Reflex sympathetic dystrophy of the upper extremity—a 5.5-year follow-up

Part I. Impairments and perceived disability

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The aim of this retrospective and long-term follow-up study was to identify impairments resulting from reflex sympathetic dystrophy (RSD) of the upper extremity and to analyze the relationship between impairment and disability in RSD patients.

The study group consisted of a referred sample of 65 RSD patients, with clinical signs in the upper extremity. RSD developed after fractures of the wrist or hand in 29 patients or after a carpal tunnel release in 9 patients. The mean interval between the RSD diagnosis and our evaluation was 5.5 (3–9) years (SD = 0.8). The main outcome measurements were the impairments assessed by standard physical examination. ADL and pain were quantified with a visual analogue scale (VAS). Pain was evaluated immediately before and after the physical examination and the perceived pain was determined in the week before the examination.

*Significant differences in impairments were found between the affected and the unaffected sides ($p < 0.05$). According to the AMA-guides, the impairments did **not** lead to disabilities. Significant correlations were found between VAS-ADL and VAS-pain in the last week prior to evaluation and full fist grip-strength. Pain seems to be the most disabling effect.*

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Reflex sympathetic dystrophy (RSD) is a complex regional pain syndrome (Stanton-Hicks et al. 1995). It is complex because: 1) its etiology is poorly understood; 2) the natural causes are diverse; 3) there are many criteria for RSD; 4) many therapies have been described and 5) many definitions have been proposed (Kozin et al. 1976, Lankford 1980, Goris 1985, Amadio et al. 1991, Geertzen et al. 1994, Stanton-Hicks et al. 1995). Most therapies are claimed to be effective (Hannington-Kiff 1977, Kozin et al. 1981, McCain et al. 1983, Goris 1985). However, they are mainly based on short-term follow-up studies (Hannington-Kiff 1977, Kozin et al. 1981, McCain et al. 1983, Goris 1985). Long-term follow-up studies of RSD are few and the populations studied are small (Subbarao and Stillwell 1981, Atkins et al. 1990, Field et al. 1992, Veldman et al. 1993, Bickerstaff and Kanis 1994). The results of the different long-term follow-up studies of RSD are similar, although the follow-up times differ enormously, ranging from 9 weeks (Atkins 1990) up to 10 years (Field et al. 1992). The features found in these studies were stiffness in the hand and shoulder, pain, reduction in grip strength, swelling, inflammatory signs, neurological signs, atrophy and vasomotor and sudomotor changes (Subbarao and Stillwell 1981, Field et al. 1992, Veldman et al. 1993). The first-mentioned features are, in fact, impairments. Only one of the follow-up studies described the instruments for measuring impairments (Bickerstaff and Kanis 1994). Therefore, quantification of the severity of the impairments in RSD in other studies is almost impossible.

Follow-up studies suggest that an "early" diagnosis and subsequently an "early" initiation of therapy might result in a better outcome than therapy initiated in a later stage of RSD, but no evidence is given for this statement (Subbarao and Stillwell 1981, Atkins et al. 1990, Field et al. 1992, Veldman et al. 1993, Bickerstaff and Kanis 1994). Moreover, the time span for "early" and "late" diagnoses and treatment has not been defined.

The aims of this study are:

1) to analyze the long-term outcome for RSD patients in terms of impairment. In this context, we use the

following definition: "Impairment is any loss or abnormality of psychological, physiological or anatomical structure in terms of function, temporary or permanent" (WHO 1980);

2) to analyze to what extent impairments restricted ADL, as experienced by the patients;
3) to analyze the relationship between "early" diagnosis and treatment, in relation to the objective impairments. We defined "early" as within 2 months after the causative event and "late" as later than 2 months after that event;
4) to analyze to what extent impairments lead to disability according to the "Guides to the Evaluation of Permanent Impairment" of the American Medical Association (AMA; Doege and Houston 1993).

Patients and methods

From the medical archives of the Department of Rehabilitation, all files with the diagnosis code 733.7 of the International Classification of Diseases, 9th revision, Clinical Modification (ICD-9-CM) were extracted. The symptoms of the patients were verified by checking the criteria previously described: pain and presence of at least three of the following: edema, hyperemia, hyperesthesia, hyperhidrosis, and/or a limitation in the range of motion (Geertzen et al. 1994). Of the 195 medical records extracted, the majority concerned patients with lower extremity RSD. Some records were not classified correctly, probably because the initial diagnosis was made by several doctors with different levels of training. Finally, 93 patients (64 women, 29 men) with upper extremity RSD were asked to participate in this study of whom 14 patients refused or were not able to participate because of illness, age or travelling distances. The addresses of 5 patients were not known; 8 patients did not reply and one patient had died of cancer, leaving 65 patients, comprising 48 women and 17 men, in the study.

