

University of Groningen

Therapy-Resistant Complex Regional Pain Syndrome Type I

Bodde, M.I.; Dijkstra, P.U.; den Dunnen, W.F.A.; Geertzen, J.H.B.

Published in:
Journal of Bone and Joint Surgery-American Volume

DOI:
[10.2106/JBJS.J.01329](https://doi.org/10.2106/JBJS.J.01329)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2011

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):
Bodde, M. I., Dijkstra, P. U., den Dunnen, W. F. A., & Geertzen, J. H. B. (2011). Therapy-Resistant Complex Regional Pain Syndrome Type I: To Amputate or Not? *Journal of Bone and Joint Surgery-American Volume*, 93(19), 1799-1805. <https://doi.org/10.2106/JBJS.J.01329>

Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

Therapy-Resistant Complex Regional Pain Syndrome Type I: To Amputate or Not?

Marlies I. Bodde, MD, Pieter U. Dijkstra, PhD, Wilfred F.A. den Dunnen, MD, PhD, and Jan H.B. Geertzen, MD, PhD

Investigation performed at the University Medical Center Groningen, Groningen, The Netherlands

Background: Amputation for the treatment of long-standing, therapy-resistant complex regional pain syndrome type I (CRPS-I) is controversial. An evidence-based decision regarding whether or not to amputate is not possible on the basis of current guidelines. The aim of the current study was to systematically review the literature and summarize the beneficial and adverse effects of an amputation for the treatment of long-standing, therapy-resistant CRPS-I.

Methods: A literature search, using MeSH terms and free text words, was performed with use of PubMed and EMBASE. Original studies published prior to January 2010 describing CRPS-I as a reason for amputation were included. The reference lists of the identified studies were also searched for additional relevant studies. Studies were assessed with regard to the criteria used to diagnose CRPS-I, level of amputation, amputation technique, rationale for the level of amputation, reason for amputation, recurrence of CRPS-I after the amputation, phantom pain, prosthesis fitting and use, and patient functional ability, satisfaction, and quality of life.

Results: One hundred and sixty articles were identified, and twenty-six studies with Level-IV evidence (involving 111 amputations in 107 patients) were included. Four studies applied CRPS-I diagnostic criteria proposed by the International Association for the Study of Pain, Bruehl et al., or Veldman et al. Thirteen studies described symptoms without noting whether the patient met diagnostic criteria for CRPS-I, and nine studies stated the diagnosis only. The primary reasons cited for amputation were pain (80%) and a dysfunctional limb (72%). Recurrence of CRPS-I in the stump occurred in thirty-one of sixty-five patients, and phantom pain occurred in fifteen patients. Thirty-six of forty-nine patients were fitted with a prosthesis, and fourteen of these patients used the prosthesis. Thirteen of forty-three patients had paid employment after the amputation. Patient satisfaction was reported in eight studies, but the nature of the satisfaction was often not clearly indicated. Changes in patient quality of life were reported in three studies (fifteen patients); quality of life improved in five patients and the joy of life improved in another six patients.

Conclusions: The previously published studies regarding CRPS-I as a reason for amputation all represent Level-IV evidence, and they do not clearly delineate the beneficial and adverse affects of an amputation performed for this diagnosis. Whether to amputate or not in order to treat long-standing, therapy-resistant CRPS-I remains an unanswered question.

Level of Evidence: Therapeutic Level IV. See instructions to Authors for a complete description of levels of evidence.

Disclosure: None of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), from a third party in support of any aspect of this work. None of the authors, or their institution(s), have had any financial relationship, in the thirty-six months prior to submission of this work, with any entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. Also, no author has had any other relationships, or has engaged in any other activities, that could be perceived to influence or have the potential to influence what is written in this work. The complete **Disclosures of Potential Conflicts of Interest** submitted by authors are always provided with the online version of the article.



A commentary by Richard J. de Asla, MD, is linked to the online version of this article at jbjs.org.

Complex regional pain syndrome type I (CRPS-I), formerly termed reflex sympathetic dystrophy, is characterized by severe pain in the distal part of an extremity that may develop after a noxious event or spontaneously. The intensity of the pain is disproportionate to the inciting event. The pain is described as burning and continuous, and it may worsen with movement, touch, or stress. Abnormal swelling, changes in skin color and temperature, and changes in sweating in the region of the pain vary over time¹.

