



Factors predicting outcome after anterior neurectomy in patients with chronic abdominal pain due to anterior cutaneous nerve entrapment syndrome (ACNES)



Frederique M.U. Mol, MD^{a,b,*}, Claire H. Jansen, MD^{a,b}, William van Dijk, MD^{a,b}, Percy van Eerten, MD^{a,b}, Mark R. Scheltinga, MD^{a,b}, Rudi M. Roumen, MD^{a,b}

^a Department of Surgery, Máxima Medical Center, Veldhoven, The Netherlands

^b SolviMáx, Center of Expertise for ACNES, Center of Excellence for Abdominal Wall and Groin Pain, The Netherlands

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ABSTRACT

Background: Chronic abdominal pain due to anterior cutaneous nerve entrapment syndrome may require surgery to provide long-term pain relief in up to 70% of patients. Factors predicting outcome after an anterior neurectomy are unknown. The aim of the study is to identify factors associated with treatment failure to possibly allow for optimizing patient counselling and selection.

Methods: Characteristics of anterior cutaneous nerve entrapment syndrome patients who were unresponsive to nonsurgical therapies and underwent an anterior neurectomy in a tertiary referral center from 2011 to 2016 were analyzed. Treatment failure was defined as <50% pain reduction using a numeric pain rating scale (numeric pain rating score 0–10) approximately 2 months postoperatively. A prediction model based on a multivariate regression analysis was tested for its discriminative value.

Results: A total of 495 patients (78% female, median age 40 years, range 8–83) undergoing an anterior neurectomy were eligible for analysis. Pain medication use (odds ratio 1.84, $P = .027$, confidence interval 1.07–3.17), abdominal surgery in the past (odds ratio 1.85, $P = .026$, confidence interval 1.08–3.18), the presence of paravertebral tender points at exit points of intercostal nerves (odds ratio 2.58, $P = .003$, confidence interval 1.39–4.80), and failure to favorably respond to a diagnostic rectus sheath block (odds ratio 3.74, $P = .000$, confidence interval 3.74 – 7.10) were identified as factors predicting surgical failure. However, a prediction model including these 4 factors had poor accuracy with an area under the curve of 0.64 (confidence interval 0.58–0.70).

Conclusion: The present study identified risk factors associated with treatment failure that are useful in counseling anterior cutaneous nerve entrapment syndrome patients prior to a surgical intervention.

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Background

Up to 30% of patients with chronic abdominal pain of unknown origin may suffer from an abdominal wall-related syndrome such as anterior cutaneous nerve entrapment syndrome (ACNES).^{1,2} Discomfort associated with ACNES is often mistakenly considered by physicians as visceral pain resulting from irritable bowel syndrome.³ However, a detailed physical examination in an ACNES patient may identify distinct properties, such as altered abdominal skin sensation, a positive Carnett's sign, and a predictable fingertip point of maximum pain.^{4,5} The abdominal pain is supposedly

caused by entrapped sensory cutaneous terminal branches of abdominal intercostal nerves at the level of the abdominis rectus muscle.^{6,7}

At the start of the twenty-first century, the ACNES diagnosis was considered controversial and was seldom listed in differential diagnostic considerations of abdominal pain entities. In the Netherlands, however, there is now increasing recognition of this syndrome among general practitioners and specialists. Treatment modalities, such as injection therapy,⁸ pulsed radio frequency ablation (PRF),⁹ or a neurectomy^{10,11} of entrapped nerves, were all, to a certain extent, found to be successful in selected patients. Early favorable experiences led to the creation of a dedicated outpatient clinic for patients with abdominal wall and groin pain. An overwhelming response of referrals resulting from media attention and peer group lectures followed. As a result, over 1,500 ACNES patients were evaluated and treated at this center of expertise between 2003 and 2017.

* Corresponding author: Department of Surgery, Máxima Medical Center, Postbus 7777, 5500 MB Veldhoven, The Netherlands.

E-mail address: frederique.mol89@gmail.com (F.M.U. Mol).

