Original Research

EXPLORING PULSED RADIOFREQUENCY ABLATION FOR ANTERIOR CUTANEOUS NERVE ENTRAPMENT SYNDROME: INSIGHTS FROM A FIVE-PATIENT CASE SERIES

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ABSTRACT

Background: Anterior cutaneous nerve entrapment syndrome (ACNES) is an underrecognized cause of chronic abdominal pain resulting from entrapment of the anterior cutaneous branches of thoracoabdominal intercostal nerves. While conservative management with local anesthetics and corticosteroids offers temporary relief for many patients, a subset remains refractory to these interventions. Pulsed radiofrequency (PRF) ablation has emerged as a minimally invasive neuromodulatory technique for various neuropathic pain conditions.
Objective: To evaluate the clinical outcomes of ultrasound-guided PRF ablation in five patients with refractory ACNES.
Methods: Five patients with chronic localized abdominal pain (duration >6 months), positive Carnett's sign, and temporary relief from diagnostic nerve blocks underwent two ultrasound-guided PRF sessions targeting the affected anterior cutaneous nerve branches. The sessions were performed two weeks apart, each consisting of a 10-minute application (42°C, 45V). Pain intensity was assessed using the Numeric Rating Scale (NRS, 0-10) at baseline, 2 weeks, 4 weeks, and 8 weeks post-procedure. Secondary outcomes assessed were sleep quality (measured by NRS) and the Patient Global Impression of Change (PGIC).
Results: At 4 and 8-week follow-up, four of five patients (80%) demonstrated clinically meaningful pain reduction (≥50% from baseline). In these responders, mean NRS of pain decreased from 6.8 to 2.3. Pain relief was accompanied by corresponding improvements in sleep quality and PGIC scores indicating moderate to marked benefit. No significant adverse events were observed.
Conclusion: These findings suggest that PRF ablation may represent a safe and effective minimally invasive option for patients with refractory ACNES, warranting further investigation in larger controlled studies.

Keywords: Anterior Cutaneous Nerve Entrapment Syndrome, ACNES, Pulsed Radiofrequency, PRF, Chronic Abdominal Pain, Neuropathic Pain, Intercostal Nerve.

INTRODUCTION

Chronic abdominal pain represents a common clinical challenge with diverse etiologies ranging from visceral pathology to functional disorders and parietal wall syndromes. Among the frequently overlooked causes of chronic abdominal wall pain is anterior cutaneous nerve entrapment syndrome (ACNES), first described over nearly a century ago but still underrecognized in clinical practice.

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ACNES results from entrapment of the anterior cutaneous branches of the intercostal nerves (T7-T12) as they pierce the rectus abdominis muscle and anterior rectus sheath at a 90-degree angle (Figure 1) [1]. This anatomical vulnerability, combined with factors such as increased intra-abdominal pressure, trauma, surgical scarring, or repetitive strain, can lead to nerve compression, ischemia, and subsequent neuropathic pain. The syndrome is estimated to affect approximately 1 in 1,800 individuals, with a female predominance of 4:1 and peak incidence observed in the 15-20 and 35-45 age groups [2]. Among patients presenting with acute abdominal pain to emergency departments, up to 2% may have ACNES, while the prevalence rises to 10-30% in those with chronic abdominal wall pain undergoing gastroenterological evaluation [3, 4].

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The diagnosis of ACNES is primarily clinical, characterized by well-localized abdominal pain that patients can typically pinpoint with one finger. The pathognomonic Carnett's sign- where palpation of the tender point elicits increased pain during abdominal muscle contraction compared to relaxation- helps distinguish parietal from visceral pain sources [5]. Additional supportive findings include a positive pinch test and allodynia over the affected dermatome.

Management of ACNES follows a stepwise approach. Conservative measures including activity modification and systemic analgesics often prove inadequate given the mechanical nature of the entrapment. Ultrasound-guided injections of local anesthetics with or without corticosteroids at the point of maximal tenderness serve both diagnostic and therapeutic purposes, with success rates ranging from 38% to 87% in various series [6]. For patients with refractory symptoms, surgical options including anterior neurectomy have demonstrated efficacy in 86-100% of cases. However, the invasive nature of surgery and potential for neuroma formation have prompted interest in minimally invasive alternatives [7, 8].