Various treatments for CRPS-I have been described, including physical therapy, medication, sympathetic nerve block, sympathectomy, and neuromodulation; however, limited evidence is available regarding the effectiveness of these therapies^{2,3}. To the disappointment of both the patient and the clinician, therapy for long-standing CRPS-I does not result in a cure in many cases and may not even provide any beneficial effects. CRPS-I should therefore be considered a severe condition with a high likelihood of continuing impairment⁴. Long-standing, therapy-resistant CRPS-I may culminate in severe pain, infections, and contractures that impede daily activities and participation in society. An amputation may be indicated if a life-threatening infection develops in a patient with therapy-resistant CRPS-I. In other cases, the impairment and/or pain may be severe enough that a patient requests amputation. However, CRPS-I as an indication for amputation remains controversial.

There is ongoing debate regarding the optimal level of amputation for patients with CRPS-I and regarding the prevalence of CRPS-I recurrence and changes in the quality of life after the amputation. Evidence-based guidelines regarding CRPS-I currently state that there is insufficient evidence to demonstrate that amputation contributes positively to the treatment of patients with long-standing, therapy-resistant CRPS-I^{3,5}. However, those guidelines excluded information published in case reports and are consequently based on only two studies^{6,7}.

Therefore, the primary aim of the current study was to systematically review the available literature, including case reports, regarding CRPS-I as a reason for amputation and to summarize the beneficial and adverse effects of an amputation. A secondary aim was to provide additional information on which clinicians can base their advice to patients with long-standing, therapy-resistant CRPS-I regarding whether to perform an amputation.

Materials and Methods

Study Identification and Selection

A literature search was performed with use of PubMed and EMBASE, using MeSH (Medical Subject Headings) terms and free text words associated with complex regional pain syndrome (including complex regional pain syndrome, CRPS, dystrophy, algodystrophy, Südeck, and reflex sympathetic dystrophy) combined with amputation. All original studies describing CRPS-I as a reason for amputation and published in Dutch, English, or Danish prior to January 2010 were considered for inclusion. The focus of our review was on the beneficial and adverse effects of amputation as a treatment for patients with CRPS-I, and not on the effects of other treatments. The reference lists of the identified studies were also searched for additional relevant studies that had not been found by the database search.

We excluded studies regarding CRPS-II (causalgia), expert opinions that did not include descriptions of clinical cases, commentaries by editors,

commentaries on previous publications or poster abstracts, and studies that described the onset of CRPS-I following an amputation.

Study Analysis

Each of the included studies was assessed to determine whether it reported on the CRPS-I diagnostic criteria used (see Appendix), level of amputation, amputation technique, rationale for the level of amputation, reason for amputation, recurrence of CRPS-I after the amputation, phantom pain, prosthesis fitting and use, and patient functional ability, satisfaction, and quality of life. As we were not aware of any formal tool suitable for assessing these case studies, we developed our own assessment tool specific to this patient group and based on assumptions regarding adequacy of reporting. A random sample of three studies was assessed by two of the authors (M.I.B., J.H.B.G.) to determine the completeness of the assessment tool. These two authors then determined by consensus whether to include or exclude each study. Finally, the same two authors used the tool to independently assess each of the included studies. Discrepancies were resolved by discussion until a consensus was reached; a third author (P.U.D.) provided a binding verdict if no consensus could be reached.

Data Extraction

Data were extracted from the included studies independently by two authors (M.I.B., J.H.B.G.). Data for the individual patients were extracted when available; otherwise, summary statistics were extracted. Since the reporting in many of the studies appeared to be incomplete, results are presented as the number of patients with a particular outcome divided by the number of patients for which that outcome was reported, expressed as the percentage and an associated 95% confidence interval.

Source of Funding

Funding for the study was provided by the Pain Rehabilitation Innovation Center. The funding source did not play a role in the study.

Results

Study Inclusion

One hundred and sixty candidate articles were identified by the literature search (after removal of duplicates). One hundred and thirty-eight of these articles were excluded: 110 were not related to the topic, nine involved causalgia, eight involved the onset of CRPS-I following amputation, seven were expert opinions or reviews regarding CRPS-I, three were comments by an editor or letters to an editor, and one was not in any of the specified languages. Five additional articles were identified by examining the reference lists of the candidate articles. Two articles very likely involved the same patient^{8,9}; the less informative of these articles was excluded⁹. Thus, twenty-six studies were available for analysis (Fig. 1).

The twenty-six included articles were published between 1948 and 2009 (see Appendix). Eleven articles reported on a group of patients who had CRPS-I (case series). Five articles reported on both patients with CRPS-I and patients without CRPS-I, but a subgroup could be identified as having undergone amputation due to CRPS-I. The remaining ten articles reported on a single patient. No case-control studies were identified, and the studies therefore all represented Level-IV evidence.