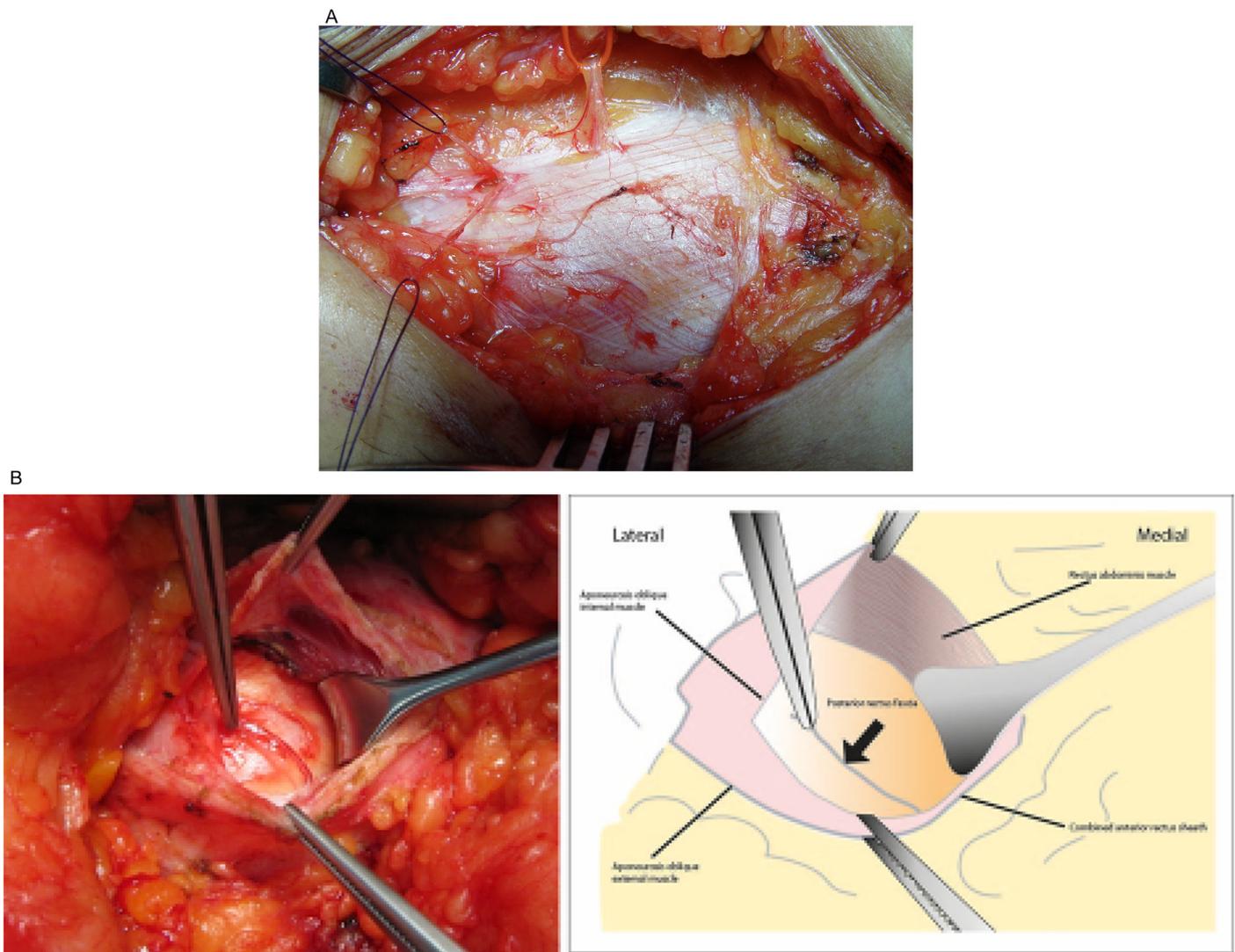


Fig. 1. (A) Performing an anterior neurectomy. All end branches of the neurovascular bundle perforating the anterior rectus fascia (loops) within a radius of 4–5 cm from the trigger point are destroyed, either by cauterization or ligation. In the posterior neurectomy (B) this is done at the deeper level where the nerve branches enter laterally and run over the posterior rectus fascia and dorsal of the rectus muscle.¹¹

Previous research in this extensive patient population included randomized controlled trials on the efficacy of local injection therapy and a surgical neurectomy, as well as alternative secondary approaches for nonresponders.^{8,10,11} However, surgical success is not always achieved. Considering a 70% long-term surgical success rate, the identification of factors potentially predicting the efficacy of a neurectomy may aid in counseling these patients with often severe pain (numeric pain rating score [NRS] 7–8) before initiating any form of invasive surgery.¹² The aim of this prospective database study is to identify patient characteristics that are associated with treatment failure allowing for optimized patient selection.

