformity. In order to avoid later skrinking and the danger of infection, teno-

Fig. 6a.

Fig. 6b.

Fig. 6c.

Fig. 6a, b, c. Patient I. S. I. after operation. Contractures of the hand and fingers following burns. Fibrous ankylosis of the carpo-metacarpal joint of the thumb. Bony ankylosis of the metacarpophalangeal joint of the index finger and of one interphalangeal joint of the middle finger (a). The same patient after operation: excision of scars, capsulotomy of joints, arthroplasty of second metacarpophalangeal joint and skin plasty. Free tendon plasty of the thumb and transposition of the flexor carpi radialis (b, c).

elongation was performed through a small additional incision made proximally to the defect (Fig. 6).

c) Plastic reconstruction of the extensor tendons: Here the authors used well known methods of reconstruction, such as free transplants of either tendons or fascia. In some cases this was supplemented by a transposition of muscles.

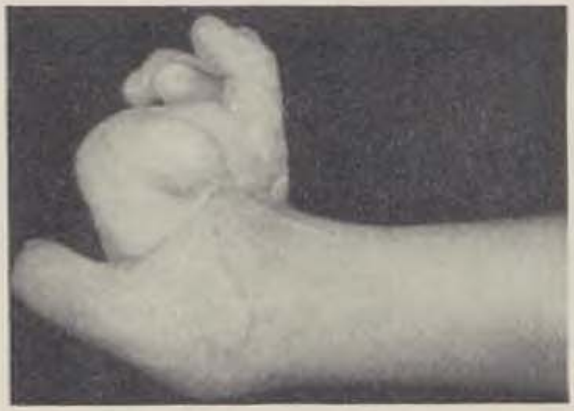

Fig. 7a.

Fig. 7b.

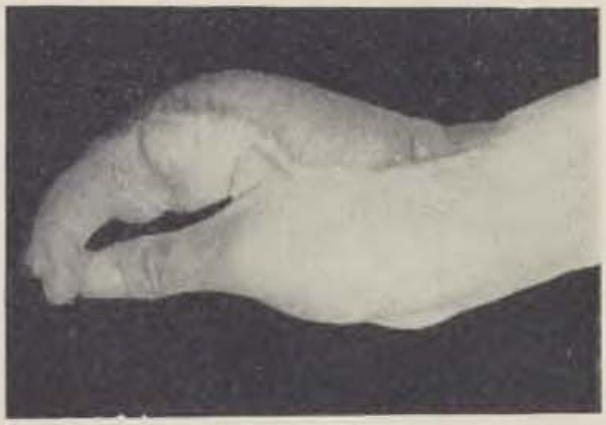

Fig. 7c.

Fig. 8.

Fig. 7a, b, c. Scar contracture after burns. Dislocation of metacarpophalangeal joints, ankylosis of interphalangeal joints, traumatic amputation of the index-finger (a, b). Patient A. M. U. after operation: excision of scars, capsulotomy of joints, resection in the region of ankylotic interphalangeal joints, skin plasty and free tendon plasty (c).
Fig. 8. Bone grafts widening the space between metacarpals I—II and II—III.

4. Method of treatment in rigid dislocation or ankylosis of joints: Depending on the individual case, the authors performed wide capsulotomy, osteotomy, arthroplastic resection or arthroplasty. Every operation of this type must be performed together with skin plasty. In the authors' own patients no complications were observed. The basic precondition for success is the complete covering of the defect by a skin plasty folowing the correction of all deformities.

More or less satisfactory results were obtained by the authors depending on the severity of the deformity. As a rule, in patients with contractures and

Fig. 9a.

Fig. 9b.

Fig. 9c.

Fig. 9d.

Fig. 9e.

Fig. 9a, b, c, d, e. Severe scar flexion contracture of hand and fingers combined with ulnar traction of fingers. Fifth finger is shorter and deformed. Interphalangeal joints are ankylotic. Following excision of scars and skin grafting. The flexion contracture is removed, but the ulnar traction persists (a, b). In order to remove this traction we performed amputation of the fifth finger and transported the others three fingers in an ulnar direction.

pathological dislocations not complicated by bony ankylosis, it was possible to restore the functions of grasping, i.e. both with the finger tips and the closed fist. In patients with numerous ankylotic joints, only grasping with the finger tips was restored (Fig. 7). From a cosmetic point of view the results could be regarded as good in all cases.

Correction of Lateral Contractures (Mostly Ulnar) of Metacarpophalangeal Joints

Correction of a lateral contracture often proved impossible even after complete excision of the scars and capsulotomy, because the metacarpals were firmly bound together. In these cases the authors used the following methods:

a) After complete excision of the scars the last two or three metacarpals were separated from each other to a distance of 0.5 to 1.0 cm. and a small bone graft was wedged between their diaphyses (Fig. 8).

b) If the fifth finger was severely damaged, exarticulation followed by the transposition of the fourth finger to the position of the fifth was performed. In one patient an ulnar transposition of the second, third and fourth finger was carried out (Fig. 9).

SUMMARY

The experience based on the observation of 150 patients (180 hands, age limits 1 to 49 years) operated on in the last six years, is reported. There were 120 flexion contractures (146 hands). The patients were divided into groups according to the severity of the deformity and the method of treatment used. The results are evaluated with regard to function and appearance.