The group of 65 patients studied had a mean age of 50.2 (18–82) years (SD 14.9).

The mean follow-up time was 5.5 (3–9) years (SD 0.8).

In a structured interview, the following items were assessed:

- the therapy received in the past for RSD. The answers of the patients were verified against medical records;
- the pain experienced in the last 24 hours and in the week prior to the evaluation. The pain was assessed in a semiquantitative way, on a 10 cm straight line (0 = no pain, 10 = severe pain; VAS pain).
- perceived disabilities during daily activities in the week prior to the evaluation assessed on a 10 cm straight line (0 = no difficulties, 10 = impossible; VAS-ADL) (Table 1).
- perceived physical complaints at rest and medical consumption at the time of evaluation, in relation to RSD.

A physical examination was performed, as described in 1994, and an additional score (RSD score) was attributed to the various physical findings (Geertzen et al. 1994). The examination included the presence of edema, discoloration, range of motion when making a fist (distance of fingertips to the palmar side of the hand), the ability to oppose the thumb and the distance of the thumb tip to tip of the fifth finger in maximum abduction and adduction (Geertzen et al. 1994). The minimum score attributed to the physical findings is zero points and the maximum is 64 points, in which the higher (RSD) score represents a worse manifestation of the RSD (Geertzen et al. 1994). In addition, the moving two-point discrimination (in mm) of the volar tip of the thumb and index finger was measured with a Disk Criminator (Lafayette Instrument; model 258-F00620) (Lee Dellon and Kallman 1983). The circumference (in mm) was measured with a Gulick measuring tape (Lafayette Instrument; model 258-J00305) at the base of the index finger and at the wrist.

Active range of motion was measured, with a goniometer, according to a standardized protocol, of the shoulder (outward rotation and forward flexion), elbow (flexion, extension and supination) and wrist (volar- and dorsiflexion, radial and ulnar deviation). The ranges of motion measured were compared with the ranges of motion of the upper extremity, required to perform ADL tasks. The required ranges of motion were for elbow extension and flexion (30°, 130°), supination (60°), wrist dorsiflexion (35°) and volar flexion (10°) and wrist radial (20°) and ulnar deviations (20°) (Morrey et al. 1981, Brumfield and Champoux 1984, Palmer et al. 1985, Safee-Rad et al. 1990). For the shoulder we could not find ranges of motion required for ADL. We therefore choose arbitrarily a minimum forward flexion of 140°.

Muscle strength of the hand, the three-point grip, pinch-grip and full-fist grip were measured, with a hand-held dynamometer (van der Ploeg 1992) (CITEC; Center for Innovative Technics BV; The Netherlands). All muscle-strength measurements (N) were performed 3 times for each grip-type, and the mean of these 3 measurements was used for further analysis (Mathiowetz et al. 1984, van der Ploeg 1992). All measurements were performed on the affected and unaffected sides (Table 1). All patients were measured by the same observer (P.U.D.).

Table 1. Variables, instruments and units of measurement

Variable	Instrument	Unit
Range of motion shoulder elbow wrist	Goniometer	°
Circumference digit 2 wrist	Gulick measuring tape	mm
Moving two point discrimination digit 1 digit 2	Disk Criminator	mm
Muscle strength 3-point grip pinch-grip full-fist grip	Hand-held dynamometer	N
Pain	VAS	cm
ADL	VAS	cm

Table 2. Causative events in relation to RSD (n = 65)

Event	n
Fractures[a]	29
Carpal tunnel release due to carpal tunnel syndrome	9
Hand contusions	7
Tendon tears[b]	5
Spontaneous	3
Dupuytren's contractures[c]	3
Cuts (only skin involved)	3
Various	6

[a] including 13 radius fractures (all treated conservatively with plaster of Paris), 2 antebrachii fractures (treated operatively), 4 fractures of the scaphoid bone (treated with plaster), 2 metacarpal II fractures, 1 Bennet's fracture and 1 metacarpal IV fracture (all 4 treated operatively), 2 metacarpal V fractures (treated conservatively with plaster of Paris) and 4 other fractures (ulnar bone, scaphoid bone, and 2 phalanges fractures, all treated conservatively).
[b] two partial and three complete tendon tears, without nerve involvement, all treated with operation.
[c] all operated.

Finally, the patients were asked to judge their pain on a VAS-scale immediately after the examination to analyze the effect of the physical evaluation on pain.