Methods

Data sources

This study analyzed prospectively collected data of 1,014 consecutive patients who were diagnosed and treated for ACNES at the SolviMáx Center of Excellence for Abdominal Wall and Groin Pain between May 2011 and May 2016, as documented in standard

hospital electronic patient files. Each patient is required per protocol to complete a number of standardized and center-specific questionnaires before receiving an invitation for an outpatient evaluation. As a result, complete and validated baseline information regarding a variety of parameters including duration, etiology, nature, and disease burden is obtained. NRS and verbal pain rating scores were used at follow-up visits to assess therapy success, occasionally converted by the treating specialist to percentage of pain reduction after the therapy. The center's step-up treatment protocol dictates a 6-week period of biweekly injection therapy in each new untreated ACNES patient followed by more invasive treatments, such as PRF. A neurectomy of the cutaneous intercostal nerves anterior to the rectus abdominis muscle is considered if all modalities fail. Details of this surgical procedure were published previously.^{10,11} In short, in an anterior neurectomy all end branches of the neurovascular bundle perforating the anterior rectus fascia within a radius of 4–5 cm from the trigger point are destroyed, either by cauterization or ligation (Fig. 1, A).¹⁰ In the posterior neurectomy, this is done at the deeper level where the nerve branches enter laterally and run over the posterior rectus fascia and dorsal of the rectus muscle (Fig. 1, B).¹¹

The effect of such an anterior neurectomy is standardly assessed some 2 months after treatment during an outpatient follow-up visit. Although 2 months may appear to be a short period of follow-up, previous studies showed that success after a neurectomy is rather an on-off phenomenon. Success or not is very often quite clear directly after this type of surgery, whereas the difference between effect on pain perception at 2 months and >1 year is negligible.^{10,12}

Study design

This database study included all patients who were diagnosed with ACNES and who ultimately received an anterior neurectomy as a first-step surgical procedure. A patient was considered to have ACNES if at least 2 of the 3 following characteristics were identified during the interview and physical examination:

- A history of abdominal complaints with 1 specific point of maximum pain
- Local somatosensory disturbances at this point of maximum pain or a positive pinch test
- Positive Carnett's sign at the point of maximum pain⁶

Patients who underwent other types of surgery as a first procedure, such as a neurectomy posterior to the rectus abdominis muscle, were excluded. All patients signed informed consent forms allowing for the use of anonymized patient-related outcome measures. Results of questionnaires data, patient history, and physical examination were entered in the hospital's electronic files by treating specialists. Coding of these data into a study database was performed and monitored by 2 independent investigators.

Outcome variables

Surgical success was defined as a minimum of 50% pain reduction on NRS scores compared to baseline values at 2 months follow-up after surgery as dictated by international pain literature standards and as previously published.^{13,14} Long-term success rates, encompassing recurrences after 2 months, were not investigated in this study.

Factors possibly related to outcome

Characteristics potentially influencing treatment success based on previous pain literature were body mass index (BMI), age, sex, duration of symptoms, average pain scores, and pain medication use.^{15–18} Treating specialists (M. S. and R. R.) suggested that a number of ACNES-specific factors, such as onset mechanism (categorized as spontaneous, after recent abdominal surgery, after or during pregnancy, after sports trauma or accident, after flu or other), abdominal surgery in the past, uni- or bilateral complaints, anatomical level of pain, previous treatments, effect of a diagnostic rectus sheath block, and presence of intercostal or paravertebral tender points along the intercostal nerve's tract, would all potentially be factors predicting failure or success. Comorbidities, such as other pain syndromes or concurrent gastrointestinal syndromes including irritable bowel syndrome, were also deemed relevant and tabulated.