The groups differ according to the principles of treatment.

Flexion contractures are always severe but destruction of both tendons and bones are rarely observed.

The authors used radical excision of the scars, lateral capsulotomy of the finger joints and discission of the lateral portions of the dorsal aponeurosis. They prefer a combination of local plasty with free skin grafts of ¾ thickness in adults and full thickness in children. In children they apply a transplant which exceeds the size of the defect by $^1/_6$ to $^1/_5$, because the hand of the child grows faster than the transplant.

Extension contractures are the more severe deformities. Radical excision of scars together with the tendons, joint capsules and ligaments, if necessary even resection of joints, should be carried out so that complete correction of the position of the hand is attained. The defect is most frequently covered by a flap, an operation frequently combined with the reconstruction of the tendons and joints which can be effected in one stage or in two stages. The authors describe some original methods: A modification of the Italian flap, correction of ulnar deviation, transpositions of fingers, etc.

According to the authors, both extension and flexion contractures should be treated within three months after the injury, in infants within two years. They lay stress on physiotherapy and elastic splinting of fingers (Fig. 5) as important measures in postoperative treatment.

ВЫВОДЫ

Оперативное лечение рубцовых контрактур кисти и пальцев после ожогов

Я. Холевич, И. Матев

В статье приводится опыт, основывающийся на лечении 150 больных (180 случаев контрактур) в возрасте от 1 до 55 лет, прооперированных в течение последних 6 лет. 120 контрактур было сгибательных, а 30 — разгибательных. Прооперированные больные распределены на группы в зависимости от тяжести контрактуры и способа лечения. Оценка результатов произведена в зависимости от достигнутой функции и внешнего вида.

Лечебные принципы в обеих группах контрактур являются разными. Сгибательные контрактуры всегда являются тяжелыми и деструктивными, причем как в отношении сухожилий, так и нервно-сосудистых пучков.

Авторы применяют радикальное иссечение рубцов, латеральную капсулотомию на суставах пальцев и иссечение латеральных частей тыльного апоневроза. Они предпочитают комбинацию местной пластики со свободной пересадкой в ¾ толщины у взрослых и во всю толщину у детей. У детей применяется трансплантат на $^1/_6$—$^1/_5$ больше чем какими являются размеры дефекта, так как рука растет быстрее чем трансплантат.

Разгибательные контрактуры представляют собой более тяжелые деформации. Лечение авторы производят путем радикального иссечения рубцов вместе с сухожилиями, суставными сумками и связками, а иногда они прибегают даже к резекции сустава вплоть до полной коррекции положения кисти. Дефекты они покрывают трубчатым лоскутом, зачастую в комбинации с восстановлением сухожилий, мобилизацией суставов, иногда во втором этапе. Авторы приводят некоторые оригинальные способы: модификацию плечевого лоскута, восстановление паратенония, расширение ладони путем остеопластической реконструкции, исправление ульнарной контрактуры, перемещение пальцев и т. д.

По мнению авторов сгибательные и разгибательные контрактуры следует лечить через 3 месяца после ожога а у грудных детей — до 2 лет. Подчеркивается значение физиотерапии и эластического шпонирования пальцев.

RÉSUMÉ

Thérapie opératoire des contractures de la main après des brûlures

J. Holevich, I. Matev

Discussion des expériences acquises au cours de l'observation de 150 malades (180 mains, malades âgés de 1—55 ans) ayant été opérés au cours des 6 dernières années. Il s'agit de 120 contractures de flexion et de 30 contractures d'extension. Les malades opérés sont classés d'après le degré de gravité et d'après la manière de traitement. Les résultats sont jugés d'après les succès fonctionnelles et thérapeutiques.

Des principes thérapeutiques différents sont employés pour les deux groupes.

Les contractures de flexion sont toujours graves et destructives, aussi bien en ce qui concerne les tendons que par rapport aus faisceaux vasculo-nerveux.

Les auteurs pratiquent l'excision radicale de la plaie, la capsulotomie latérale des articulations digitales, l'excision de la partie latérale de l'aponévrose dorsale. Ils préfèrent les greffes locales combinées à des transplantations libres, en utilisant un greffon cutané qui comprend les ¾ de l'épaisseur pour les adultes et l'épaisseur toute entière pour les enfants. Chez les enfants, ils utilisent des greffons dont les dimensions dépassent d'un sixième ou d'un cinquième la surface à couvrir, étant donné que la croissance de la main progresse plus rapidement que celle du greffon.

Les contractures d'extension représentent des déformations plus graves. Pour la thérapie de celles-ci, ils se servent d'excisions radicales de la plaie, effectuées simultanément avec celles des tendons, des capsules et des ligaments et, le cas échéant, de la résection de l'articulation jusqu'à l'obtention d'une correction totale de la position de la main. La défectuosité est couverte d'un lambeau tubulaire, souvent avec remplacement simultané des tendons et mobilisation des articulations, parfois en deux étapes. Les auteurs indiquent certaines méthodes originales: Une modification du lambeau brachial, la restauration de la paratonie, l'élargissement de la paume de la main à l'aide d'une reconstruction ostéoplastique, la correction de la déviation cubitale, la transposition des doigts et d'autres. D'après l'avis des auteurs, les contractures de flexion et d'extension doivent être réparées dans un delai de trois mois après la brûlure, chez les nourrissons dans un delai de deux ans. Les auteurs insistent sur l'importance de la physiothérapie et de l'éclissement élastique des doigts.