Patients

One hundred and seven patients were described. Thirty-eight patients were men and fifty-five were women; the sex was not reported for the remaining fourteen patients in three studies¹⁰⁻¹². The mean age at amputation, calculated on the basis of twenty-

one studies (fifty-four patients), was 40.3 years^{7,8,13-31}; a median age of forty-two years (range, twenty-three to seventy-three years) was reported in one additional study⁶. The mean time between CRPS-I onset and amputation, calculated on the basis of eighteen studies (forty-eight patients), was sixty-nine months^{7,8,13-20,22-25,27,28,30,31}; a median time of 30 months (range, five months to eighteen years) was reported in one additional study⁶. The age or the time between onset of the syndrome and amputation could not be derived from the reported information in the remaining studies. The duration of follow-up after amputation was reported in eight studies (twenty-two patients); the median duration was 16.5 months and the mean was twenty-eight months^{15,17-20,23,30,31}.

CRPS-I Diagnostic Criteria

Diagnostic criteria for CRPS-I proposed by the International Association for the Study of Pain (IASP)¹ were applied in one study (fourteen patients)¹⁵, criteria proposed by Bruehl et al.³² were applied in one study (two patients)²², and criteria proposed by Veldman et al.³³ were applied in two studies (thirty-six patients)^{6,13}. Thirteen studies (twenty-seven patients) reported symptoms without noting whether patients fulfilled formal criteria for CRPS-I prior to the amputation^{8,10,11,16-19,21,23,24,28,30,31}. The symptoms reported in these studies included many different sensory, autonomic, and motor changes (e.g., pain, skin temperature and color changes, swelling, hyperalgesia, allodynia, skin and muscle atrophy, and decreased range of motion). The remaining nine studies (twenty-eight patients) reported the diagnosis without indicating either the diagnostic criteria used or the symptoms^{7,12,14,20,25-27,29,34}. Radiographic findings were reported in nine studies^{7,8,11,16-18,21,29,30}. The first use of the term CRPS-I in the studies included in this review was in 1999 (see Appendix).

The inciting event was reported for ninety-three patients in twenty-four studies^{6-8,12-31,34}, and included immobilization,

TABLE I Level of Amputation in Patients with Complex Regional Pain Syndrome-I

Amputation Level	No. of Amputations*
Upper limb	37
Transhumeral	12
Elbow disarticulation	0
Transradial	10
Fingers or rays	2
Level not described	13
Lower limb	63
Transfemoral	16
Knee disarticulation	8
Transtibial	12
Syme or toes	2
Level not described	25
Not described	11
Total	111*

*Four patients underwent amputation of more than one limb.

soft-tissue injury, and fracture. An unknown cause of the CRPS-I was reported in four of the ninety-three patients^{7,15,27}. The inciting event was not discussed in the remaining two studies (fourteen patients).

Treatment Prior to Amputation

Limited information regarding treatment prior to the amputation was reported in the included studies, but treatments employed included physical therapy, medication, sympathetic nerve block, sympathectomy, neuromodulation, occupational therapy, and psychological interventions.

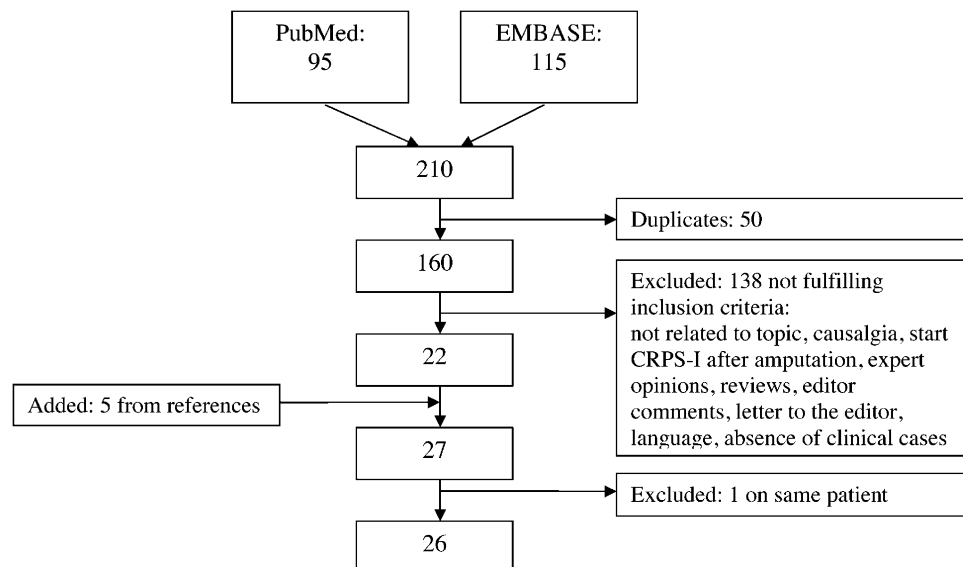


Fig. 1

Flowchart showing the identification of included studies involving amputation for the treatment of complex regional pain syndrome-I (CRPS-I).