Pulsed radiofrequency (PRF) ablation has emerged as a neuromodulatory technique for various neuropathic pain conditions. Unlike continuous thermal radiofrequency that causes irreversible nerve destruction, PRF delivers short pulses of high-frequency current (typically 500 kHz) in a pulsed manner (2 pulses per second) with careful temperature monitoring to maintain tissue temperature below 42°C [9]. This approach induces neuromodulatory effects through transient electric field exposure without significant thermal neuroablation, potentially offering durable pain relief while minimizing the risk of deafferentation pain or neuroma formation [10].

The application of PRF in ACNES remains relatively novel. Werner and colleagues reported on nine patients with ACNES who underwent PRF treatment following rectus sheath blockade, observing that all six patients with positive diagnostic blocks maintained pain relief at six months post-PRF [11]. In a larger retrospective analysis of 26 patients, Maatman and colleagues demonstrated that PRF achieved short-term success (>50% pain reduction at 6-8 weeks) in 50% of patients, with a median effect duration of four months [12]. More recently, a case report documented successful PRF application in an 11-year-old pediatric patient with disabling ACNES refractory to conservative management [13].

This case series aims to contribute to the growing body of evidence by presenting five patients with refractory ACNES who underwent ultrasound-guided PRF ablation, with detailed clinical outcomes and follow-up data.

METHODS

Study Design and Patient Selection- This prospective case series included five consecutive patients diagnosed with ACNES who underwent ultrasound-guided PRF at the Department of Physical Medicine and Rehabilitation, Shija Academy of Health Sciences, Langol, Imphal, between January 2025 and October 2025. The diagnosis of ACNES was established based on the following criteria: (1) chronic localized abdominal pain lasting more than six months; (2) tender point localized to a small area (<2 cm²) corresponding to the lateral border of the rectus abdominis muscle; (3) positive Carnett's sign; (4) temporary pain relief (≥50% reduction for at least 2 hours) following ultrasound-guided diagnostic block with 3 mL of 1% lidocaine at the point of maximal tenderness; and (5) failure of conservative management including physical therapy and systemic analgesics (NSAIDs, gabapentinoids, or tricyclic antidepressants). Exclusion criteria included identifiable visceral pathology, previous abdominal surgery at the pain site, bleeding diathesis, local infection, pregnancy, or allergy to local anesthetics.

All patients provided written informed consent for the procedure and for inclusion in this case series. The study was conducted in accordance with the Declaration of Helsinki and approved by our institutional review board.

Pre-Procedure Assessment- Baseline demographic and clinical data were collected for all patients, including age, gender, body mass index (BMI), pain duration, pain location, previous treatments, and pain etiology. Primary outcome measures were assessed using the 11-point Numeric Rating Scale (NRS), where 0 represents "no pain" and 10 represents "worst possible pain." Secondary outcomes included sleep interference, evaluated using a separate NRS (0 = no interference, 10 = complete inability to sleep due to pain), and the Patient Global Impression of Change (PGIC). All patients underwent a standardized physical examination including assessment of Carnett's sign and the pinch test.

Procedure Technique- All procedures were performed in daycare setting under sterile conditions. Continuous electrocardiographic monitoring, pulse oximetry, and blood pressure monitoring were maintained throughout the procedure. Patients were positioned supine with appropriate exposure of the abdominal wall.

The point of maximal tenderness was identified through careful palpation and marked. High-frequency ultrasound (SONOACE X7 linear transducer, LN5-12) was then used to visualize the abdominal wall layers including the subcutaneous tissue, anterior rectus sheath, rectus abdominis muscle, and posterior rectus sheath (Figure 1). The anterior cutaneous nerve branch was identified as a

small hyperechoic structure piercing the anterior rectus sheath at the lateral border of the rectus abdominis muscle, typically adjacent to a small perforating vessel.