ZUSAMMENFASSUNG

Die operative Behandlung von Kontrakturen der Hand nach Verbrennungen

J. Holevich, I. Matev

Die vorliegende Arbeit bringt Erfahrungen an 150 Patienten (180 Handkontrakturen) im Alter von 1 bis 55 Jahren, die in den letzten sechs Jahren zur operativen Behandlung gelangten. Bei ihnen bestanden 120 Flexionskontrakturen und 30 Extensionskontrakturen. Die Patienten wurden nach dem Grad der Störung und nach der Art der Behandlung eingeteilt. Die Ergebnisse werden nach der erzielten Funktion und dem kosmetischen Effekt beurteilt.

Die Behandlung beider Gruppen von Kontrakturen richtet sich nach unterschiedlichen therapeutischen Prinzipien.

Die Flexionskontrakturen sind stets schwer und weisen destruktive Veränderungen sowohl an den Sehnen als auch an den Gefäss-Nerven-Bündeln auf.

Die Verfasser wenden radikale Exzision der Narben, laterale Kapsulotomie an den Fingergelenken sowie Exzision der lateralen Abschnitte der dorsalen Aponeurose an. Sie bevorzugen eine Kombination der lokalen Plastik mit der freien Übertragung eines Hauttransplantats von ¾ Hautdicke bei Erwachsenen, von ganzer Hautdicke bei Kindern. Bei Kindern benützen sie ein Transplantat, das um ein Sechstel bis ein Fünftel grösser ist, da sich die Hand schneller entwickelt als sich das Transplantat vergrössern kann.

Extensionskontrakturen sind schwerere Deformationen. Zur Behandlung wenden die Verfasser die radikale Exzision der Narben zugleich mit der der Sehnen, Gelenkskapseln und Ligamente an, gegebenenfalls auch die Gelenksresektion bis zur totalen Korrektion der Handstellung. Der Defekt wird entweder gleich oder erst bei der zweiten Operation mit einem Tubuluslappen gedeckt, oftmals in Kombination mit Sehnenersatz und Gelenksmobilisierung. Die Verfasser führen mehrere originelle Operationsarten an: Modifikation des Oberarmlappens, Rekonstruktion des Paratenoniums, Erweiterung des Handtellers durch osteoplastische Rekonstruktion, Korrektion der ulnaren Deviation, Fingertranspositionen und anderes mehr. Extensions- und Flexionskontrakturen sollen nach Ansicht der Verfasser drei Monate nach der Verbrennung, bei Säuglingen innerhalb zwei Jahren behandelt werden. Auf Physiotherapie und elastische Schienenverbände der Finger wird Nachdruck gelegt.

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LOCAL PLASTY WITH OPPOSING TRIANGULAR FLAPS IN THE TREATMENT OF SCAR CONTRACTURES OF THE SKIN AFTER BURNS

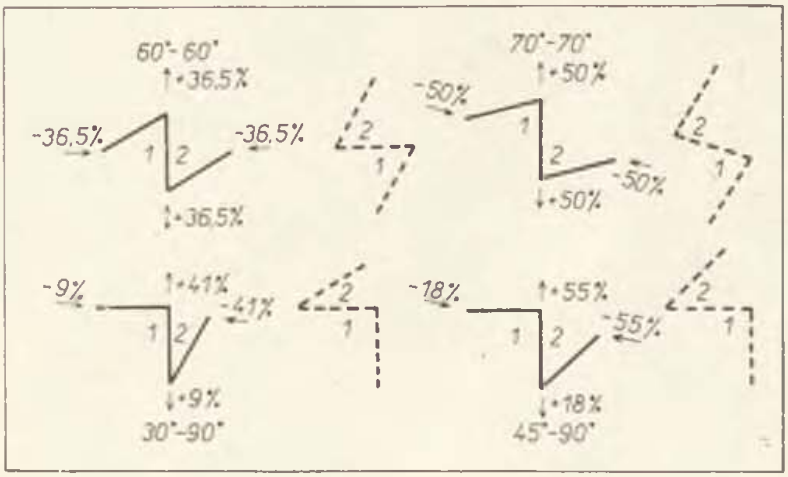
A. T. TITOVA

The treatment of scar contractures in the skin following burns of large areas of the body surface is a difficult task because there is not enough suitable skin available for plastic operations.

The various authors divide scar contractures of the skin into groups both according to the degree to which the scars impede function and to the character of the scars. For local plasties flat atrophic scars causing but little contracture, are considered suitable.

Contractures caused by keloid scars are treated by excision and covering the defects with a free skin graft or flap.

The author does not share the widespread opinion that keloid scars following burns are quite unsuitable for plastic operations because long ago she became convinced that the scar loses its keloid character when the tension, acting in the direction of the scar, is removed. At the same time she excises only limited portions of the keloid scars together with skin ridges, which maintain inflam-



Tab. 1. Diagram of the patterns of two opposing triangular flaps before and after exchange.