TABLE II Summary of Reasons for Amputation and Outcome in Patients with an Amputation Due to Long-Standing, Therapy-Resistant Complex Regional Pain Syndrome-I*

	No. with the Outcome	Percentage (95% Confidence Interval)	References
Reason for amputation (n = 54)			
Pain	43	80 (67 to 88)	7,8,13-15,17-19,21,23,24,26-31
Dysfunctional limb	39	72 (59 to 82)	7,8,13-15,17,18,20,23,26-29,31
Gangrene, infection, or ulceration	25	46 (34 to 59)	7,13,15-18,20,22,23,26,27,29-31
Explicit wish of the patient	24	44 (32 to 58)	15,17,18,21-23,26,27,31
Outcome			
Recurrence of CRPS-I (n = 65)			
In stump	31	48 (36 to 60)	6-8,14,15,17-21,23,27,28,31
In one or more other extremities	3	5 (2 to 13)	23,28,31
Phantom pain (n = 37)	15	41 (26 to 57)	7,11,14,16-18,20,21,23,24,27,28,30,31,34
Prosthesis (n = 49)			
Upper limb			
			6,7,16-18,31,34
Fitted with prosthesis (n = 19)	13	68 (46 to 85)	
Use of prosthesis (n = 13)	3	23 (8 to 50)	
Lower limb			
			6,20,27,31,34
Fitted with prosthesis (n = 30)	23	77 (59 to 88)	
Use of prosthesis (n = 23)	11	48 (29 to 67)	
Functional ability			
No limitation in self care or activities of daily living (n = 11)	9	82 (52 to 95)	6,7,18,20,27,34
Paid employment (n = 43)	13	30 (19 to 45)	6,7,18,20,27,31,34

*n indicates the number of patients for which information regarding a parameter was available.

Amputations: Limb, Level, and Technique

A total of 111 amputations were reported. Four patients each had two limbs amputated; these amputations were performed at the same time or within a short time frame. Thirty-seven amputations were reported to involve the upper limb and sixty-three, the lower limb (Table I). The level of amputation was not reported in one study (eleven patients)¹⁰. The rationale for the level of amputation was reported in one study (eight patients)¹³, in which the location was described as proximal to the level of disturbance of skin sensation. The surgical technique and the duration of the surgery were not reported in any of the studies. Use of epidural pain medication was reported in one study (eight patients)¹³. Intraoperative complications were reported to be absent in five studies (thirty-three patients)^{6,16-18,20} and were not discussed in the remaining studies. Postoperative complications were discussed in nine studies (forty-four patients); wound infections, delayed healing, or pressure ulcers were noted in fourteen patients in two of the studies and complications were reported to be absent in the other seven studies; thus, the rate of postoperative complications was 32% (95% confidence interval [CI], 20% to 47%)^{6-8,16-20,22}.

Reasons for Amputation

The reasons for amputation were reported in twenty studies (fifty-four patients)^{7,8,13-24,26-31}. The predominant reasons for

amputation were pain, a dysfunctional limb, and gangrene, infection, or ulcers (Table II). Some studies reported that the amputation was explicitly requested by the patient. A combination of reasons for amputation was reported in most of the twenty studies, with two, three, or four reasons reported for forty-five of the patients (83%)^{7,8,13-15,17-21,23,26-31}.

Recurrence of CRPS-I and Occurrence of Phantom Pain

Data regarding CRPS-I recurrence were reported in fourteen studies (Table II), although the criteria used for the diagnosis of recurrence were not reported. Thirty-one of sixty-five patients had a reported recurrence in the stump. A more extensive amputation was performed because of recurrence in two patients^{21,23}. One of these patients also developed CRPS-I in the contralateral leg, which was also treated with amputation²³. Two additional patients developed CRPS-I in a different extremity following the initial amputation but did not require an amputation of the second extremity^{28,31}. Phantom pain was reported in fifteen patients in fifteen studies (Table II)^{7,11,14,16-18,20,21,23,24,27,28,30,31,34}.

