THE HEALING RATE OF LEG ULCERS

A Clinical and Statistical Study of 233 Patients Hospitalized with Leg Ulcers

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Abstract. In a series of 73 males and 160 females hospitalized with leg ulcers due to long-lasting venous insufficiency the areas of the ulcers were measured weekly. The rapidity of healing of each ulcer is expressed graphically: The logarithm of the ulcer areas is plotted against time. Most often straight lines are obtained where the regression relates to the rapidity of healing: *"The 9/10 healing time"*, which is the number of weeks it takes for the curve to cover a decade on the logarithmic paper, i.e. the time it takes for an ulcer to heal to one-tenth of its original size.

The *purpose* of the investigation was to examine the healing course of a large number of leg ulcers in order to find an applicable numerical expression of the healing time.

INTRODUCTION

A great number of physiological methods, more or less clinically applicable, are available to assess quantitatively the degree of *arterial* circulatory capacity of the legs: Walking distance, skin temperature, oscillometry, plethysmography, rheography (11), ^{133}Xenon clearance (13, 20) and pulse amplitude. Methods used to diagnose and to localize defects of the *venous* circulation are well known (3, 6, 10, 17) but they are of little practical use when it comes to the assessment of slighter variations of the venous capacity, e.g. those due to topical or internal treatment. This is regrettable because 90 % of all leg ulcers are considered to be due to venous insufficiency (8, 22). The need for quantitative determination of the effect of various treatments of leg ulcers is amply demonstrated in many papers where the authors calculate simply with average treatment time or give only personal opinions (4, 12, 16, 23).

Very conspicuous results of venous surgery and of skilled bandaging in series of younger and middle aged mobile patients show that venous leg ulcers grow or diminish principally due to the degree of venous stasis (6, 7, 8, 9). That it is possible to affect venous leg ulcers by other means, e.g. by drugs applied topically or systemically, is often maintained but rarely proven.

The first attempt to describe quantitatively the rapidity of healing of leg ulcers was made by Luger (14):

Healing quotient = Hq =

$$\frac{\text{area of ulcer covered by epithelium}}{\text{days of treatment}}$$

This method was applied in papers by Ehlers (5), by Hæger (7) and later again by Luger (15) this time to assess the effect of topical treatment with antibiotics.

Stene & Perdrup (18, 21) described a sophisticated mathematical model for healing curves of leg ulcers, but unfortunately it proved to be too complicated for routine use, for which reason the present study was undertaken. Arma-Szlachcic & Strehler (1) and Arma-Szlachcic (2) calculate the time it takes an ulcer to diminish by 50 % using a method which in principle is similar to ours.

AUTHOR'S INVESTIGATIONS

The patients

The calculation of healing time is based upon a series of 73 males and 160 females with ulcers of the distal third of the leg or just below the ankles. They were all hospitalized for the whole period

Table I. *Schematic presentation of some clinical data*

	73 ♂ (% of 73)	160 ♀ (% of 160)
Older than 63 years	50	
Older than 72 years		50
Under 60 years	36	18
Diabetes	9.6	4.4
Polyarthritis	2.7	15.0
Cerebral hemorrhagia (earlier)	4.1	3.8
Heart failure	14.0	11.0
Past phlebitis	41	42
Earlier sclerosing injections	15	19
Earlier venous surgery	26	6
Relapsing ulcer for 10 years or more	48	41
Relapsing ulcer for 1 year or less	20	28
Area of ulcer over 100 cm²	2.7	6.3
Area of ulcer less than 6 cm²	41	34
Ulcer of right leg	39	33
Ulcer of left leg	45	51
Ulcer of both legs	16	16
Considerable edema of foot and leg	30	27
Cyanosis of foot and part of leg (in erect position)	60	44
Severely reduced mobility of ankle joint	19	36
Severely reduced mobility of knee joint	4	28
Severely reduced mobility of hip joint	7	16
Disabled gait	33	57
Obesity (≥ 20 % overweight)	21	40
Anemia (under 12 g % Hb)	8	35
Serumelectrophoresis Albumin < 3.50 g %	16	26
Globulin > 1.20 g %	29	23
Poor arterial supply	44	24
Heavy smokers	45	14
Non smokers	29	61

Fig. 1. Ordinate: Ulcer area in cm². Abscissa: Healing time in weeks. Ordinary millimetre graph paper.

in question in the Dermatological Department at the Rudolph Bergh's Hospital, Copenhagen, between November 1966 and May 1967. None of the patients were able to follow treatment in our out-patient department either because of the nature of their ulcers or because of other invalidity. Their clinical data are given schematically in Table I.