Following sterile skin preparation and infiltration with 1% lidocaine for superficial anesthesia, a 22-gauge, 10-cm radiofrequency cannula with a 10-mm active tip (TherMedico NK1) was advanced under real-time ultrasound guidance using an in-plane technique. The cannula tip was positioned immediately adjacent to the identified nerve, between the anterior and posterior fascia of the rectus abdominis muscle at the point of maximal tenderness.

Sensory stimulation at 50 Hz was performed to confirm appropriate placement, with the goal of reproducing the patient's typical paresthesia at 0.3-0.5 V. Motor stimulation at 2 Hz was performed to ensure absence of muscle contraction in the abdominal wall or lower extremities, confirming that the cannula was not in close proximity to motor nerve fibers.

Once satisfactory placement was confirmed, pulsed radiofrequency treatment was administered using a radiofrequency generator (TherMedico NK1). The PRF protocol consisted of two cycles of 300 seconds each (total 10 minutes) with a pulse width of 20 milliseconds and pulse rate of 2 Hz, maintaining a tip temperature below 42°C and maximum voltage of 45V. During the procedure, patients were monitored for any discomfort or adverse effects. Following completion of PRF, 1 mL of 0.5% bupivacaine was injected through the cannula to provide immediate post-procedural analgesia. The cannula was then removed, and a sterile dressing was applied. A repeat procedure was performed after an interval of two weeks.

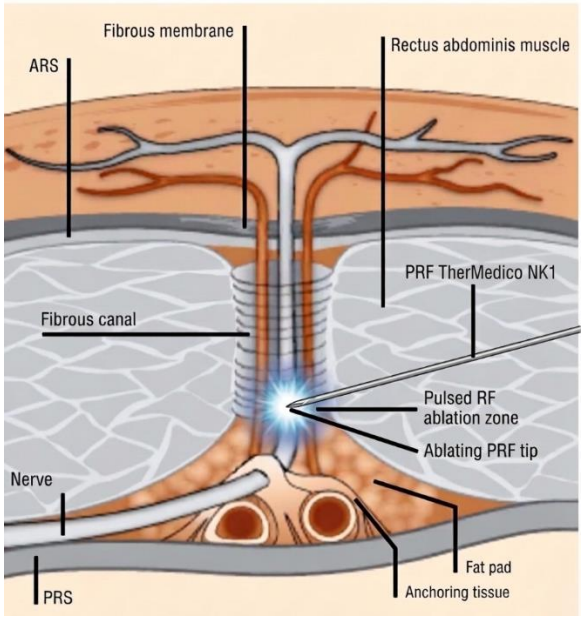

Figure 1. Pulsed Radiofrequency Ablation (PRF) of Anterior Cutaneous Nerve

ARS- Anterior Rectus Sheath, PRS- Posterior Rectus Sheath.

Post-Procedure Care and Outcome Assessment- Patients were monitored for 30 minutes post-procedure for any immediate adverse events. They were instructed to resume normal activities as tolerated but to avoid strenuous abdominal exercise for one week. All patients maintained a pain diary documenting daily NRS scores and any rescue analgesic use.

Outcome assessments were performed at baseline and at 2 weeks, 4 weeks, and 8 weeks post-procedure. The primary outcome measure was the proportion of patients achieving clinically meaningful pain reduction, defined as ≥50% decrease in NRS score from baseline at follow-ups. Secondary outcome measures included: (1) mean NRS scores at each time point; (2) sleep interference NRS scores; (3) Patient Global Impression of Change (PGIC) at 8 weeks, rated on a 7-point scale from 1 (very much worse) to 7 (very much improved); (4) duration of pain relief; and (5) adverse events.

Successful treatment was defined as ≥50% pain reduction sustained for at least 6 weeks post-procedure. Patients who experienced pain recurrence were offered repeat PRF or referral for surgical consideration.