Fig. 1a. Fig. 1b.

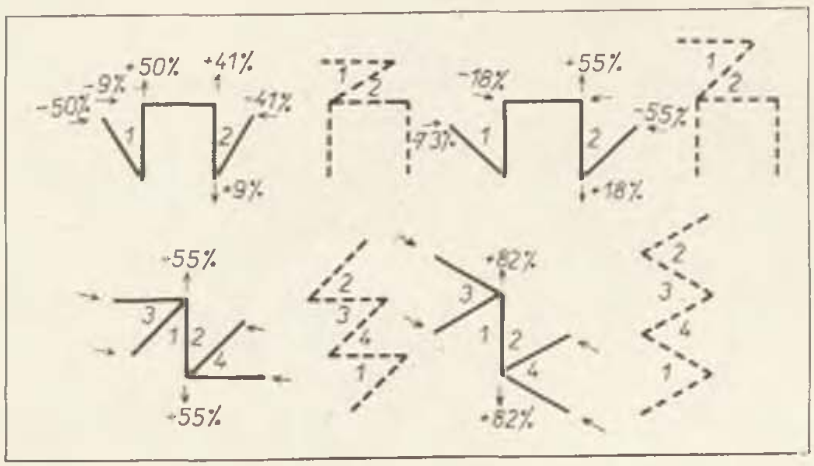
Fig. 1a. Scar contracture of the skin of the neck in a girl aged six. — Fig. 1b. The same patient ten years after treatment.

mation, and in the remaining scar she tries to ease the tension using local plasties with opposing triangular flaps as elaborated by Limberg.

In the treatment of scar contractures of the skin great significance is ascribed to elaborating the plan of operation for the entire period of treatment. No endeavour is made to repair the contracture in one stage at all costs. Observations in the patients with scar contractures in the skin bear witness to the fact that it is always possible to attain good results by simple, little traumatizing, local plasties carried out in stages.

In analyzing the contracture it is important to determine the main direction in which the shrinking of the surface is taking place and then, first of all, effect lengthening in these directions.

Results depend a great deal on the correct pattern and site of the opposing triangular flaps which ought to be chosen so that they suit every concrete situation.



Tab. 2. Diagram of complicated patterns of opposing triangular flaps before and after exchange.

Tab. 1 shows the patterns of the two exchangeable opposing triangular flaps with angles of 60^0—60^0, 75^0—75^0, 30^0—90^0 and 45^0—90^0 which are used most frequently. The increase in length and decrease in width is given as a percentage in relation to the length of the middle incision of the pattern.

In Tab. 2 the diagrams of the initial and ultimate shape of incisions in complicated patterns of opposing triangular flaps, are depicted.

Fig. 2a. Fig. 2b.

Fig. 2c. Fig. 2d.

Fig. 2a. Scar contracture of the skin of the neck in a girl aged eight. — Fig. 2b. The same after two plastic operations carried out in stages. — Fig. 2c, d. Diagram of the first operation with local flap exchange.

In the combination of the two patterns with angles of 30^0—90^0 or 45^0—90^0, one of the side incisions is common to both. This combination of patterns may be used in cases where there is sufficient mobile skin available, particularly at the basis of narrow flaps; after exchange of the flaps the lengthening of the scar corrresponds to the area of two narrow flaps.

The combination of two patterns with angles of 45^0—90^0 or 60^0—120^0 has a common middle incision.

The advantage of these patterns is that al the lengthening (in the first case 110%, in the second 164%) is effected in the direction of the middle incision

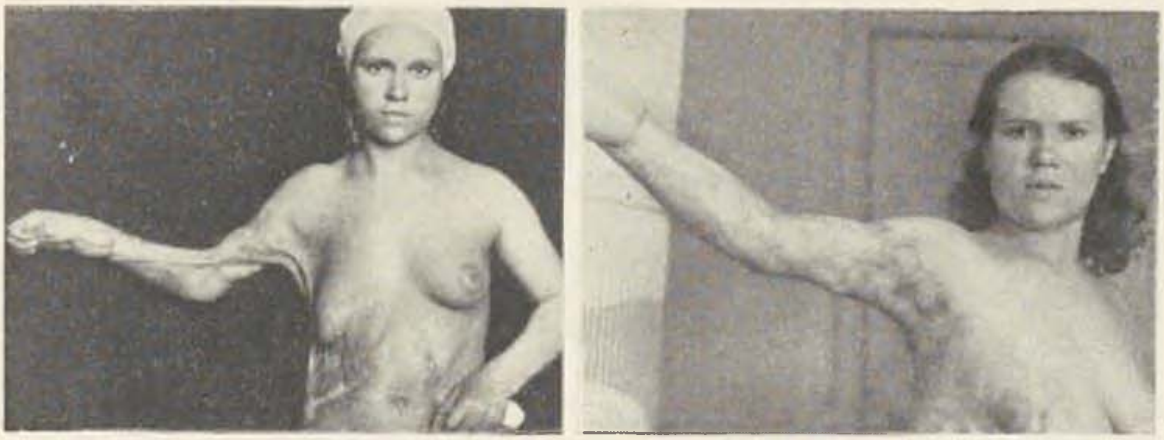


Fig. 3a. Fig. 3b.