The selection of leg ulcer patients presented, abandoned by surgeons, repeatedly hospitalized for long periods, is like that found in most dermatological clinics and known as a crux medicorum.

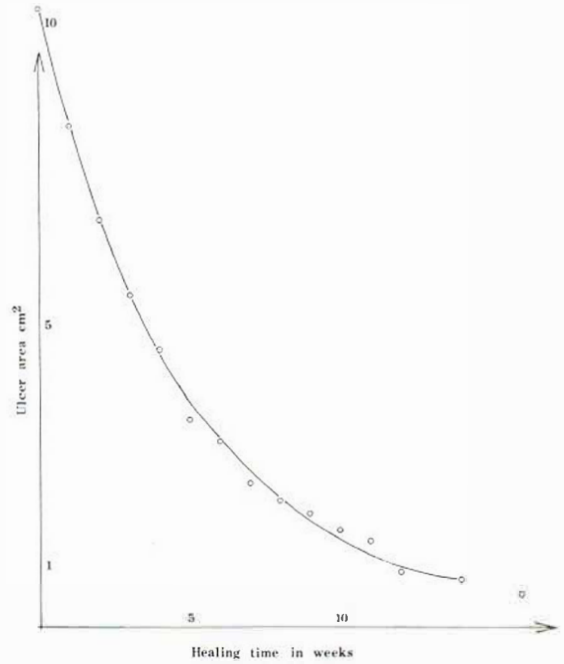*The treatment* was made as simple and as uniform as possible: dressings with 0.1 % solution of silver nitrate, or of 0.25% chloramine, or Carbo-wax® with 0.5 % Cetavlon® or silver nitrate ointment. The adjacent skin was painted with 1 % alcoholic solution of eosine. The patients were mobilized as much as possible, elastic bandages were applied during the day, the foot of the bed was elevated. Coexisting internal diseases were of course treated according to current standards.
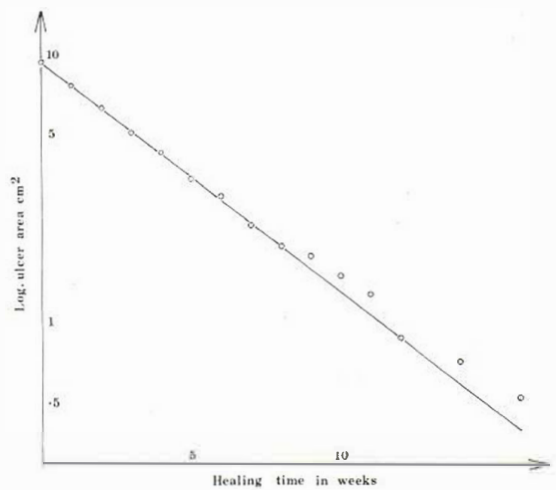

Fig. 2. The same ulcer as in Fig. 1. Ordinate: Log. ulcer area in cm². Abscissa: Healing time in weeks. Logarithmic millimetre graph paper.
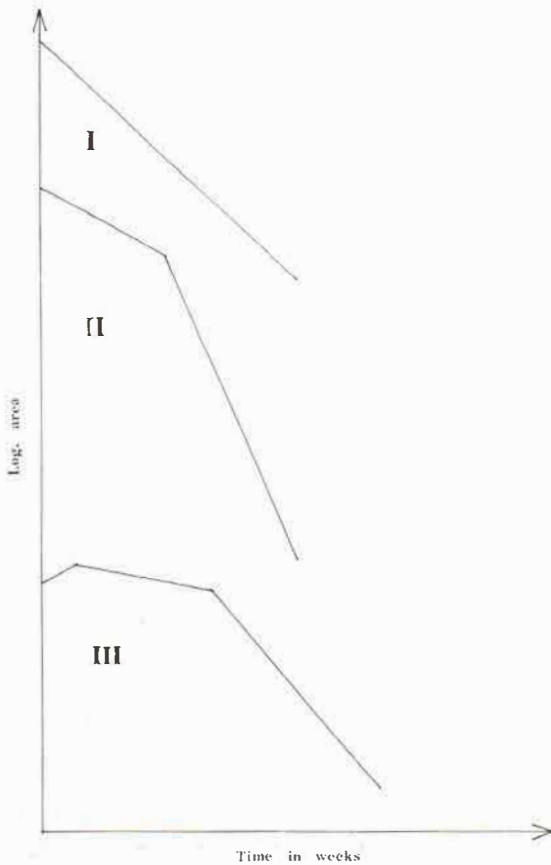
Fig. 3. Typical courses of healing of leg ulcers. Ordinate:
Log. ulcer area. Abscissa: Healing time in weeks. (I) Same
healing course as in Fig. 2. (II) After a slow start, maybe
due to filling up of cavity the epithelialization accelerates
and then follows the steep part of the curve. (III) At first
the ulcer increases in size, then the healing proceeds as
in graph II.