Case Presentations

Case 1- A 55-year-old woman presented with 7 months of sharp, stabbing right lower quadrant abdominal pain, localized to a 2-cm spot 5 cm lateral to the midline. Pain worsened with standing, walking, or tight clothing; supine position offered

partial relief. She had no significant medical or surgical history. Prior ultrasound, colonoscopy, and gynaecological exam normal. Pharmacological management with ibuprofen, acetaminophen, and gabapentin (escalated to 1200 mg daily) proved largely ineffective.

Physical examination revealed a tender point in the right lower quadrant with positive Carnett's sign and allodynia to light touch. Diagnostic block with 3 mL of 1% lidocaine provided 90% pain relief for approximately 4 hours, confirming the diagnosis of ACNES. Baseline NRS was 7 (ranging from 5 to 8). Sleep interference was rated as 6 due to frequent nocturnal awakening.

An uneventful ultrasound-guided PRF of the T11 anterior cutaneous branch was performed. At 2 weeks, the NRS was 4 (42% reduction), falling to 2 (71% reduction) by 4 weeks with improved sleep and cessation of all analgesics. At 8 weeks, NRS was 3 with a PGIC of 5. No adverse events were observed.

Case 2- A 65-year-old man presented with seven months of right upper quadrant pain, described as a constant dull ache with sharp flares localized to a 2-cm area at the right costal margin. The pain disrupted his work and exercise. Prior abdominal CT and upper endoscopy were normal, and he failed NSAIDs and physical therapy. On examination, a tender point was identified at the right T9 dermatome with a positive Carnett's sign, confirming abdominal wall pain. A diagnostic block using 3 mL of 1% lidocaine provided 80% pain relief for 3 hours. Baseline Numeric Rating Scale (NRS) was 8, with sleep interference at 7. The patient then underwent ultrasound guided PRF of the anterior cutaneous branch of T9, which was well tolerated. At 2 and 4 weeks, NRS decreased to 3 (63% reduction), and by week 4, sleep interference improved to 2. At 8-week follow-up, he maintained NRS of 3, with a PGIC score of 6 and no adverse effects.

Case 3- A 68-year-old woman presented with 16 months of left upper quadrant pain localized to a 1.5-cm area at the left upper quadrant, exacerbated by coughing and movement. Extensive imaging, including ultrasound and CT, was normal. Prior trigger point injections offered progressively shorter relief. Examination revealed point tenderness at the left T10 dermatome with positive Carnett's sign. Baseline NRS was 7, with sleep interference of 7. A diagnostic block provided 50% relief for 3 hours. PRF of the anterior cutaneous branch of T10 was performed uneventfully. At 8 weeks, NRS was 4 (43% reduction), with sleep interference improved to 3, though PGIC score was 4, indicating no perceived change.

Case 4- A 62-year-old man presented with 12 months of sharp, well-localized left lower quadrant pain. Despite no prior surgeries and normal evaluations, NSAIDs offered no relief. Examination revealed point tenderness at the left T11 dermatome with a positive Carnett's sign. A diagnostic block provided 95% pain relief for 5 hours. Baseline NRS was 8 during activities, with sleep interference rated 6. PRF of the anterior cutaneous branch of T11 was performed. At 2 weeks, NRS decreased to 3 (63% reduction). By 4 weeks, NRS improved to 2 (75% reduction), with resolved sleep interference. At 8-week follow-up, he maintained an NRS of 2 and reported a PGIC score of 7 ("very much improved"), with no adverse events.

Case 5- A 47-year-old man presented with 14 months of left lower quadrant neuropathic pain, beginning 3 years after laparoscopic inguinal hernia repair. The burning, lancinating pain was located 5 cm medial to the scar, with associated allodynia. Previous treatments, including gabapentin (1800 mg), pregabalin, and steroid injections, provided minimal, transient relief. Examination revealed tenderness at the left T12 dermatome with a positive Carnett's sign. A diagnostic block produced 70% relief for 2 hours. Baseline NRS was 6, with sleep interference also 6. PRF of the anterior cutaneous branch of T12 was performed uneventfully. At 2 weeks, NRS decreased to 3 (50% reduction). By 4 weeks, NRS remained 3, sleep interference improved to 3, and he reduced gabapentin by 50%. At 8 weeks, he maintained excellent results with NRS of 1 (83% reduction) and a PGIC score of 6, with no adverse events.