Fig. 3. Scar contracture of the skin in the axilla and the elbow in a girl aged 18 before (a) and after (b) treatment.

and, at the same time, the reserve of mobile skin is taken up in the direction of the longer diagonal of each of the two patterns.

When repairing scar contractures in the skin the aim is not only to restore function, but the affected part must also regain its proper appearance. This must be particularly borne in mind when treating scar contractures in the skin of the neck.

Fig. 1a shows a contracture in the neck of a girl aged six. The numerous, considerably shortened and keloid scars have caused shortening of the antero-lateral aspect of the neck accompanied by a substantial widening of the neck in a transverse direction. In this case the correctly drawn up plan of treatment must aim at lengthening of the shortened surface of the neck together with a transverse narrowing. At intervals of 10 to 12 months a total of four operations, using opposing triangular flaps, were performed, as a result of which the contracture was removed and the correct shape of the neck restored. After relieving the tension the scars lost their keloid character (Fig. 1b).

In analogous cases plasties with two, and even three combined patterns of the side incisions, forming opposing triangular flaps with angles of 40^0—90^0 or 30^0—90^0, are used in clinical practice.

Fig. 2 shows a photograph of an eight-year-old girl with a skin contracture caused by numerous shrunken scars.

By an operation performed in two stages, in the first of which three of the patterns described above and in the second another two, were used, the author succeeded in reconstructing the shape of the neck. The narrow flaps were swung to the level of the hyoid where they formed the skin reserve indispensable for the free movements of the head.

In skin contractures in the region of the axilla, the upper extremity and particularly the fingers, scars crossing the flexor surface of joints, are frequently found. In these cases the use of one pair of opposing, triangular flaps is little

effective. It is usually necessary to use a series of triangles placed one behind the other in the direction of the main scar, and calculated so that the skin reserve along the whole length of the scar is used to its full extent.

Fig. 3 shows a girl of 19 with scar contractures of the skin in the axilla, the elbow and the trunk, before and after treatment.

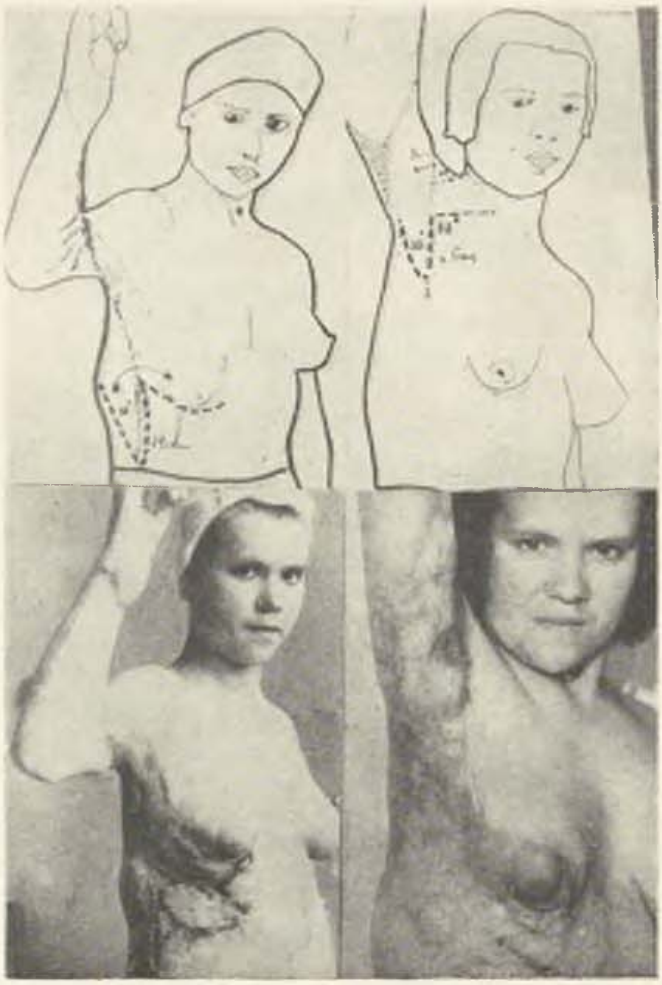


Fig. 4. Diagram of operation using plastic patterns with angles of 30^0—90^0 in combination with a free skin graft. Diagram of reconstructive operation for scar contracture using two pairs of opposing triangular flaps placed one behind the other along the crest of the scar ridge.

These extensive scar contractures were repaired surgically in eight stages using 13 patterns of opposing triangles in combination with free skin grafts measuring 6 × 14 cm. The diagrams of each operation are depicted in Fig. 4.

It should be mentioned that, at the beginning, local plasties were performed at sites some distance from joints (shoulder, thorax), because using remote skin reserves permitted maximum corrections of the contracture.

Fig. 5 shows a flexion skin contracture of four fingers of the left hand in a man prior to and after treatment. From the diagram of the operations it can

be seen that the plan becomes more complicated with increasing severity of the contracture.

