

# CT-guided stellate ganglion blockade vs. radiofrequency neurolysis in the management of refractory type I complex regional pain syndrome of the upper limb

Adrian Kastler · Sébastien Aubry · Nicolas Saille ·  
Demosthene Michalakis · Gaye Siliman ·  
Guillaume Gory · Jean-Louis Lajoie · Bruno Kastler

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## Abstract

**Objective** To describe and evaluate the feasibility and efficacy of CT-guided radiofrequency neurolysis (RFN) vs. local blockade of the stellate ganglion in the management of chronic refractory type I complex regional pain syndrome (CRPS) of the upper limb.

**Methods** Sixty-seven patients were included in this retrospective study between 2000 and 2011. All suffered from chronic upper limb type I CRPS refractory to conventional pain therapies. Thirty-three patients underwent stellate

ganglion blockade and 34 benefited from radiofrequency neurolysis of the stellate ganglion. CT guidance was used in both groups. The procedure was considered effective when pain relief was  $\geq 50\%$ , lasting for at least 2 years.

**Results** Thirty-nine women (58.2 %) and 28 men (41.8 %) with a mean age of 49.5 years were included in the study. Univariate analysis performed on the blockade and RFN groups showed a significantly ( $P < 0.0001$ ) higher success rate in the RFN group (67.6 %, 23/34) compared with the blockade group (21.2 %, 7/33) with an odds ratio of 7.76.

**Conclusion** CT-guided radiofrequency neurolysis of the stellate ganglion is a safe and successful treatment of chronic refractory type I CRPS of the upper limb. It appears to be more effective than stellate ganglion blockade.

## Key Points

- Complex regional pain syndrome is painful, disabling and often refractory to treatment.
- Sixty-seven percent of patients had lasting pain relief (2 years) after radiofrequency neurolysis.
- Retrospective study showed a significantly higher success rate for radiofrequency neurolysis.
- CT guidance is mandatory for a successful and safe procedure.

**Keywords** CT guidance · Stellate ganglion · Neurolysis · Radiofrequency · Infiltration

## Introduction

Complex regional pain syndrome (CRPS) is a chronic impairment characterised by severe pain associated with sensory, autonomic and motor symptoms [1]. The natural course and pathophysiology of CRPS remains elusive and

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A. Kastler  
Radiology Department,  
University Hospital CHU Gabriel Montpied,  
63000 Clermont-Ferrand, France

S. Aubry · N. Saille · D. Michalakis · B. Kastler  
Radiology and Interventional Pain Unit,  
University Hospital CHU Jean Minjoz,  
Besancon, France

A. Kastler · S. Aubry · G. Gory · B. Kastler  
I4S Laboratory-EA 4268-IFR 133, Franche Comté University,  
Besancon, France

G. Siliman  
Clinical Investigation Center,  
University Hospital CHU St Jacques,  
Besancon, France

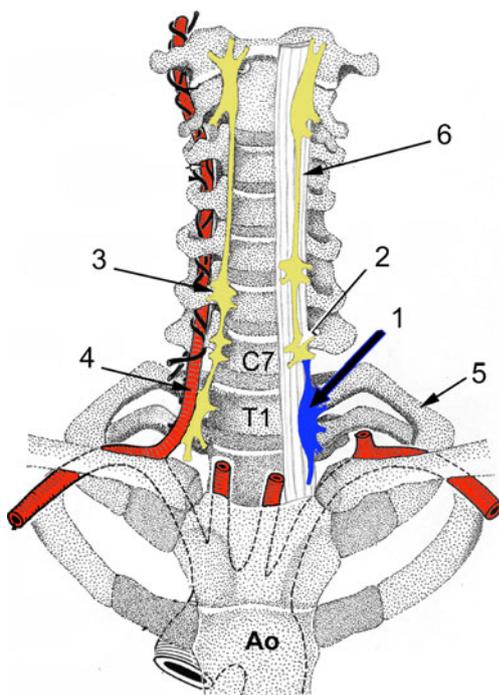
J.-L. Lajoie  
Pain evaluation and Management Unit,  
University Hospital CHU Jean Minjoz,  
Besancon, France