RESULTS

Patient Demographics and Baseline Characteristics- A total of five patients (2 women, 3 men) with a mean age of 59.4 years (range 47-65 years) were included in this case series. The mean duration of pain prior to PRF treatment was 11.2 months (range 7-16 months). Pain locations included right lower quadrant (n=1), left lower quadrant (n=2), right upper quadrant (n=1), and left upper quadrant (n=1), corresponding to dermatomes T9 through T12. Two patients (patient 3 and 5) had identifiable precipitating events (severe coughing episode, postoperative), while three had spontaneous onset. All patients had failed at least two prior treatment modalities including systemic analgesics and physical therapy; three had received prior trigger point injections with temporary benefit. Baseline mean NRS score for the cohort was 7.2 ± 0.84 (range 6-8). Baseline mean sleep interference NRS was 6.2 ± 0.45 (range 6-7) (Table 1).

Table 1. Patient Demographics and Baseline Characteristics

Patient	Age	Gender	Pain Duration (months)	Pain Location	Dermatome	Precipitating Event	Baseline NRS	Baseline Sleep NRS
1	55	F	7	RLQ	T11	None	7	6
2	65	M	7	RUQ	T9	None	8	6
3	68	F	16	LUQ	T10	Severe coughing	7	7
4	62	M	12	LLQ	T11	None	8	6
5	47	M	14	LLQ	T12	Post-herniorrhaphy	6	6
Mean ± SD	**59.4±8.44**	**2 F:3 M**	**11.2±4.09**				**7.2±0.84**	**6.2±0.45**

RLQ- Right Lower Quadrant, RUQ- Right Upper Quadrant, LUQ- Left Lower Quadrant, LLQ-Left Lower Quadrant

Treatment Outcomes- All five patients successfully underwent ultrasound-guided pulsed radiofrequency (PRF) without any procedural complications. The average procedure time, from skin preparation to completion, was 32 minutes (range: 26–37 minutes).

At the 2-week follow-up, three of the five patients (60%) reported clinically meaningful pain relief, defined as a ≥50% reduction from baseline. In these responders, the mean Numeric Rating Scale (NRS) score decreased from 7.33 ± 1.16 at baseline to 3.0 ± 0.0 at two weeks, reflecting a 59% reduction.

By the 4-week follow-up, four of the five patients continued to experience clinically significant pain relief, with a mean NRS of 2.5 ± 0.5- a 65% reduction from baseline. Patient 3 did not achieve clinically significant pain reduction at any follow-up point. Among responders, sleep interference scores improved in parallel with pain reduction, decreasing from a mean of 6.0 ± 2.2 at baseline to 2.0 ± 0.8 at four weeks (67% reduction).

At the 8-week follow-up, all patients maintained their level of pain relief, with a mean NRS of 2.6 ± 1.14 (64% reduction from baseline). Patient 4, who showed an excellent initial response (NRS reduction from 8 to 3), maintained an NRS of 2. Patient 5 maintained an NRS of 1 (down from 6), and Patient 1 remained at 3 (down from 7). Patient 2 sustained their initial response (from 8 to 3) through eight weeks, while Patient 3 was classified as a partial responder, with NRS improving from 7 to 4.

Overall, the procedure achieved an 80% success rate (4 out of 5 patients), defined as ≥50% pain reduction sustained for at least six weeks (Table 2).

Table 2. Individual Patient Outcomes Following PRF

Patient	Numerical Rating Scale (NRS) of Pain				% Reduction at 8 weeks	PGIC at 8 weeks	Response Status
	Baseline	2 weeks	4 weeks	8 weeks			
1	7	4	2	3	57.1	5	Responder
2	8	3	3	3	62.5	6	Responder
3	7	5	4	4	42.8	4	Partial responder
4	8	3	2	2	75.0	6	Responder
5	6	3	3	1	83.3	6	Responder
Mean ±SD	7.2±0.84	3.6±0.89	2.8±0.84	2.6±1.14	63.9%±16.4%	5.4	

PGIC, Patient Global Impression of Change (1 = very much worse, 4 = no change, 7 = very much improved).