To restore the little contracted second finger to normal function it sufficed to use a combination of two opposing triangular flaps. In the correction of the contracted third finger it was necessary to combine patterns with angles of

Fig. 5a.

Fig. 5b.

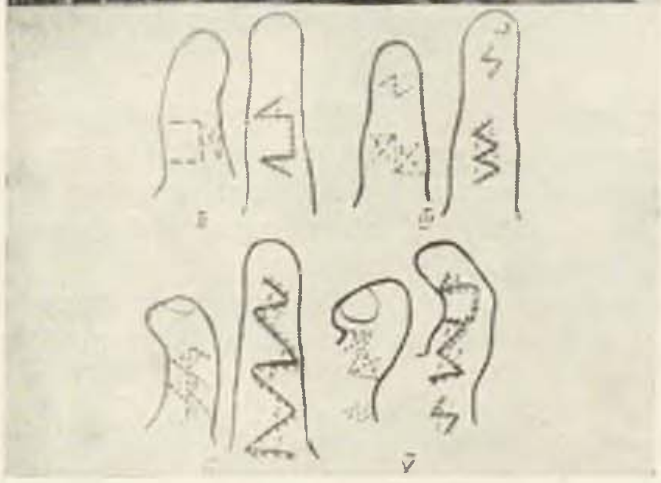


Fig. 5a. Flexion contracture of second to fifth finger of the left hand due to skin scars in a man aged 35 before and after treatment. — b. Diagram of local plasty.

45^0—90^0 and supplement them by patterns with angles of 60^0—60^0 placed successively along the crest of the scar.

On the fourth finger, too, three plastic patterns were used but because of the severe contracture of the scar the middle incision of all triangles was partially in common.

For the reconstruction of the contracted fifth finger three plastic patterns of opposing triangular flaps were used together with a small free skin graft implanted at the level of the distal interphalangeal joint.

In the reconstruction of fingers with severely contracted scar bands good

results may be obtained by using a combination of two patterns with angles of 60^0—120^0 (Fig. 6).

This report is based on the experience obtained in the treatment of 134 patients of an age ranging between 5 and 46 years suffering from scar contrac-

Fig.6b.

Fig.6c.

Fig. 6a.

Fig. 6. Flexion contracture of second finger of the left hand due to a skin scar in a boy aged ten (a). Diagram of operation (b), result (c).

tures of the skin in the neck and the upper extremities. In the treatment carried out in stages, 488 patterns of opposing triangular flaps were used.

During the healing of the wounds, marginal sloughing of the tip of the flap occurred 53 times, which, however, did not impair the ultimate results and only caused a 6—10 day prolongation of treatment.

Local plasties with opposing triangular flaps have always given good results, particularly in patients operated on in stages with intervals of several months.

SUMMARY

The use of local tissue in plasties with opposing triangular flaps for the repair or, at least, improvement of skin contractures is recommended. The author reports on her own patients.

Good results depend on the correct indication, on the choice of the most suitable patterns of opposing triangular flaps and on subsequent physiotherapy.

On planning the operation we ought to be guided by the following principles:

1. Careful handling of the tissues is a precondition for the preservation of blood and lymph circulation which guarantees better scars.

2. Treatment of contractures in stages is based on the fact that new scar bands appear after operation due to improved joint movement and that new reserves of mobile skin develop at sites where they were used up in the preceding operation.

The choice of the plastic patterns depends on the nature and the length of the scar, and on the reserve of mobile tissue in its vicinity. Long scar bands ought

to be broken up by a series of opposing flaps placed one after the other along the scar crest. Broad and short scars are best loosened by using more complicated patterns which permit the best use to be made of the reserve of mobile skin in the vicinity.

If there is a great shortage of tissue it is advisable to combine opposing triangular flaps with a free skin graft.

ВЫВОДЫ

Местная пластика встречными треугольными лоскутами при лечении кожных рубцовых контрактур после ожогов

А. Т. Титова

Использование местных тканей при пластике встречными треугольными лоскутами позволяет устранить, а в наиболее тяжелых случаях ослабить кожную рубцовую контрактуру. В статье приводятся собственные случаи из практики.

Успех лечения зависит от определения правильных показаний к операции, выбора наиболее подходящих фигур пластики встречными треугольными лоскутами, а также от последующего применения физиотерапевтического лечения.

При составлении плана операции мы принимаем во внимание следующие соображения:

1. Бережное отношение к тканям создает благоприятные условия крово- и лимфообращения, что приводит к улучшению рубца.

2. Этапность в лечении кожных рубцовых контрактур обусловлена тем, что после операции появляются новые рубцовые тяжи по мере увеличения объема движений в суставе и с течением времени возникают новые запасы подвижной кожи в тех участках, где предыдущей операцией эти запасы были уже полностью использованы.

Выбор фигур пластики обусловлен характером и протяженностью рубцов, а также запасами подвижных тканей вблизи от него.

Длинные рубцовые тяжи целесообразно рассекать серией фигур встречных треугольных лоскутов, расположенных последовательно по направлению рубца.

Широкие, короткие рубцовые тяжи-складки следует рассекать более сложными фигурами пластики, которые позволяют наиболее полно использовать запасы подвижной кожи около рубца.