Statistical methods

Data were analyzed using SPSS version 22.0 software (SPSS Inc, Chicago, IL). The outcome measure was dichotomized by means of effectiveness (\geq or $<$ 50% pain reduction, success, or failure, respectively). Patient characteristics and clinical findings were dichotomized as well (except for age, duration of symptoms, and NRS

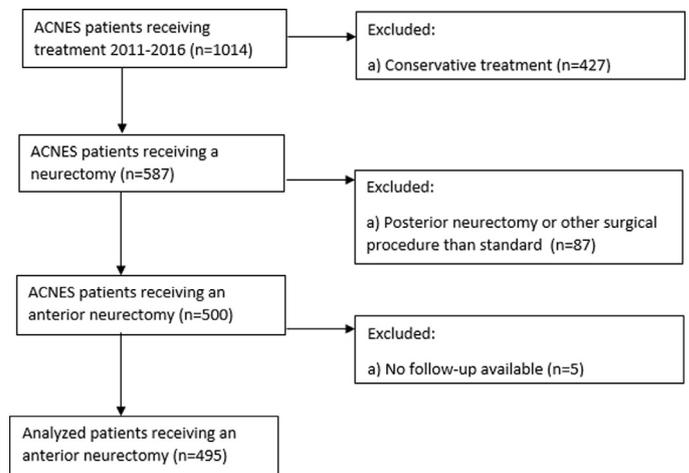


Fig. 2. Patient selection from the database, identifying patients who underwent an anterior neurectomy as first surgical procedure.

scores) and tested for confounding properties by univariate analysis (Table 1). A variable was only tested for significance if at least 85% of the data were complete. Categorical demographic variables were compared using the χ^2 test. Continuous data were analyzed using the independent t -test or Mann-Whitney U test when appropriate.

Significant confounders ($P \leq .10$) were included as covariates in a multivariate logistic regression model as a means to determine a possible association between potential prognostic variables and outcome measures. The corresponding odds ratios (OR) and 95% confidence intervals (95% CI) were calculated. A >1.0 OR indicates a higher chance of failure, whereas a <1.0 OR indicates a lower chance. A likelihood ratio backward (rather than a forward) stepwise regression method was utilized to limit the chance of suppressor effects and risk of a type-II error. The discriminative ability of the prediction model was assessed by calculating the area under the curve (AUC) of the receiver operating characteristic curve and sensitivity and specificity of the model at multiple cutoff points. Statistical significance for the multivariate logistic binary regression was set at $P \leq .05$.

Results

Patient selection

A total of 587 unique patients underwent a neurectomy for ACNES at the SolviMáx center during the 5-year time period. A group of 87 patients were excluded because a different neurectomy protocol was executed as the primary procedure, either because of an earlier neurectomy in a referring facility or a posterior neurectomy (Fig. 2). Follow-up data regarding the outcome variable was available in 99% (495/500) of patients. Subject characteristics are depicted in Table 2.

Estimates of effects in 495 ACNES patients

A total of 395 patients (79.8%) had a successful response ($\geq 50\%$ pain reduction) after a neurectomy. This percentage is consistent and similar to previously reported outcomes in various subgroups of this cohort.^{9,19} A multivariate analysis, including factors that were found by univariate analysis (Table 1) to negatively influence outcome, demonstrated that medication use, previous abdominal surgery, the effect of a diagnostic rectus sheath block, and the presence of paravertebral tender points along the nerve's tract

Table 1
Oversight of univariate analysis and various cofounders; bold *P* values are significant.

Variable	<i>n</i>	Odds ratio	Lower limit	Upper limit	<i>P</i> value
Sex					
Male	90	1	Reference	Reference	Reference
Female	405	0.83	0.46	1.49	.53
Baseline VAS					
<7	269	1	Reference	Reference	Reference
≥7	184	0.78	0.53	1.10	.16
BMI (kg/m²)					
<30	394	1	Reference	Reference	Reference
>30	84	0.71	0.41	1.23	.22
Age					
<45	304	1	Reference	Reference	Reference
>45	191	0.68	0.44	1.06	.09
Unilateral					
Bilateral	73	0.68	0.38	1.21	.19
Side					
Right	283	1	Reference	Reference	Reference
Left	135	0.80	0.48	1.34	.40
Dermatome					
Th7	6	0.89	0.10	7.92	.92
Th8	40	0.71	0.30	1.71	.45
Th9	55	0.52	0.25	1.08	.10
Th10	120	0.49	0.28	0.87	.013
Th11	185	1	Reference	Reference	Reference
Th12	87	0.73	0.38	1.43	.36
Onset					
No evident cause	275	1	Reference	Reference	Reference
After accident/sports trauma	27	0.49	0.20	1.19	.11
After/during pregnancy	17	0.96	0.27	3.48	.95
After flu	14	0.52	0.16	1.71	.27
Following recent abdominal surgery	144	0.69	0.42	1.14	.15
Other	11	0.55	0.14	2.15	.38
Abdominal surgery in the past					
Yes	266	0.58	0.37	0.91	.017
No	223	1	Reference	Reference	Reference
Duration					
<6 months	107	1.36	0.77	2.37	.29
>6 months	382	1	Reference	Reference	Reference
Pain medication use					
Yes	239	0.52	0.32	0.84	.007
No	203	1	Reference	Reference	Reference
Previous treatment					
Yes	306	0.72	0.44	1.18	.19
No	161	1	Reference	Reference	Reference
Intercostal trigger points					
Yes	89	0.67	0.39	1.15	.15
No	405	1	Reference	Reference	Reference
Paravertebral trigger points					
Yes	75	0.51	0.29	0.88	.015
No	419	1	Reference	Reference	Reference
Dx injection effect					
>50% pain	372	1	Reference	Reference	Reference
<50% pain	60	0.34	0.19	0.61	.001