A. Kastler (✉)  
Hôpital Gabriel Montpied, CHU Clermont-Ferrand,  
58 Rue Montalembert,  
63000 Clermont-Ferrand, France  
e-mail: adriankastler@gmail.com

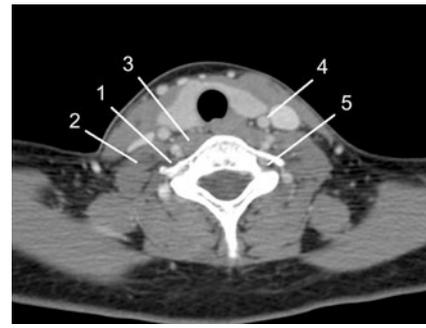
existing pharmacological pain management options are controversial and inefficient [2]. Stellate ganglion blockade is a widely performed and effective procedure in CRPS management [3]; however, little information on long-term results is available and overall results show poor long-term outcome [3–5]. Radiofrequency neurolysis has become a common procedure in the management of chronic neuropathic pain [6, 7]. The purpose of this study was therefore to compare stellate ganglion blockade and radiofrequency neurolysis under CT guidance in the management of type I CRPS of the upper limb.

### Anatomical background

Knowledge of the anatomical surroundings of the stellate ganglion is a necessary condition for a safe and successful procedure (Figs. 1 and 2). The stellate ganglion is formed by the fusion of both inferior cervical and first thoracic sympathetic ganglia in 80 % of cases [8]. It appears as a rather large, oval-shaped structure (2.5×1×0.5 cm) alongside the spinal axis. Although anatomical variations are possible, it lies posteriorly to the vertebral artery [9], anteriorly to the neck of the first rib (cranial component) and the transverse process of C7 vertebra (major caudal component), medially to the scalene muscle and laterally to the longus colli muscle. It is situated 0.5 cm anterior to the bony structures



**Fig. 1** Anatomical figure showing the stellate ganglion. 1 Left stellate ganglion; 2 intermediate cervical ganglion; 3 superior cervical ganglion; 4 right vertebral artery; 5 left first rib; 6 left longus colli muscle



**Fig. 2** Planning enhanced CT slice at C7 level. 1 Right stellate ganglion; 2 right scalene muscle; 3 right longus colli muscle; 4 left carotid artery; 5 left vertebral artery

separated by both soft tissue and the longus colli muscle. The caudal component lies in close proximity to the apical pleura.

### Materials and methods

A total of 67 patients were included in this retrospective study between 2000 and 2011. All patients presented with chronic refractory upper limb CRPS type I as established by the International Association for the Study of Pain [10] and a positive stellate ganglion blockade in order to confirm diagnosis. Exclusion criteria were as follows: patients in whom a CRPS type I diagnosis was not clear, patients with a negative stellate ganglion blockade, and patients presenting with CRPS type II (causalgia) or upper limb neuralgia. The decision to perform either blockade or RFN was made by the operator and was based on multiple factors including: the patient's desire to undergo either treatment after clear information on the procedures' pitfalls, possible complications and outcome. The pre-procedure planning CT was also taken into account in case of technical difficulty performing RFN. Thirty-four of the 67 patients benefited from an RFN. Therefore, the cohort was divided into two groups: the blockade group and the RFN group. In both groups, patients presented CRPS type I pain refractory to all attempted previous management.

Clinical outcome in both groups was assessed and compared. Local Institutional Review Board approval was obtained and written informed consent was waived. Medical records of patients were reviewed by one of the authors and the following data were collected and evaluated: demographic data (age, sex), clinical history (date of procedure, previous pain therapies) and information on pain (detailed below). In case of missing data, patients were contacted by phone by one of the authors.

## Pain

Pain was assessed using Visual Analogue Scale scores (0–10) by the authors immediately before and after the procedure and noted in patients' medical records. Regular follow-up examinations (up to 2 years after procedure) were scheduled with interventional radiology and pain physicians: pain was assessed using the same VAS scores. The procedure was considered to be effective (main efficacy criteria) when pain relief was  $\geq 50\%$ , lasting for at least 2 years; this was defined as clinical success. Mean duration of pain before the procedure was noted. It was defined as chronic when lasting for at least 6 months. A score of less than 2 was graded as mild pain, a score between 2 and 5 was graded as moderate pain, and a score above 5 was graded as severe [11]. The topography and aetiology of pain as well as the presence of accidents at work were also noted.