При большом недостатке тканей считаем целесообразным сочетание пластики встречными треугольными лоскутами со свободной пересадкой кожи.

RÉSUMÉ

La plastie locale à l'aide des lambeaux glissants triangulaires dans le traitement des contractures cicatricielles en séquelles des brûlures

A. T. Titova

L'auteur montre sur les cas de la clinique l'usage des tissus des environs en forme des lambeau glissants triangulaires dans la réparative des contractures de la peau.

Les bons résultats dépendent de l'indication précise, du choix juste des figures de ces lambeaux et de la thérapie post-opératoire. En envisageant l'opération, on doit prendre garde:

1. Le ménagement des tissus doux, physiologique, est capable de créer de bonnes conditions pour la restauration de la circulation sanguinaire et lymphatique, dont on a besoin pour obtenir de bonnes cicatrices esthétiques.

2. La réparation en étapes est nécessaire dans le traitement des contractures faute des nouvelles cicatrices crées par l'opération elle-même ensuite des mouvements augmentés dans les articulations, et par l'apparition des réserves de la peau mouvable sur les lieux des opérations précédentes.

Le choix des figures se fait d'après la longueur des cicatrices en estimant la possibilité des mouvements de la peau des environs. Il est nécessaire d'abréger de longues cicatrices par des séries de lambeaux glissants, suivants la direction de la cicatrice.

Les cicatrices courtes, mais larges, exigent des figures plus compliquées utilisant le mieux les réserves des tissus des environs, capables du déplacement.

Si l'on a à faire avec le manque tissulaire on peut se servir de la combination lambeau glissant — l'autotransplantation libre.

ZUSAMMENFASSUNG

Die Lokalplastik mittels dreieckiger Keillappen bei der Behandlung von Narbenkontraktionen nach Verbrennungen

A. T. Titova

Die Verwertung von Lokalgeweben bei Keillappen-Plastik ist zur Beseitigung und in schweren Fällen zur Verminderung von Hautkontraktionen zweckmässig. Berichtet wird über Fälle vom Arbeitsplatz.

Der Behandlungserfolg ist von der richtigen Indikation, Auswahl der zweckmässigsten Figurentypen der Keillappen, sowie nachfolgender Verwendung physikalischer Therapie abhängig. Die Operationsplanung erfolgt unter folgenden Gesichtspunkten:

1. Eine schonende Behandlung der Gewebe bietet gute Vorbedingungen für den Blut- und Lymphokreislauf, was eine Besserung der Narben bedeutet.

2. Eine etappenweise Kontraktionsbehandlung wird dadurch bedingt, dass infolge erhöhter Gelenksbeweglichkeit neue Narbenstreifen nach der Operation in Erscheinung treten. Weiters auch durch den Umstand, dass sich weiteren Verlauf neue Vorräte an beweglicher Haut in den Stellen zeigen, wo sie bereits durch eine vorhergehende Operation verwertet wurden.

Die Figurenauswahl ist durch Charakter und Länge der Narbe und Vorräten an verschiebbaren Geweben in deren Umgebung bedingt. Es ist zweckmässig lange Narbenstreifen durch eine Serie von Keillappen zu unterbrechen, die in Narbenrichtung hintereinander gelagert sind.

Breite, kurze Narbenstreifen sind durch kompliziertere Figuren zu unterbrechen, die eine bestmöglichste Verwertung der Vorräte an verschiebbarer Haut in der Umgebung ermöglichen. Bei grösserem Gewebsmangel ist es zweckmässig die Keillappen-Plastik mit freier Hauttransplantation zu kombinieren.

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REPORT ON THE SCIENTIFIC CONFERENCE ON POLISH PLASTIC SURGERY

Held in the Polanica-Zdrój Spa on June 2—3rd 1961

The staff of the Department of Plastic Surgery in the Polanica-Zdrój spa held a conference to celebrate the tenth anniversary of the foundation of their department. On this occasion, they reported on their work documented by many illustrations. Dr. Michal Krauss, head of the department, opened the conference, which was attended by many guests, with a talk on the development of plastic surgery in the Polish People's Republic. It was founded by Dr. Michalek-Grodzku who studied plastic surgery abroad and started working at several Warsaw hospitals before the Second World War. During the war up to the occupation he carried out plastic operations in a military hospital. After the liberation Dr. Grodzku endeavoured to resume his work but it was only in 1951 that he obtained 30 hospital beds in Polanica. He started work under very primitive conditions aided only by Dr. Krauss. Shortly afterwards, however, he fell ill and died in the same year. Up to 1953 when he was joined by Dr. Kratochwil Dr. Krauss remained alone acting as director, surgeon and assistant. During 1954 Dr. Krauss worked on the Prague clinic where he had been sent by the Polish government, together with three Polish surgeons. After his return the number of hospital beds for plastic surgery was raised and two more doctors appointed. Later on, a children's ward with 15 beds was established and a paediatrician appointed. After that development proceeded rapidly. The hospital was classed in the category of specialized hospitals and a laryngologist, stomatologist, paediatrician and anaesthetisiologist were added to the staff. The work of the hospital then increased rapidly, the number of hospitalized patients rising from 59 in 1951 to 954 in 1960 and the number of operations from 112 to 996.