Prostheses, Patient Satisfaction, and Changes in Quality of Life

The fitting of a prosthesis was reported in nine studies (forty-nine patients)^{6,7,16-18,20,27,31,34}. Thirty-six patients (73%) were fitted with a prosthesis, and fourteen (39%) of the thirty-six

used the prosthesis (Table II). The latter includes one patient who was reported to have been “successfully fitted,”¹⁶ which we interpreted to indicate use of the prosthesis after the fitting. Some information regarding the patient’s functional ability was reported in seven studies (fifty-two patients)^{6,7,18,20,27,31,34} (Table II). Patient “satisfaction” was reported in eight studies (fifty-one patients)^{6,7,18,23,27,30,31,34}, but it was often not clear whether this “satisfaction” was related to functional ability, pain reduction, or prevention of infection. Changes in quality of life were reported in three studies (fifteen patients)^{27,31,34}. Quality of life improved in all three of the patients described by De Boer et al.²⁷ and in both of the patients described by Lundborg et al.³¹. “Joy of life” was reported to improve in six of the ten patients in the remaining study³⁴.

Discussion

The literature review revealed twenty-six studies describing 107 patients who underwent amputation for the treatment of long-standing, therapy-resistant CRPS-I. However, only one study in 2008 and one in 2009^{15,22} used the diagnostic criteria for CRPS-I proposed by the IASP¹ or the criteria proposed by Bruehl et al.³². This is remarkable since the IASP criteria were published in 1994 and the more stringent criteria of Bruehl et al. were published in 1999. Consequently, we cannot be certain that all of the patients described actually had CRPS-I. The limited use of these internationally accepted criteria has been noted previously, in 2002³⁵. Diagnostic criteria for reflex sympathetic dystrophy defined by the American Association for Hand Surgery in 1990³⁶ were referred to in some of the other studies, but it was never specifically stated that the patients fulfilled these criteria^{7,17}. The studies generally also made limited mention of the reasons for amputation, rationale for the level of amputation, amputation technique, complications during or after surgery (including recurrence of CRPS-I), phantom pain, prosthesis use, patient satisfaction, or changes in quality of life.

Recurrence of CRPS-I in the stump following the amputation was reported in 48% of the patients. However, this result was strongly influenced by the outcomes reported in the study by Dielissen et al. in 1995, in which all of the patients were diagnosed with recurrence of CRPS-I⁶. The 100% recurrence rate in that study might be related to the application of the criteria proposed by Veldman et al. These criteria permit a diagnosis of CRPS-I even in the absence of pain, which is a curious state of affairs since CRPS-I is a pain syndrome. Alternatively, the high recurrence rate in the study by Dielissen et al. may have stemmed from the specific center at which the study was conducted. We performed a post hoc analysis to assess the impact of the data from Dielissen et al. by reanalyzing the CRPS-I recurrence rate after excluding the twenty-eight patients in that study. Only three (8%) of the other thirty-seven patients had a recurrence of CRPS-I in the stump. Thus, the study by Dielissen et al. had a major impact on the estimated recurrence rate. Patients with long-standing, therapy-resistant CRPS-I who are considering amputation should be informed of the variation in published recurrence rates and the consequent

difficulty in predicting whether recurrence of the CRPS-I will occur.

The overall prevalence of phantom pain was 41% in the studies that included information on this outcome; the reported prevalence in other published studies has ranged from 9% to 85%³⁷⁻⁴⁰. However, since the frequency of occurrence of phantom pain and the extent of the resulting impairment were not often described in the studies included in the current review, patients with long-standing, therapy-resistant CRPS-I cannot be adequately advised regarding this outcome.

The most commonly reported reasons for amputation were pain and a dysfunctional limb. Gangrene, infection, and ulceration were cited less commonly. Although pain was cited as one of the reasons for amputation in 80% of the patients, none of the studies reported patient satisfaction related to the level of pain following the amputation.

A set of recommendations regarding the amputation procedure used for the treatment of long-standing CRPS-I was published in 1995⁶. One of these recommendations was to amputate proximal to the level of signs and symptoms of CRPS-I in order to reduce the recurrence rate. However, no case studies have been published since 1995 to evaluate the effects of this recommendation.

Only 39% of the patients fitted with a prosthesis actually used it (23% of upper-limb amputees and 48% of lower-limb amputees). A previous report involving amputations for all causes noted a rate of 56% in upper-limb amputees compared with 84% in lower-limb amputees⁴¹. Prosthesis use in our review of patients with an amputation for the treatment of CRPS-I was very low. The included studies did not clearly state the reasons that the prosthesis was not worn, although the residual pain that was commonly reported in the studies may have been one of the reasons.

Reports of patient satisfaction and changes in quality of life were so fragmentary that conclusions could not be drawn. Almost one-third of the patients had paid employment after the amputation.

The ratio of men to women who underwent an amputation for the treatment of long-standing, therapy-resistant CRPS-I was 1:1.4. In contrast, the ratio of men to women with CRPS-I has previously been reported to be approximately 1:3⁴², and the ratio of men to women with long-standing CRPS-I (minimum duration, two years; mean duration, 5.8 years) has been reported to be 1:4⁴. Thus, men with long-standing CRPS-I appear to undergo amputation at a higher rate than women. This difference could be due to publication bias, if reports regarding men who undergo amputation are more likely to be written and published than reports regarding women. Alternatively, men may choose amputation more often than women do. We do not have evidence regarding these possibilities.