Statistics

Data analysis performed in the SPSS-package included: descriptive statistics, paired t-tests to analyze differences in active range of motion, circumference and muscle strength between the affected and unaffected sides, and t-testing to analyze differences in impairments of patients with an "early" diagnosis and a "late" diagnosis and in patients with or without a wrist or hand fracture or a carpal tunnel release as a causative event; calculation of correlation coefficients to analyze the relationship between VAS-ADL and impairments and linear regression for predicting VAS-ADL on the basis of several impairments (according to a statistical equation VAS-ADL = C1.A + C2.B +C3). For all statistics, a level of significance, $p \leq 0.05$, was accepted.

Results

57 patients were right-dominant and 8 left-dominant. In 42 patients, the right hand was affected. In 38 patients the dominant side was affected. RSD developed after fractures of the wrist or hand in 29 patients or after a carpal tunnel release in 9 patients (Table 2).

The mean interval between causative event and the diagnosis RSD was 2.3 (1–5) months. 48 patients were diagnosed and treated within 2 months ("early" diagnosis) and the other 17 patients were diagnosed and treated between 2 and 5 months ("late" diagnosis). No differences were found in impairments between the "early" and the "late" diagnosis groups.

Impairments

Discoloration was present in 26 patients. Slight differences in volume between the hands were present in 17 patients.

The mean RSD score on the affected (RSD) side was 5.6 (0–50; SD 8.6) and on the unaffected side 0.7 (0–8; SD 1.5). The RSD scores in our physical examination comprised 63 patients, because 2 patients had a history of RSD of both hands, so the results could not be compared with the unaffected side. There were no significant differences between the sexes.

The active range of motion was significantly larger on the unaffected side, except for elbow-flexion (Table 3). The results of the active range of motion measurements between patients with a fracture of the hand or wrist and those without a fracture on the affected side are listed in Table 4. In some patients, however, there were evident impairments: forward flexion of the shoulder was less than 140° in 4 patients, contractures of the fingers were found in 2 patients and a range of motion of the elbow and wrist, less than required to perform ADL was found in 8 patients.

The muscle strength was significantly greater at the unaffected side (Table 5). Muscle strength of men was significantly greater than that of women in all 3 grip-types (Table 6). Six male patients and 24 female patients had a grip strength less than the P5 as described by van der Ploeg (van der Ploeg et al. 1991).

Table 3. Results of range of motion measurements (°) in the affected and unaffected sides

	Affected side mean (SD)	range	Unaffected side mean (SD)	range	p-value
Forward flexion	164 (18)	90–182	169 (14)	110–180	0.005
Outward rotation[a]	39 (18)	-10–84	44 (17)	6–86	0.001
Elbow flexion	147 (4)	138–157	147 (4)	137–159	0.5
Elbow extension[b]	8 (6)	-9–26	6 (5)	-8–25	0.003
Supination	99 (19)	30–146	103 (16)	69–144	0.04
Dorsiflexion	55 (13)	0–78	61 (8)	40–78	0.000
Volar flexion	67 (16)	0–90	74 (10)	40–96	0.000
Radial deviation	32 (10)	0–54	36 (10)	18–58	0.001
Ulnar deviation	31 (10)	0–48	37 (9)	16–56	0.000

p-values are based on a paired t-test.
[a] outward rotation has a negative range value because there were patients with an inward rotation contracture.
[b] elbow-extension has a negative range value because some patients could overextend their elbow.

Table 4. Comparison of range of motion measurements (°) between patients with a fracture of the hand or wrist (n=29) and those without a fracture (n=35) of the affected side, mean (SD)

	Fracture	No fracture	p-value
Supination	93 (20)	105 (16)	0.007
Volar flexion	61 (18)	71 (13)	0.015
Ulnar deviation	27 (11)	34 (8)	0.004

p-values are based on t-tests for independent samples. No other significant differences were found in the range of motion between the groups. The ranges of motion in the fracture group fell well within the ranges required for ADL.

Table 5. Muscle strength (N) of 3 measurements in 3 grips in RSD patients, mean (SD)

	Affected side	Unaffected side	p-value
Full-fist grip	170 (104)	231 (105)	0.001
Three-point grip	74 (37)	91 (33)	0.001
Pinch-grip	57 (34)	64 (21)	0.001

p-values are based on a paired t-test.

Table 6. Muscle strength (N) in women and men in 3 grips in RSD patients, mean (SD)

	Men	Women	p-value
Full-fist grip			
affected side	271 (112)	129 (67)	<0.001
unaffected side	350 (98)	183 (59)	<0.001
Three-point grip			
affected side	106 (42)	61 (25)	<0.001
unaffected side	127 (31)	77 (20)	<0.001
Pinch-grip			
affected side	77 (25)	49 (19)	<0.001
unaffected side	83 (23)	57 (15)	<0.001

p-values are based on a paired t-test.