The department of plastic surgery is excellently equipped and the entire atmosphere, organisation of the work and the results achieved bear witness to the high qualifications of the staff.

The conference itself with its large attendance offered a brilliant picture. Doc. Dr Goldstein from Lodz presided. The first day was devoted to congenital malformations — mainly harelip and cleft palate — and the excellent results obtained by Mc Dowell-Brown's method in harelip plasty were demonstrated. Krauss and his associates treat both these defects systematically by very well organised team-work. Primary pharyngoplasty is performed only in severe total clefts. Dr. Wylyczak, the anaesthesiologist of the Institute described in detail the anaesthesia used and the paediatrician Dr. Zawistowska spoke about pre- and postoperative care in the children's department.

A large number of surgeons and stomatologists who carry out these operations in Poland took part in the lively debate. Problems connected with clefts, especially the question of possible prevention of these malformations were also discussed.

In the later part of the programme there was a very interesting lecture of Dr. Krauss and Kratochwil on the tubed flap. The technique used is very delicate giving excellent

results. Well deserved attention and much applause were paid to the reconstruction of the nose by the tubed flap and the correction of saddle nose. The other themes such as the treatment of haemangiomas, X-ray ulcers, plastic operations of the eyelids, the reconstruction of the vestibulum oris and others gave evidence of the high degree of technical and practical skill of the Polanica Institute of Plastic Surgery.

The Institute is situated in the lovely milieu of the spa which has been charmingly improved in the course of the last five years.

The jubilee-conference presented a fine picture of Polish plastic surgery in Polanica-Zdrój for which we most heartily congratulate Dr. Krauss and his colleagues.

F. Burian

ANNOUNCEMENTS

THE CZECHOSLOVAK MEDICAL SOCIETY J. Ev. PURKYNĚ announces the

Czechoslovak Medical Congress

with international participation in Prague from the 12th—17th November 1962 on the occasion of the 100th Anniversary of the Foundation of the Czech Medical Association in Prague and the Czech Medical Journal „Časopis lékařů českých".

The SCIENTIFIC PROGRAMME of the congress will be focussed on urgent problems of medical science and the health services.

The PLENARY MORNING SESSIONS will be devoted to the following problems: The task of basic research in the development of medical science and the health services. — Hygiene and epidemiological service as the main tool of the preventive trend of Czechoslovak health services. — The concept of clinical medicine. — Theory and organisation of the health services. — Perspectives of the Czechoslovak health services.

For the AFTERNOON SESSIONS in paralell groups the following themes have been selected:

1. Relations, structures and functions in the nervous system.
2. Pharmacology of the nervous system.
   Pharmacology of biologically active substances occurring in tissue.
3. Experimental embryology
   a) experimental teratology
   b) comparative blastogenesis and placentation.
4. Mechanism of malignant cell alteration.
5. Sanitary aspects of the protection and formation of the environment of man. Sanitary problems pertaining to standards of maximum permissible concentrations of noxious substance in the environment of man.
   Sanitary problems of education and the health protection of children and adolescents.
   Scientific Bases of Dietotherapy for Working People.
6. Diseases of the respiratory tract of bacterial and virus origin (aetiology, epidemiology and prevention).
   Problems of antibody formation and non-specific resistance.
7. Physiology of work.
   Radiation hygiene.
   Combating dust and silicosis.
   New chemical substances in industry.
8. Tuberculosis: epidemiology, prevention and treatment.
9. Changes in the functional state of the organism after acute exercise.
10. Atherosclerosis.
    Thromboembolic disease.
    Pyelonephritis.
    Chronic hepatitis.
11. Cardiosurgery.
    Problems of extracorporeal circulation.
    Surgery of inborn and acquired heart defects.
    Experimental cardiovascular surgery.
    Surgery of vascular diseases of the CNS.

12. Inborn defects and their prevention.
13. Diseases of the paradental tissue and the oral mucosa.
    Malignant tumours of the orofacial region.
14. The newborn and premature infant.
    Child growth and development.
    Scientific foundations of further development of child care.
15. Influence of work on the female organism.
    Physiology of labour and prevention of the development of pain.
    Human reproduction — regulation of fertility incl. anticonception.
16. Psoriasis.
17. Experimental research of higher nervous activity.
18. Toxic factors in mental disorders.
19. Reflex pathogenic mechanism of nervous diseases.
20. Prevention in the work of the health district doctor.
21. Training at medical faculties and postgraduate training.

SIMULTANEOUS TRANSLATION in English, French, German and Russian will be ensured during plenary sessions and in English and Russian during the group sessions. — During the Congress there will be a **HEALTH EXHIBITION** and a **SOCIAL AND CULTURAL PROGRAMME** will be organised. — **APPLICATION** for participation in the scientific programme of group sessions together with brief summaries (not exceeding 250 words) in English or Russian in three copies must be forwarded by February 28, 1962 to the following adress: Prof. Karel Raška, M. D., Czechoslovak Medical Society J. Ev. Purkyně, Sokolská 31, Prague 2.

The Czechoslovakian plastic Surgeons participate to the Congress on the session on inborn defects and their prevention.

LECT. PROKOP MÁLEK, M. D.:

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