Safety and Adverse Events- No major adverse events were observed during or after any of the procedures. There were no cases of bleeding, infection, hematoma formation, visceral injury, or motor weakness. One patient reported mild, transient discomfort at the injection site, which resolved spontaneously within 48 hours without the need for intervention. No patients experienced new sensory disturbances or allodynia in the treated dermatomes.

DISCUSSION

This case series describes outcomes of ultrasound-guided PRF ablation in five patients with refractory ACNES. Our findings suggest PRF may provide meaningful pain relief for selected patients failing conservative management, with 80% maintaining clinically significant improvement at eight weeks. This response rate aligns with published literature. Maatman and colleagues reported 50% short-term

success in 26 patients, while Werner and colleagues found all six patients with positive diagnostic blocks maintained six-month relief, suggesting block response may predict outcomes [11, 12]. Similarly, our responders demonstrated robust diagnostic block responses (70-95% relief), whereas the single partial responder had only 50% relief, though sample size limits conclusions.

Ultrasound guidance offers advantages over landmark-based techniques, enabling precise visualization of the nerve piercing the anterior rectus sheath, confirmation of cannula placement adjacent to the nerve, and avoidance of vascular structures and the peritoneal cavity [13]. Sensory stimulation reproducing the patient's typical paresthesia further confirms correct localization prior to PRF delivery.

PRF's mechanism in ACNES remains incompletely understood. Unlike continuous thermal radiofrequency causing heat-induced coagulation necrosis, PRF delivers short pulses with intervening silent phases, maintaining tissue temperature below the 42°C thermal injury threshold. Proposed mechanisms include high-intensity electric fields modulating neuronal membrane function, altering gene expression in pain pathways, and reducing ectopic discharge from injured nerves—explaining pain relief without sensory deficits associated with neuroablative techniques [14]. The temporal response pattern—benefit emerging within two weeks and persisting at least eight weeks—aligns with neuromodulatory mechanisms requiring time for gene expression changes and neural plasticity [15].

The safety profile was excellent, with only minor transient injection-site reactions. This favorable profile, combined with minimally invasive nature, positions PRF as an attractive intermediate option between conservative management (trigger point injections) and surgical neurectomy. For PRF non-responders or those with recurrence, anterior neurectomy remains an option with reported 86-100% success rates [6,7].

Several limitations merit acknowledgment: small sample size limiting generalizability and precluding predictor analysis; absence of a control group unable to exclude placebo effects; relatively short eight-week follow-up; single-center experience by experienced operators; and lack of systematic sensory testing to detect subclinical nerve injury.

Despite these limitations, our findings contribute to growing evidence supporting PRF for refractory ACNES. The procedure offers advantages: minimally invasive, outpatient setting, low complication risk, does not preclude subsequent surgery, and may provide durable relief for appropriately selected patients.

Future research should include larger prospective studies with extended follow-up to determine long-term efficacy and optimal repeat procedure timing. Randomized controlled trials comparing PRF to sham or standard care (serial trigger point injections) would provide higher-level evidence. Additionally, investigating predictors of response- diagnostic block characteristics, symptom duration, allodynia presence- could refine patient selection and improve outcomes.

CONCLUSION

This case series suggests that ultrasound-guided pulsed radiofrequency (PRF) of the affected anterior cutaneous nerve branches is a safe and potentially effective minimally invasive option for refractory anterior cutaneous nerve entrapment syndrome (ACNES). Among five patients, 80% achieved clinically significant pain relief sustained through eight weeks. The procedure was well-tolerated with no major adverse events, supporting the biological rationale for neuromodulation in mechanical neuropathic pain. These findings align with existing literature. While larger controlled trials are needed to confirm efficacy, PRF offers a valuable middle ground between temporary relief from injections and permanent surgical neurectomy in the stepwise management of ACNES.

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Conflicts of Interest- The authors declare no conflicts of interest related to this work.

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