## Procedures

All procedures (RFN and blockades) were carried out under local anaesthesia on an outpatient basis under CT guidance and in aseptic conditions (Siemens Somatom Sensation CT 64-channel system, Erlangen, Germany). Patients were placed in supine position with their head looking opposite to the puncture site. An initial axial 2.5-mm-thick planning CT from vertebrae C6 to T2 was carried out with contrast media to localise the stellate ganglion and display possible intervening vascular structures [12] (vertebral artery) (Fig. 2). The safest possible pathway (lateral or preferably trans-scalenic anterior lateral) was then chosen in order to avoid inadvertent vascular structure puncture and the corresponding skin entry point was marked. A safe step-by-step progression of the needle was then carried out under CT guidance until the needle tip artefact was accurately placed at one of two defined targets: either between the vertebral artery and the C7 process or the neck of the first rib facing the T1 vertebral body.

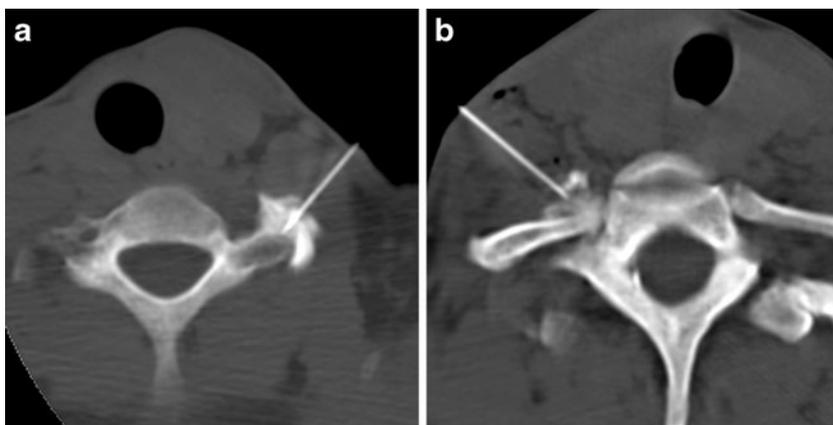
In the case of blockade of the stellate ganglion, 66-mm- or 88-mm-long 22G needles were used and accurate needle tip placement at either the C7 or T1 process level was confirmed by injection of diluted contrast media (Fig. 3). A mixture of fast- and slow-acting anaesthetic [2 ml of lidocaine hydrochloride (1 %) and 3 ml of ropivacaine hydrochloride (0.25 %)] were then injected. Average duration of the blockade procedure was 15.1 min. Technical success was defined as the ability to insert the needle and inject the anaesthetic mixture at the pre-planned target site.

In the case of RFN, two needles were inserted at both the C7 and the T1 sites when technically possible (Fig. 4), following the same step-by-step placement until the needle tip was correctly located at the defined target sites. Injection of the diluted contrast material at both the C7 and the T1 sites was then done in order to confirm both accurate needle tip placement and the absence of inadvertent arterial puncture. The radiofrequency needles used were 55-mm- or 105-mm-long 22G needles, and two different types of generators could be used randomly: Radionics Cosman or Neurotherm Generator. Stimulation mode was then used at both 50 mHz and 2 Hz in order to determine sensory perception thresholds (in volts) and to confirm the absence possible surrounding motor nerve in close proximity to the needle tip. Neurolysis was then started and three 60-s RFN cycles were performed at each level in lesion mode at 70, 80 and 90 °C depending on the patients' tolerance. Needle placement could be modified between each cycle (1 mm) if necessary. Average duration of the RFN procedure was 34.5 min. Technical success was defined as the ability to satisfactorily position the RF needle and undergo three RF cycles at at least one of two target sites.

