Capillary blood gas analysis in complex regional pain syndrome: a pilot study
ECTH Tan¹, MH de Keijzer² and RJA Goris¹

Abstract

Background The pathophysiology of complex regional pain syndrome type 1 (CRPS 1) is still a matter of debate. An inflammatory reaction may cause the syndrome. Increasing evidence points to a role for impairment of oxygen metabolism in the affected limb.

Methods In this pilot study (16 patients) we performed capillary blood gas analysis in extremities with acute CRPS 1, in order to assess oxygen saturation and lactate concentrations. Comparison was made with the unaffected limb for capillary blood pH, pO₂, SaO₂, and lactate and glucose concentrations.

Results No statistically significant differences could be found.

Conclusions Capillary blood gas analysis is not useful to detect changes in oxygen saturation and lactate concentrations in CRPS 1.


Introduction

Complex regional pain syndrome type 1 (CRPS 1) is a poorly understood syndrome which may occur in an extremity after even a minor injury or operation. In the acute phase, CRPS 1 is characterized by signs and symptoms of inflammation within the affected extremity. Although the clinical signs and symptoms of CRPS 1 are well known, the underlying pathophysiology remains unclear. Sudeck¹ hypothesized that an excessive inflammatory reaction may cause the syndrome. Recent studies supporting the inflammatory theory include:

- The dominance of clinical signs and symptoms of inflammation – such as unexplained severe pain, oedema, difference in skin temperature, difference in skin color – in the affected extremity at the onset of CRPS 1²
- An increased extravasation of indium-labelled Ig, indicating increased capillary permeability for macromolecules³
- An increased deposition of lipofuscin, indicating oxidative stress³
- Increased systemic concentrations of bradykinin and calcitonin gene-related peptide⁵
- A therapeutic response to various oxygen radical scavengers⁴
- Increased lactate concentrations within the skin of the affected extremity in patients with CRPS 1³
- Higher concentrations of interleukin (IL)-6 and tumour necrosis factor (TNF)-α in the involved extremity in comparison with the uninvolved extremity⁶

In earlier studies, we found significantly elevated oxygen saturation levels in venous blood samples obtained from the vena cubiti in the affected upper extremity, compared with the unaffected contralateral limb.¹³ Therefore, we were interested in assessing capillary oxygen and lactate levels in the affected limb.

In this pilot study, we performed capillary blood gas measurements in the extremities of the affected limb in patients with acute CRPS 1 in order to assess oxygen saturation and lactate concentration compared with the unaffected contralateral limb.

Methods

The study was performed in the out-patient clinic of the Department of Surgery, University Medical Centre Nijmegen. All new patients presenting with signs and symptoms of acute CRPS 1 were invited to participate in the study. Patients with abnormalities in the contralateral limb were excluded. The study protocol
was approved by the Human Ethical Committee of Arnhem-Nijmegen.

The following criteria were used in making the diagnosis of CRPS 1:\(^2\)

- The presence of at least four of the following five signs and symptoms: unexplained diffuse pain and tenderness in the distal part of the extremity, difference in skin colour in relation to the healthy symmetrical limb, diffuse oedema, difference in skin temperature in relation to the healthy symmetrical limb, and limited range of movement.

- An increase in the above signs and symptoms during exercise.

- The signs and symptoms above were present in an area much larger than the area of primary injury or operation and included the area distal to the primary injury.