Table 7. Circumference measurements (mm) with a Gulick measuring tape, mean (SD)

Circumference	Affected side	Unaffected side	p-value
Wrist	165 (12)	165 (12)	0.85
Digit 2	68 (7)	68 (6)	0.29

p-values are based on a paired t-test.

The circumferences of the wrist and digit 2 show no significant differences regarding the affected and unaffected sides (Table 7).

The mean values of the two-point discrimination test of the affected side were for the thumb 4.4 (2–8; SD 1.4) mm and, for the index finger, 4.2 (2–12; SD 1.6) mm. The values on the unaffected side were 4.0 (2–7; SD 1.3) mm and 3.8 (2–8; SD 1.2) mm, respectively. Moving two-point discrimination of the thumb was more than 6 mm in 5 patients at the affected side and in 3 patients at the unaffected side.

Physical remaining complaints

Only 6 patients had no physical complaint. 48 patients had pain when exposed to cold; decrease in muscle strength was felt by 45 patients and pain by 38 patients (Table 8).

The mean VAS-pain score in the week prior to examination was 2.0 (0–10; SD 2.4), directly before our examination 1.2 (0–8; SD 1.8) and directly after examination 2.3 (0–9; SD 2.6). This increase in pain in 33 patients was significant ($p < 0.001$). In 5 patients, pain decreased during the examination.

Table 8. Physical remaining complaints perceived by patients 5–9 years after RSD

Physical complaint	%	n
Pain when exposed to cold	74	48
Decrease in muscle strength	69	45
Pain	58	38
Stiff upper extremity joints	55	36
Decrease in ability to handle objects	46	30
Decrease in tactile sense	34	22
Must see to handle objects	31	20
Pain when exposed to heat	22	14
Tremor or involuntary movements	5	3

Many patients have more than one complaint. Pain is a common remaining complaint.

Activities of daily life

The mean VAS-ADL score was 2.0 (0–9; SD 2.2). 22 patients perceived no ADL disabilities (VAS = 0).

Significant correlations were found between VAS-ADL and VAS-pain (=A) last week (r = 0.65) and VAS-ADL and the full-fist grip strength (=B) (r = –0.55). Linear regression revealed C1 = 0.47 ($p < 0.0001$), C2 = –0.006 ($p<0.004$), C3 = 2.23 ($p < 0.0001$) in the statistical equation: VAS-ADL = C1*A +C2*B + C3. The model explained 50% of the total variance of VAS-ADL.

Treatment

All patients were treated in our Department of Rehabilitation. During the years, the treatment changed from RIS blocks and paramedical treatment to dimethylsulfoxide (DMSO) application or N-acetylcysteine per os, both hydroxyl radical scavengers, in combination with paramedical treatment, because of results previously published (Goris 1985). Regional intravenous ismelin blocks were given to 13 patients, dimethylsulfoxide to 42 patients and N-acetylcysteine to 13 patients. Physiotherapy and occupational therapy (including splinting) were given to 64 patients and 28 patients, respectively.

Medication in relation to the RSD (analgetics and/or psychopharmacons) was still being taken by 12 patients. 2 patients were receiving psychotherapy and 10 patients were seeing alternative (medical) therapeutists such as mesmerists or "color therapists".

Discussion

On the basis of results in this study it is obvious that RSD patients, after a mean interval of more than 5 years, still have impairments and perceive disabilities in ADL.

Pain was the major complaint, although the mean VAS-pain scores in the week before examination, at the time of and just after examination were not high (Table 8). Thus, regarding pain, there may be a discrepancy between the subjective complaints and the pain-measurements. Moreover, the measurements increased pain in 33 patients, although active motions were measured.

Differences in range of motion were significant between the unaffected and affected sides except for elbow flexion. However, the mean difference between affected and unaffected sides was never more than 7°, which falls within the clinically accepted variation in range of motion measurements (Nicol 1989). All mean active movements were within the range needed to perform ADL, such as eating and dressing (Morrey et al. 1981, Brumfield and Champoux 1984, Safee-Rad et al. 1990). The differences in range of motion have therefore no clinical relevance for ADL. There are, however, for some patients evident impairments. ADL tasks require a minimal range of motion for the joints of the upper extremity (Morrey et al. 1981, Brumfield and Champoux 1984, Palmer et al. 1985, Safee-Rad et al. 1990). The restrictions of range of motion in the shoulder, elbow and wrist might cause difficulties for ADL tasks on the basis of literature findings. However, the patients with the evident range-of-motion impairment did not score higher on the VAS-ADL.