Calculations

The size of each ulcer is measured once a week.
A trained nurse traces the exact circumference of
each ulcer on transparent paper. By means of a
planimeter (Ott-Kompensations-Polarplanimeter)
the area of the ulcer is calculated with close
accuracy by the same person (chief medical sec-
retary).

The arterial supply of the legs, Table I below, is
estimated in each patient by means of rheography
and pulse palpation.

Healing rate

Readings of interdependent time (in weeks) and
area of ulcers (in cm^2) were plotted for each ulcer

in a system of coordinates. In this way we ob-
tained curved lines, never straight lines (see
Fig. 1).

Because many biological developments proceed
logarithmically we again plotted the area of each
ulcer against the healing time in weeks, this time
on logarithmic millimetre graph paper. The curves
now approximated straight lines (Fig. 2).

In logarithmic graph paper the decades are
equal. A decade is the distance between 0.1 and
1 or between 1 and 10 or between 10 and 100.
Curves with logarithmic characteristics form
straight lines on logarithmic graph paper.

Not all ulcers have such regular healing curves.
It is, however, possible to divide the majority of
the curves into three main groups (Fig. 3).

"The 9/10 healing time" is now defined as the
number of weeks it takes until the ulcer has
healed to one-tenth of its size on the first day in
hospital, in other words: how many weeks it takes
the curve to cover a decade on the logarithmic
millimetre graph paper. For practical purposes we
made a pattern to transform the regressions of
the curves into "9/10 healing times". Curves like
group I of Fig. 3 give no problems. Broken curves
like Fig. 3 group II or III are more problematic.
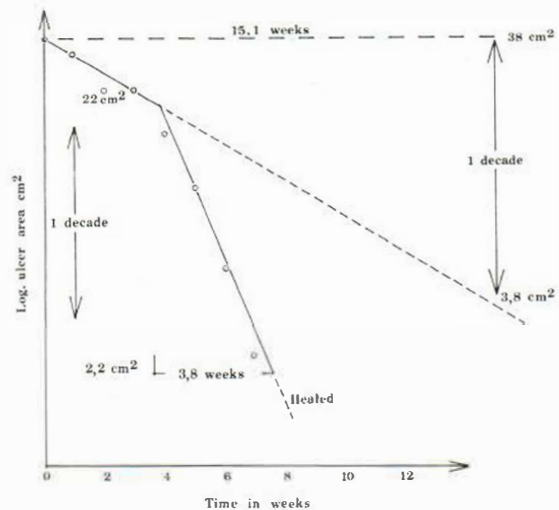An example is shown in Fig. 4.

Fig. 4. Example from Fig. 3 II. "The 9/10 healing time"
of this ulcer would be 15.1 weeks if the whole course
follows the first part of the curve. After ca 3 weeks the
healing accelerates and the ulcer heals from 22 cm^2 to
2.2 cm^2 = one decade in 3.8 weeks i.e. the second "9/10
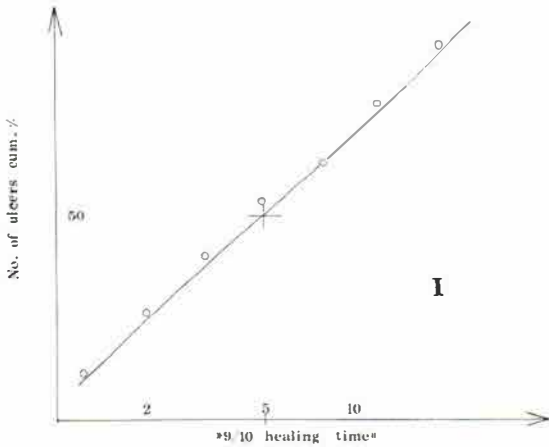healing time" is only 3.8 weeks.