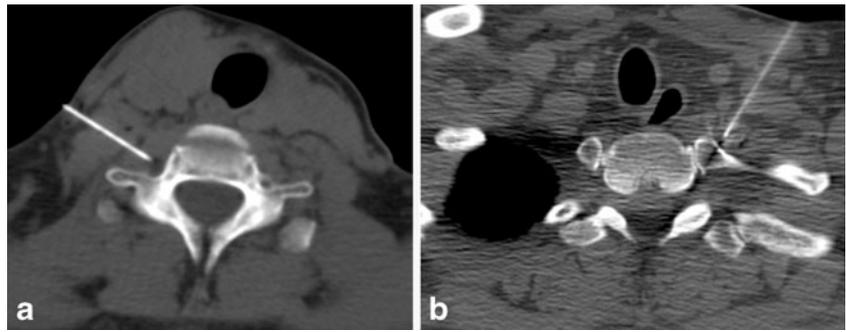
## Statistical methods

Descriptive statistics (frequencies, averages, standard deviations and extreme values) were used for population description. A global *P* value of less than 0.05 was considered to indicate a statistically significant difference. Univariate and

**Fig. 3** Accurate contrast media diffusion at C7 (a) and T1 (b) site prior blockade



**Fig. 4** Accurate radiofrequency neurolysis (RFN) needle placement at C7 (a) and T1 (b) target sites



Multivariate analyses were performed and statistical comparisons between groups used were as follows: chi-squared test for categorical variables, Student’s *t*-test for Gaussian quantitative variables and the non-parametric Wilcoxon test for semi-quantitative or quantitative non-Gaussian variables. Analyses were performed using SAS v9.3 (SAS Institute Inc.; Cary, NC, USA).

**Results**

**Patients**

A total of 67 patients were included in this study, 39 women (58.2 %) and 28 men (41.8 %). Thirty-four patients benefited from a stellate ganglion radiofrequency neurolysis and 33 from a stellate ganglion blockade. Overall mean age was 49.5 years old (range 25 to 81 years) with no significant difference between the two groups. Aetiologies and topographies of pain are detailed in Table 1.

**Pain**

Mean VAS score in both groups was 7.4±0.98 and was therefore graded as severe. No statistical difference was

found between the blockade group (7.3/10) and the RFN group (7.5/10).

Univariate analysis performed on the blockade and RFN groups showed a significantly (*P*<0.0001) higher success rate in the RFN group (67.6 %, 23/34) than in the blockade group (21.2 %, 7/33), with an OR of 7.76. A statistically significant difference in the mean duration of pain before the procedure was found (33.8 months in the blockade group vs. 16.3 in the RFN Group, *P*<0.0113). On the other hand, no differences were found between the two groups when comparing age, sex, side of pain and relation to accident at work. These results are detailed in Table 2.

No statistical difference was found when comparing efficacy and pre-procedure pain duration or VAS before the procedure. Moreover, no link was found between efficacy and sex, aetiology or presence of an accident at work. These results are detailed in Table 3.

Multivariate analysis performed on the variables procedure type, pre-procedure pain duration and aetiology (traumatic vs. non traumatic) showed statistical significance between the criteria efficacy and procedure type (*P*=0.0015). Pre-procedure duration and aetiology of pain were not statistically significant (*P*>0.05).

Technical success rates in the blockade and RFN group were respectively 100 % and 92 % (34/37) and did not differ

**Table 1** Distribution of aetiology and topography of pain in both groups

Topography	Blockade group	RFN group	Total
Wrist	33.3 % (11/33)	26.5 % (9/34)	29.8 % (20/67)
Shoulder	24.2 % (8/33)	26.5 % (9/34)	25.4 % (17/67)
Hand and shoulder	18.1 % (6/33)	26.5 % (9/34)	22.4 % (15/67)
Hand	6 % (2/33)	20.6 % (7/34)	13.4 % (9/67)
Arm	18.1 % (6/33)	0 %	8.9 % (6/67)
<b>Aetiologies</b>			
Post-traumatic	42.4 % (14/33)	24/34 (70.6 %)	56.7 % (38/67)
Post-surgical	48.5 % (16/33)	8/34 (23.5 %)	35.8 % (24/67)
Post-ganglion curettage	6 % (2/33)	0	3 % (2/67)
Post-hemiplegia	0 %	2/34 (5.9 %)	3 % (2/67)
Post-zoster	3 % (1/33)	0	1.5 % (1/67)