All patients were non-fasting and were managed according to a standardized treatment protocol.\(^3\) After giving informed consent, they were brought to a climate-controlled room maintained at 24°C and allowed to acclimatize for approximately 15 min. Capillary blood was collected from a finger or toe of the CRPS extremity, followed by sampling from the symmetrical part of the contralateral unaffected limb. The average time between blood collection and blood gas analysis was 7.5 min (range 3–18 min). The blood gas analyses were performed with a Chiron 865 blood gas analyser (Bayer BV, Mijdrecht, The Netherlands). Skin temperature was measured with an infrared (ear) thermometer (First Temp ‘Genius’ Digital Ear Thermometer; Sherwood Medical, Crawley, UK) held 1 cm above the skin surface. The difference between warm and cold is based on the initial skin temperature in relation to the healthy symmetrical limb, and limited range of movement.

| Table 1. Results of capillary blood gas analyses, comparing the affected and unaffected limb |
|---------------------------------|-----------------|-----------------|-----------------|
|                                | All patients (n = 16) | Warm CRPS (n = 7) | Cold CRPS (n = 9) |
|                                | CRPS/normal | P      | CRPS/normal | P      | CRPS/normal | P      |
| pO\(_2\) (kPa)                  | 9.47/9.11    | 0.25   | 10.09/9.04 | 0.03*  | 9.05/9.14  | 0.81   |
| pH                              | 7.42/7.41    | 0.33   | 7.41/7.41  | 0.82   | 7.42/7.42  | 0.86   |
| Glucose (mmol/L)                | 6.4/6.38     | 0.45   | 6.6/6.4    | 0.18   | 6.3/6.3    | 0.69   |
| Lactate (mmol/L)                | 2.1/2.1      | 0.98   | 1.9/2.3    | 0.12   | 2.2/1.9    | 0.55   |
| SaO\(_2\) (%)                   | 98.9/96.2    | 0.24   | 97.4/95.9  | 0.51   | 95.5/96.2  | 0.11   |

\(^*P<0.05.\) CRPS = chronic regional pain syndrome.

Statistical analysis was performed using the paired t-test. Results were considered significant when \(P<0.05\).

Results and discussion

Sixteen patients (4 men, 12 women) were included in this study, with mean (range) age being 48 (16–70) years. Twelve patients (75%) had CRPS 1 within an upper extremity. In 10 patients (62.5%), the right limb was involved. The clinical signs and symptoms started after a minor injury in 10 patients, after an operation in five and spontaneously in one. The mean (range) interval between the start of symptoms and capillary puncture studies was 7 (0–22) months. The mean (range) score on the visual analogue pain score was 4.3 (1–10) and the mean difference in skin temperature was \(-0.8 (-5.10 \text{ to } +1.80)\)^\(\circ\). No statistical significance could be found, comparing the laboratory data from the CRPS limb and the normal limb. From five blood samples taken (three in warm CRPS 1 and two in cold CRPS 1 patients), no co-oximetry parameters could be measured and calculated due to clotting of the sample. As a consequence, the co-oximetry parameters are based on 11 patients. When dividing the patients according to the skin temperature difference, there was a significant increase in pO\(_2\) in the warm CRPS limb (10.09 kPa, range 7.24–12.11 kPa) versus the healthy limb (9.04 kPa, range 6.8–10.74 kPa), while lactate concentrations were lower but not statistically significantly different. In the cold group, oxygen saturation tended to be lower.

These results suggest that the differences found in this pilot study merely reflect the differences in arterial blood flow through the skin in the affected extremity. In a warm extremity with CRPS 1, arterial blood flow has been shown to be significantly increased, while being significantly reduced in cold CRPS 1.\(^3\) Consequently, tissue pO\(_2\) and O\(_2\) saturation values follow the same trend, while lactate concentrations depended on the dilution factor caused by the arterial bloodflow. In addition, in the study of Birklein et al.,\(^5\) at least six out of nine patients were observed to have a cold skin
temperature, possibly explaining the higher blood lactate concentrations found.

Conclusions
In this study, we could not determine significant differences in $pO_2$, oxygen saturation and lactate concentration in capillary blood samples from the affected versus the unaffected contralateral limb in patients with CRPS 1. In capillary blood, $pO_2$ and oxygen saturation were close to arterial values. Therefore, capillary blood gas analysis may not be sufficiently sensitive to detect increases in venous oxygen saturation and lactate production in this condition.

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References
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