Dx, diagnostic

were predictive (Table 3). Both the anatomical level of the point of maximum pain (abdominal quadrant) and advanced age were of relevance in the univariate analysis but appeared nonsignificant in the multivariate analysis and were thus removed from the final model.

These 4 factors formed a significantly better model than a priori prediction for neurectomy failure, but the model itself still had poor accuracy with an AUC of 0.64 (CI 0.58–0.70). An AUC of <0.70 is generally regarded as a “poor” or “failed” discriminative value (Fig. 3). In other words, if the aim is that no therapy should be withheld from patients who would otherwise have had a successful neurectomy (high specificity), the model is of limited value to predict therapy failure (low sensitivity). Interestingly, not a single patient in the present study cohort had all of these 4 risk factors.

Discussion

The present study is the first to aim at identifying significant factors predicting failure of a neurectomy of the anterior twigs of the cutaneous branches of intercostal nerves in patients with ACNES. The a priori chance for failure is low, ranging from 20%–30%, because an anterior neurectomy is an overall successful procedure that leads to complete pain remission in a substantial subgroup of patients.⁹ This, however, raises high expectations in a vulnerable patient group with severe pain. After a neurectomy failure, further surgical exploration by means of a posterior neurectomy can still benefit some 50% of the remaining patients, but beyond this procedure effective treatment options are scarce.¹¹

Preoperative pain medication use, abdominal surgery in the past, a negative response after a diagnostic rectus sheath block,

Table 2
Characteristics of ACNES patients undergoing an anterior neurectomy during a 5-year time period in a tertiary referral center.

Patients	(n = 495)
Age*	40 (8–83)
Sex ratio M:F	1:4.5
Height (cm)†	169 (11) cm
Weight (kg)†	73 (17) kg
BMI (kg/m²)†	25 (5)
Etiology (n)	
Spontaneous	56%
Following recent abdominal surgery	30%
Accident/sports injury	5%
Pregnancy	3%
After a flu	3%
Other	3%
Duration of pain prior to diagnosis (months)*	26 (1– >120)
NRS normal†	6 (2)
NRS peak†	8 (2)
Previous conservative treatment elsewhere for ACNES	62%
Abdominal wall point of max. pain location (dermatome)	
Th7	2%
Th8	8%
Th9	11%
Th10	24%
Th11	37%
Th12	18%
Abdominal wall point of max. pain location (side)	
Right	57%
Left	27%
Bilateral	16%

* Data are presented as medians with ranges.
† Data are presented as means with standard deviations.

Table 3
Factors associated with failure of an anterior neurectomy in ACNES patients; dermatome level was removed from multivariate analysis (P = .47).

	B (SE) [P value]	Odds	CI 95%
Constant	-2.51(0.30)		
Pain medication use	0.61(0.28)[.027]	1.84	1.07–3.17
Abdominal surgery in the past	0.62(0.28)[.026]	1.85	1.08–3.18
Paravertebral trigger points	0.95(0.32)[.003]	2.58	1.39–4.80
Effect diagnostic rectus block	1.32(0.33)[.000]	3.74	3.74–7.10

R² = 0.086 (Cox & Snell); 0.135 (Nagelkerke); Model X² 34.14 P < 0.001.
SE, standard error

and the presence of paravertebral tender points were found to be associated with anterior neurectomy failure in this study. Unfortunately, a prediction model based on these parameters had a low discriminative ability and did not provide clear cutoff values dictating whether a neurectomy should be denied. Possible reasons for low predictive properties may be related to the influence of other, unstudied factors or to the strict definition of therapy failure that was used in the present study. Nevertheless, the findings of this study will aid surgeons and pain specialists in deciding to more adequately counsel patients for a neurectomy, particularly if they have multiple risk factors.