**Table 2** Univariate analysis in both the blockade and the radiofrequency neurolysis groups

Variables		Total (n=67)	Stellate ganglion blockade (n=33)	Radiofrequency neurolysis (n=34)	P value
Pre-procedure pain duration	Mean±SD	24.93±28.12	33.78±33.78	16.33±17.89	Student's <i>t</i> test 0.0113
Pre-procedure VAS score	Mean±SD	7.40±0.98	7.30±0.98	7.50±0.99	0.4176
Sex	Female	39 (58.21 %)	20 (60.61 %)	19 (55.88 %)	Chi-squared test 0.6951
	Male	28 (41.79 %)	13 (39.39 %)	15 (44.12 %)	
Side	Right	33 (49.25 %)	17 (51.52 %)	16 (47.06 %)	0.7153
	Left	34 (50.75 %)	16 (48.48 %)	18 (52.94 %)	
Accident at work	Yes	31 (46.27 %)	15 (45.45 %)	16 (47.06 %)	0.8952
	No	36 (53.73 %)	18 (54.55 %)	18 (52.94 %)	
Efficacy	Yes	30 (44.78 %)	7 (21.21 %)	23 (67.65 %)	0.0001 OR=7.76
	No	37 (55.22 %)	26 (78.79 %)	11 (32.35 %)	

statically. In the RFN group, three patients were not included in the study owing to technical failure of RFN due to impossible safe needle positioning; in these cases, RFN was not performed. Moreover, out of the 34 RFN procedures performed, we report 4 single-site (C7 or T1) RFN procedures. In these cases, RFN at the C7 level could not be performed owing to technical access difficulties: the proximity of motor nerve structures in three cases and difficult accurate C7 needle placement visualised on planning CT slices in one case. Three out of these four performed procedures were a clinical failure.

In the blockade group the mean duration of pain relief in case of failure was 40.5 days. No complications were noted in the blockade group.

In the RFN group, the complication rate was very low (1.7 %) and only two minor complications occurred: one case of transient Horner's syndrome (3 weeks) and one case of pre-vertebral haematoma.

## Discussion

This study shows significant longer lasting pain reduction with stellate ganglion RFN than stellate ganglion blockade. Indeed, >50 % pain reduction lasting for at least 2 years was obtained in 67.6 % of treated patients in the RFN group as opposed to 21.2 % in the blockade group with an OR of 7.76. Even though the mean delay of pain before the procedure was significantly lower in the RFN group than in the blockade group, univariate analysis did not show a significant link between efficacy and pre-procedure pain duration. Moreover, multivariate analysis confirmed the statistical link between procedure type and efficacy in favour of RFN, and no link was found between efficacy and pre-procedure pain duration or aetiology. However, previous studies [13, 14] have shown better pain relief in patients who benefited from early treatment after onset of symptoms.

**Table 3** Detailed univariate analysis results regarding the criteria efficacy

Variables		Total (n=67)	Efficacy: No (n=37)	Efficacy: Yes (n=30)	P value
Pre-procedure pain duration (months)	Mean±SD	24.93±28.12	30.65±31.47	17.87±21.86	Student's <i>t</i> test 0.0548
Pre-procedure VAS	Mean±SD	7.40±0.98	7.37±0.98	7.43±1.00	0.8225
Sex	Female	39 (58.21 %)	20 (54.05 %)	19 (63.33 %)	Chi 2 test 0.4438
	Male	28 (41.79 %)	17 (45.95 %)	11 (36.67 %)	
Side	Right	33 (49.25 %)	21 (56.76 %)	12 (40.00 %)	0.1725
	Left	34 (50.75 %)	16 (43.24 %)	18 (60.00 %)	
Accident at work	Yes	31 (46.27 %)	19 (51.35 %)	12 (40.00 %)	0.3541
	No	36 (53.73 %)	18 (48.65 %)	18 (60.00 %)	

In the RFN group, these excellent long-term results were obtained after a single procedure with a minor complication rate of 1.7 % (one case of transient Horner's syndrome and one case of pre-vertebral haematoma). This very low complication rate was obtained because close attention to safety precautions was given in each patient. First, in order to avoid inadvertent vascular puncture, the following precautions are mandatory: a planning CT must be performed with contrast media and accurate CT control slices with the theoretical needle pathway should be displayed during the procedure; extended (10 s) syringe aspiration should be performed prior to either the RFN or the blockade. Second, the use of stimulation mode before the RFN is crucial in order to detect a possible surrounding motor nerve needle tip contact.