Fig. 5 I. Distribution of "9/10 healing times" of 113 ulcers with straight healing curves. Logarithmic probability graph paper. Ordinate: Cumulative % of numbers of ulcers. Abscissa: "9/10 healing times". Weeks per decade. Logarithmic intervals. Mean: 5.6 weeks per decade.
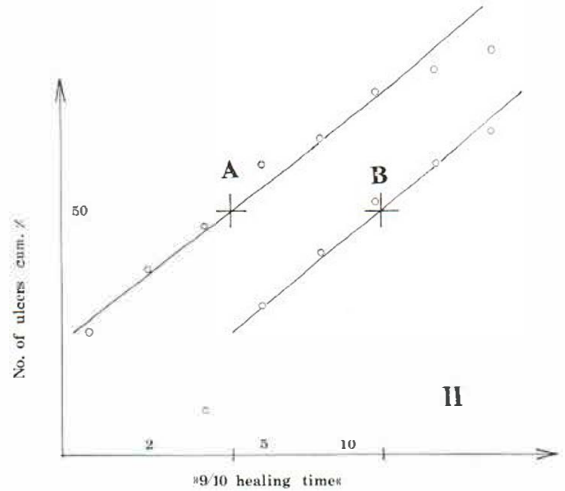

Fig. 5 II. Distribution of "9/10 healing times" of 99 ulcers with broken healing curves. Graph paper like Fig. 5 I. (A) "9/10 healing times" according to the second (steep) part of the curves. Mean 3.9 weeks per decade. (B) "9/10 healing times" according to the first part of the curves. Mean 12.5 weeks per decade.

In ulcers from Fig. 3 III the initially recorded increase is simply due to disappearance of under-mined, necrotic edges. We therefore ignore in our calculations the first, ascending part of the curve and pool the curves from group II with those from group III. The acceleration of epithelialization which in these cases begin some weeks after hospitalization may be due to the effect of treatment (19) or it happens when the bottom of the ulcer has been leveled with granulations. The steep part of the curve is probably the most realistic expression of the healing capacity and therefore of "the 9/10 healing time", also because the mean time from Fig. 5 I is in accordance with Fig. 5 II A.

Besides the patients recorded in Table II the series contains 22 patients with ulcers which did not diminish (healing time infinite) or even increased.

In case of several ulcers in the same person the *patient* is classified according to "the 9/10 healing time" of the largest ulcer.

DISCUSSION

A leg ulcer is a phenomenon which indicates the degree of vascular, most often of venous incompetence of the leg together with varying degrees of arterial insufficiency. In some patients, namely in younger patients with venous incompetence, the effect of surgery, of bandaging and of physio-

therapy is quite obvious. In other groups of patients such as those here demonstrated these treatments are rarely applicable. Other therapeutic measures might come in useful here but their effect is difficult to assess. "The 9/10 healing time" here presented is easy to carry out and easy to calculate. Our patient series is, however, homogeneous only with regard to a generally poor condition. The large dispersion of the results is therefore not surprising. The author feels that the method deserves to be applied in more homo-

Table II. *"The 9/10 healing times" of 179 patients with ulcers which did heal completely during their stay in hospital*

In cases with broken curves the steep part is recorded

"9/10 Healing time" (weeks)	Mean of the logarithm	♂	♀	Total
1.0–1.5	1.25	3	7	10
1.6–2.4	2	5	15	20
2.5–3.9	3.15	7	19	26
4.0–6.2	5	16	30	46
6.3–9.9	8	13	16	29
10–15	12.5	9	15	24
16–24	20	6	6	12
Over 25	(31.5)	5	7	12
Total		64	115	179

geneous series of patients. It might be useful to consider not only regressions but also the angles in the case of broken curves.

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