The ratio of upper limbs to lower limbs amputated for the treatment of long-standing CRPS-I was 1:1.7. In comparison, the ratio reported in other studies has ranged from 1:1.5 in a study of the general incidence of CRPS-I⁴² to 1:4 in a group of patients with long-standing CRPS-I with a “poor outcome.”⁴⁴ A ratio of approximately 1:1.6 (similar to the ratio in our

review) was found in a group of patients treated for CRPS-I with physical therapy involving exposure to pain⁴³.


A limitation of case series and case reports, such as those summarized in the current review, is that no controls are present. Consequently, these studies cannot provide strong evidence in favor of or against an intervention. When an outcome occurs in many or all cases, this may reflect a consequence of the intervention. However, a favorable outcome described in a case series or case study may also represent the self-limiting nature of the disease, a placebo effect, regression to the mean, or coincidence. The noted changes in quality of life and functional ability following amputation for the treatment of long-standing, therapy-resistant CRPS-I, for instance, may have resulted from the placebo effect, regression to the mean, or coincidence rather than from the amputation. Thus, conclusions regarding the effects of an amputation cannot be drawn with any certainty from the results of the current review.

Despite these caveats, an amputation can be justified in some cases of long-standing, therapy-resistant CRPS-I⁷. In particular, there is little doubt that an amputation is a valid choice for the treatment of therapy-resistant infection after all other CRPS-I treatments have been tried. However, other treatment options should be explored before an amputation is performed for the treatment of severe pain or a dysfunctional limb. For instance, physical therapy involving exposure to pain was recently shown to result in some improvement in function in ninety-five of 106 patients with long-standing CRPS-I. However, improvement was defined in that study as “any improvement in walking distance or speed” if the lower limb was affected or as “any improvement assessed by means of the Radboud skills test” if the upper limb was affected. Only 46% of patients would have been considered to have improved if more stringent criteria for functional improvement had been applied. Although the treatment was not specifically aimed at decreasing pain, the average pain score assessed on a visual analog scale decreased from 4.9 to 2.7⁴³.

Recently published evidence-based guidelines^{3,5} are based primarily on the findings of Stam and van der Rijst⁷ and

Dielissen et al.⁶. The current systematic review also includes data from a number of case reports as well as some larger series. We did not find reason to alter the guidelines regarding amputation for the treatment of long-standing CRPS-I. Evidence regarding the rate of CRPS-I recurrence following amputation remains controversial. Changes in the quality of life following amputation remain poorly reported. The proper level of amputation remains a topic for debate. Further research regarding the level of amputation, recurrence of CRPS-I, patient satisfaction, and changes in quality of life is necessary in order to allow physicians to advise patients considering amputation for the treatment of long-standing, therapy-resistant CRPS-I on the basis of the best evidence. At present, whether to amputate or not in order to treat long-standing, therapy-resistant CRPS-I remains an unanswered question because of weak research design and poor reporting regarding the beneficial and adverse effects of an amputation in this patient population.

Appendix

 Tables summarizing previously published diagnostic criteria for CRPS-I and the articles included in the current study are available with the online version of this article as a data supplement at jbjs.org. ■

Marlies I. Bodde, MD
Pieter U. Dijkstra, PhD
Wilfred F.A. den Dunnen, MD, PhD
Jan H.B. Geertzen, MD, PhD
Center for Rehabilitation, Department of Rehabilitation Medicine (M.I.B., P.U.D., and J.H.B.G.), and Department of Pathology and Medical Biology (W.F.A.d.D, University Medical Center Groningen, P.O. Box 30.001, 9700 RB Groningen, The Netherlands.
E-mail address for M.I. Bodde: m.i.bodde@rev.umcg.nl.
E-mail address for P.U. Dijkstra: p.u.dijkstra@rev.umcg.nl.
E-mail address for W.F.A. den Dunnen: w.f.a.den.dunnen@path.umcg.nl.
E-mail address for J.H.B. Geertzen: j.h.b.geertzen@rev.umcg.nl