We report 11 clinical failures as defined by the main efficacy criteria in the RFN group. Out of these 11 patients, 3 (27.2 %) underwent a single-site stellate ganglion RFN.

In the stellate ganglion blockade group, the average pain relief duration found in case of failure of the procedure was 40.5 days. These results are not negligible in these patients refractory to conventional therapies and are allowed by a simple and safe procedure as no complications were noted in this group. The same precautions as described above should be used. Although local anaesthetic blockade is a widely accepted technique in the management and diagnosis of upper limb CRPS [4, 14, 15], both the physiopathology of sympathetically mediated pain and precise mechanisms and the effects of local anaesthetics on sympathetic structures remain controversial and elusive [15]. Moreover, most studies available in the literature are concerned with the role of sympathetic blockade in the treatment of CRPS [16] and few studies are concerned with long-term effects: Wang et al. [13] reported pain reduction in 68 % of patients at the 3-year evaluation, Ackerman and Zhang [14] report partial relief in 36 % of patients lasting for 12 weeks, and Cepeda et al. [3] published a review in 2006 of randomised control trials but were unable to assess long-term pain relief. In all of these studies, repetitive stellate ganglion blocks were performed, thereby increasing the risk of occurrence of adverse events. Such complications include injury to adjacent structures (brachial plexus, vertebral artery, oesophagus, pleura and lung) or inadvertent arterial or epidural injections [17–19]. Previous studies have shown a higher complication rate with the use of the conventional blind technique based on external anatomical landmarks [20, 21]. The use of imaging guidance such as ultrasound or fluoroscopy [13, 22] has helped to reduce the occurrence of such complications, and it is now well established that stellate blockades should be performed under imaging guidance [23]. The most commonly used imaging guidance is to date without doubt fluoroscopy and several approaches have been described in the literature: the C6 anterior approach

[20], paratracheal C7 approach [24] and recently a new C7 oblique fluoroscopic approach [22]. Although fluoroscopic guidance has helped to reduce the complication rate of stellate ganglion blocks, some complications such as lesions to the lung or pleura may occur, especially when a C7 approach is performed in patients with emphysema. This complication can easily be overcome by the use of CT guidance, as the high image resolution allows precise needle pathway planning, especially for the T1 target. Moreover, the accuracy of needle placement allowed by the use of CT guidance, which is highly superior to that of fluoroscopic guidance, explains the low complication rate (1.7 %) found in our study. Finally, precise needle tip positioning is mandatory for successful RFN of the stellate ganglion. Indeed, in the case of stellate ganglion blockade, it has been shown that local anaesthetics diffuse alongside the adjacent structures [25, 26] and therefore immediate needle tip positioning next to the stellate ganglion is not mandatory for a successful blockade. However in the case of the RFN procedure, immediate proximity to the ganglion is mandatory for successful neurolysis as the thermoablation radius at the tip of the needle is quite small (1–2 mm) [27, 28]. Even though our results concerning the outcome of patients after stellate ganglion RFN are in agreement with those in the literature [29, 30], this study is to our knowledge the first to report two-level C7–T1 RFN under CT guidance with long-term outcome.

Limitations of our study include those inherent to retrospective studies. Moreover, pre-procedure pain duration was significantly lower in the RFN group. Even though no statistical link was shown in both univariate and multivariate analysis between efficacy and pre-procedure duration, a possible influence of pre-procedure pain duration on efficacy may not be entirely excluded.

Despite these limitations, CT-guided radiofrequency neurolysis of the stellate ganglion is a safe and successful treatment for chronic refractory CRPS type I of the upper limb. It appears to be more effective than stellate ganglion blockade.

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