The shoulder movements were measured because shoulder-hand syndromes or shoulder problems are reported in RSD patients (Veldman and Goris 1995). In our patients, we found no patient with shoulder pain, serious limitation in range of motion of the shoulder and a swollen hand. According to the AMA guides, only the impairments in shoulder forward flexion, outward rotation and elbow extension each give an impairment of 1% of the total upper extremity and the impairments found have little clinical relevance (Doege and Houston 1993).

Our findings are potentially confounded by the causative event. The majority of the range of motion limitations are found at the wrist. 29 of our patients had a fracture of the wrist or hand. Significant differences regarding range of motion, comparing patients with or without a fracture of the affected side, were found regarding supination, volar flexion and ulnar deviation (Table 4).

In general, in the analysis of muscle function the basic approach is the measurement of force. In medical practice, grading of strength according to the Medical Research Council Scale (MRC-Scale) is usually performed, but for a more quantitative approach a dynamometer is essential, especially regarding RSD patients, because they often have muscle weakness

(Veldman et al. 1993). In our study, we found significant differences between the affected and unaffected sides (Table 5). There were significance differences between both sexes (Table 6). The three-point grip strength found in our study is comparable to the three-point grip found by van der Ploeg (van der Ploeg et al. 1991) in healthy persons (control group). The muscle strength of our patients was somewhat less, which might be explained by the difference in mean age (in the study by van der Ploeg, the mean age was 34.1 years; women =33.8; men = 34.4). In our study, 6 male patients had less muscle strength than 94 N (P5) and 24 female patients had less than 65 N (P5). The other grip strengths, full-fist and pinch- grip, were not comparable to other studies because different dynamometers were used (Mathiowetz et al. 1985). Regarding grip strength, no significant differences were found between the patients with or without a fracture of the wrist or hand.

Two-point discrimination, equal to or less than 6 mm, gives according to the AMA guides normal sensibility or 0% sensory impairment (Doege and Houston 1993). Therefore, there seems to be no real clinical sensory impairment 5 years after a RSD syndrome in the majority of the patients. However, 30 patients claimed they were not able to handle small objects well, while 22 reported a decrease in tactile sense and 20 had to see what they were doing while handling small objects (Table 8). Therefore, in this respect also there is a difference between our measurements and the subjective experiences of the RSD patients. The 9 patients who developed RSD after a carpal tunnel release did not have a higher two-point discrimination.

The RSD score designed to evaluate RSD in the acute phase was also used for this study. The mean score was low: 5.6. The interpretation of this mean score may be as follows: either this score cannot evaluate a chronic RSD patient or else there is a difference between what patients perceived and what was measured.

The atrophic (third) phase consists of a pale cold skin, no edema, contractures and atrophy of all tissues (Sudeck 1938, Maurer 1940, Steinbrocker et al. 1948). Edema has been noted in the third phase in up to 13% of the subjects (Veldman 1995). In our study, the circumferences did not differ between the affected and unaffected sides (Table 7).

40% of the patients showed evidence of a minor color difference between both hands. In general, there was no strong evidence to support the 3-phase theory because we did not find grossly restricted range of motion, or many signs of atrophy, or edema and discoloration in our group.

It is often suggested that RSD should be diagnosed as soon as possible, for therapeutic reasons (Baron et al. 1996). An "early" diagnosis of RSD is said to give better outcomes (Baron et al. 1996). In this long-term follow-up study, we found no differences in impairments between patients who were diagnosed within 2 months after the causative event and those diagnosed between 2 and 5 months after it.

Significant correlations were found between the VAS-ADL, VAS-pain in the last week before examination and full-fist grip strength. This suggests a relation between restriction perceived in ADL, and pain and full-fist grip strength. There was no significant correlation between ranges of motion and the VAS-ADL, indicating that the impairments in the range of motion did not influence restriction in ADL.

Our study includes a very heterogeneous group of patients. Some tended to recover completely and others still had pain, still perceived disabilities in ADL but had no objective impairments. Therefore, it is not possible to speak about a RSD syndrome, a post-RSD syndrome or a chronic RSD syndrome. After this study their remains the question how to describe the complex of symptoms in patients several years after RSD.

Conclusion

In our patients, "chronic" RSD appeared to be a chronic syndrome in which pain and loss of full-fist muscle strength were the most evident impairments. They were strongly related to the perceived ADL disability. No other clinically relevant impairment could explain the perceived disabilities in ADL. More study of the relation between impairments, disability and quality of life in this syndrome is needed.

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