References

- Merskey H, Bogduk N. Classification of chronic pain: descriptions of chronic pain syndromes and definitions of pain terms. 2nd ed. Seattle: IASP Press; 1994. p 40-3.
- Maihöfner C, Seifert F, Markovic K. Complex regional pain syndromes: new pathophysiological concepts and therapies. *Eur J Neurol*. 2010;17:649-60.
- Perez RS, Zollinger PE, Dijkstra PU, Thomassen-Hilgersom IL, Zuurmond WW, Rosenbrand KC, Geertzen JH; CRPS I task force. Evidence based guidelines for complex regional pain syndrome type 1. *BMC Neurol*. 2010;10:20.
- de Mos M, Huygen FJ, van der Hoeven-Borgman M, Dieleman JP, Ch Stricker BH, Sturkenboom MC. Outcome of the complex regional pain syndrome. *Clin J Pain*. 2009;25:590-7.
- Perez RS, Zollinger PE, Dijkstra PU, Thomassen-Hilgersom IL, Zuurmond WW, Rosenbrand CJ, et al. [Clinical practice guideline ‘Complex regional pain syndrome type I’]. *Ned Tijdschr Geneesk*. 2007;151:1674-9. Dutch.
- Dielissen PW, Claassen AT, Veldman PH, Goris RJ. Amputation for reflex sympathetic dystrophy. *J Bone Joint Surg Br*. 1995;77:270-3.
- Stam HJ, Rijst van der H. The results of amputation in reflex sympathetic dystrophy of the upper extremity—an analysis of 7 cases. *Eur J Phys Med Rehabil*. 1994;4:134-6.
- Eyres KS, Talbot IC, Harding ML. Amputation for reflex sympathetic dystrophy. *Br J Clin Pract*. 1990;44:654-6.
- Learmonth DJA, Eyres KS, Harding ML. Reflex sympathetic dystrophy of the knee: the need for early diagnosis. *J Orthop Rheumatol*. 1992;5:63-7.
- Hooshmand H, Hashmi M. Complex regional pain syndrome (reflex sympathetic dystrophy syndrome): diagnosis and therapy—a review of 824 patients. *Pain Dig*. 1999;9:1-24.
- Poplawski ZJ, Wiley AM, Murray JF. Post-traumatic dystrophy of the extremities. *J Bone Joint Surg Am*. 1983;65:642-55.
- Busfield BT, Huffman GR, Nahai F, Hoffman W, Ries MD. Extended medial gastrocnemius rotational flap for treatment of chronic knee extensor mechanism deficiency in patients with and without total knee arthroplasty. *Clin Orthop Relat Res*. 2004;428:190-7.
- van der Laan L, ter Laak HJ, Gabreëls-Festen A, Gabreëls F, Goris RJ. Complex regional pain syndrome type I (RSD): pathology of skeletal muscle and peripheral nerve. *Neurology*. 1998;51:20-5.
- Albrecht PJ, Hines S, Eisenberg E, Pud D, Finlay DR, Connolly MK, Paré M, Davar G, Rice FL. Pathologic alterations of cutaneous innervation and vasculature in affected limbs from patients with complex regional pain syndrome. *Pain*. 2006;120:244-66.
- Hulsman NM, Geertzen JH, Dijkstra PU, van den Dungen JJ, den Dunnen WF. Myopathy in CRPS-I: disuse or neurogenic? *Eur J Pain*. 2009;13:731-6.

- 16.** Erdmann MW, Wynn-Jones CH. 'Familial' reflex sympathetic dystrophy syndrome and amputation. *Injury*. 1992;23:136-8.
- 17.** Geertzen JH, Eisma WH. Amputation and reflex sympathetic dystrophy. *Prosthet Orthot Int*. 1994;18:109-11.
- 18.** Geertzen JH, Rietman JS, Smit AJ, Zimmerman KW. A young female patient with reflex sympathetic dystrophy of the upper limb in whom amputation became inevitable. *Prosthet Orthot Int*. 1997;21:159-61.
- 19.** Rohrich RJ, Stevenson TR, Piepgrass W. End-stage reflex sympathetic dystrophy. *Plast Reconstr Surg*. 1987;79:625-6.
- 20.** Emmelot CH, Spauwen PH, Hol W, Overbeek B. Trans-tibial amputation for reflex sympathetic dystrophy: postoperative management. *Prosthet Orthot Int*. 2000;24:79-82.
- 21.** Chiowanich P, Vogelzang RL, Nemcek AA Jr, Rogers LF. Case report 758. Reflex sympathetic dystrophy syndrome (RSDS). *Skeletal Radiol*. 1993;22:124-6.
- 22.** Groeneweg JG, Antonissen CH, Huygen FJ, Zijlstra FJ. Expression of endothelial nitric oxide synthase and endothelin-1 in skin tissue from amputated limbs of patients with complex regional pain syndrome. *Mediators Inflamm*. 2008;2008:680981.
- 23.** Lausten-Thomsen U, Laursen JO. [Long-term reflex dystrophy leading to bilateral knee exarticulation]. *Ugeskr Laeg*. 2005;167:4574-5. Danish.
- 24.** Churcher MD. Algodystrophy after aortic bifurcation surgery. *Lancet*. 1984;2:131-3.
- 25.** Kler S. Remarks on the prognosis of the posttraumatic dystrophy of the extremities. *Acta Orthop Scand*. 1948;17:253-69.
- 26.** Dudzinski DM. "Amputate my arm please—I don't want it anymore". *J Clin Ethics*. 2005;16:196-201.
- 27.** De Boer KS, Schmitz RF, Van Lujt PA, Arendzen JH. Case report: functional status after transfemoral amputation in three patients with complex regional pain syndrome. *JPO*. 2007;19:91-3.
- 28.** Ritt MJPF, Jansen WBJ. Armamputatie na posttraumatische dystrofie. *Med J Delft*. 1992;4:220-3. Dutch.
- 29.** Lagier R, Van Linthoudt D. Articular changes due to disuse in Sudeck's atrophy. *Int Orthop*. 1979;3:1-8.
- 30.** Enggaard TP, Scherer C, Nikolajsen L, Andersen C. [Long term effect of spinal cord stimulation in a patient with complex regional pain syndrome and phantom pain syndrome type 1 after amputation]. *Ugeskr Laeger*. 2008;170:460. Danish.
- 31.** Lundborg C, Dahm P, Nitescu P, Appelgren L, Curelaru I. Clinical experience using intrathecal (IT) bupivacaine infusion in three patients with complex regional pain syndrome type I (CRPS-I). *Acta Anaesthesiol Scand*. 1999;43:667-78.
- 32.** Bruehl S, Harden RN, Galer BS, Saltz S, Bertram M, Backonja M, Gayles R, Rudin N, Bhugra MK, Stanton-Hicks M. External validation of IASP diagnostic criteria for Complex Regional Pain Syndrome and proposed research diagnostic criteria. International Association for the Study of Pain. *Pain*. 1999;81:147-54.
- 33.** Veldman PH, Reynen HM, Arntz IE, Goris RJ. Signs and symptoms of reflex sympathetic dystrophy: prospective study of 829 patients. *Lancet*. 1993;342:1012-6.
- 34.** Szeinberg-Arazi D, Heim M, Nadvorna H, Ner IZ, Szeinberg A, Azaria M. A functional and psychosocial assessment of patients with post-Sudeck atrophy amputation. *Arch Phys Med Rehabil*. 1993;74:416-8.
- 35.** Reinders MF, Geertzen JH, Dijkstra PU. Complex regional pain syndrome type I: use of the International Association for the Study of Pain diagnostic criteria defined in 1994. *Clin J Pain*. 2002;18:207-15.
- 36.** Amadio PC, Mackinnon SE, Merritt WH, Brody GS, Terzis JK. Reflex sympathetic dystrophy syndrome: consensus report of an ad hoc committee of the American Association for Hand Surgery on the definition of reflex sympathetic dystrophy syndrome. *Plast Reconstr Surg*. 1991;87:371-5.
- 37.** Borsje S, Bosmans JC, van der Schans CP, Geertzen JH, Dijkstra PU. Phantom pain: a sensitivity analysis. *Disabil Rehabil*. 2004;26:905-10.
- 38.** Desmond DM, MacLachlan M. Prevalence and characteristics of phantom limb pain and residual limb pain in the long term after upper limb amputation. *Int J Rehabil Res*. 2010;33:279-82.
- 39.** Ehde DM, Czerniecki JM, Smith DG, Campbell KM, Edwards WT, Jensen MP, Robinson LR. Chronic phantom sensations, phantom pain, residual limb pain, and other regional pain after lower limb amputation. *Arch Phys Med Rehabil*. 2000;81:1039-44.
- 40.** Sherman RA, Sherman CJ. Prevalence and characteristics of chronic phantom limb pain among American veterans. Results of a trial survey. *Am J Phys Med*. 1983;62:227-38.
- 41.** Raichle KA, Hanley MA, Molton I, Kadel NJ, Campbell K, Phelps E, Ehde D, Smith DG. Prosthesis use in persons with lower- and upper-limb amputation. *J Rehabil Res Dev*. 2008;45:961-72.
- 42.** de Mos M, de Bruijn AG, Huygen FJ, Dieleman JP, Stricker BH, Sturkenboom MC. The incidence of complex regional pain syndrome: a population-based study. *Pain*. 2007;129:12-20.
- 43.** Ek JW, van Gijn JC, Samwel H, van Egmond J, Klomp FP, van Dongen RT. Pain exposure physical therapy may be a safe and effective treatment for longstanding complex regional pain syndrome type 1: a case series. *Clin Rehabil*. 2009;23:1059-66.