Interestingly, the present study also demonstrates that traditional predictors of poor pain therapy outcome, such as female sex, duration of complaints, age, or opioid use, do not necessary apply in an ACNES population.²⁰ For instance, preoperative opioid use is a classic factor negatively influencing success of pain therapies.²¹ In the present study, pain medication use was not restricted to opioids and often included regimens of amitriptyline and gabapentin or just paracetamol. Rather than suggesting a mechanism of medication-induced hyperalgesia as is observed specifically with opioid use, this factor might reflect a certain coping style that negatively influences the subjective experience of

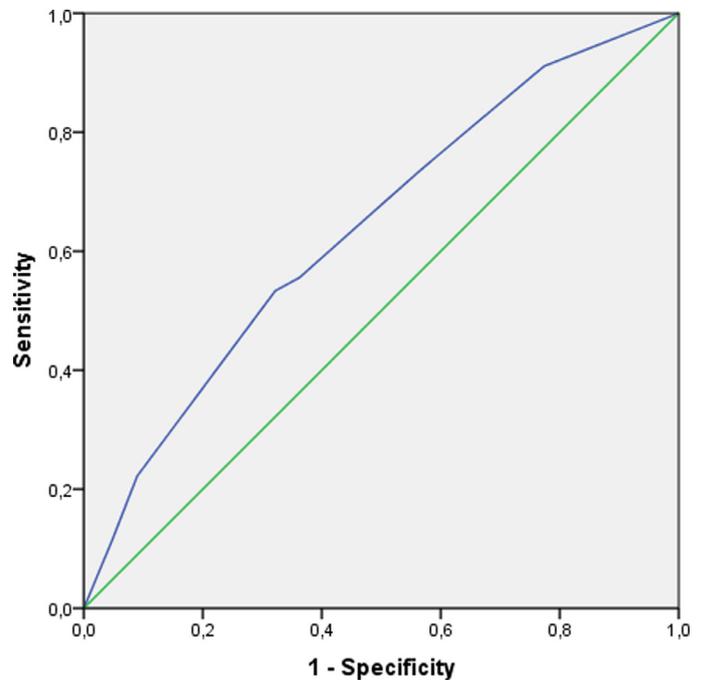


Fig. 3. ROC curve of a model with the 4 factors identified in multivariate analysis.

pain reduction opposed to patients who don't use any medication and rely on lifestyle adjustments.²² Addressing coping style in the preoperative workup should be an important part of counseling but is unfortunately often neglected.

The present study also identified abdominal surgery in the past as a factor associated with poor outcome after an anterior neurectomy. Earlier abdominal surgery, defined as either an open or a laparoscopic procedure before the intake consultation, may have changed normal anatomy of the abdominal wall. Tissue in proximity to incisions or trocar entry points may have scarred, and the sheer inflation of the abdominal cavity during laparoscopic surgery could also possibly damage small cutaneous nerves by an excessive traction force, creating a suboptimal and unpredictable surgical plane and a changed anatomy of the abdominal wall for an anterior neurectomy to be of effect. It is, however, remarkable that if surgery is identified clearly as the onset mechanism for ACNES by the patient, this sole factor did not appear to be of significant importance on the final outcome of a neurectomy, compared to the majority of patients who spontaneously develop symptoms without evident cause. We should realize that, by the definition that was used in our study, patients who labelled etiology as being related to recent abdominal surgery (n = 144) were also included in the larger group of those who scored any abdominal surgery in the past (n = 266). This could mean that lower numbers and power of the present data led to the previously mentioned outcome.

A third factor determining surgical failure is related to the patient's response to a diagnostic abdominal wall infiltration using an anesthetic agent. An inappropriate pain reduction after a diagnostic block may indicate central sensitization or spread, or a faulty administration. One may decide to repeat this block as it is our experience that a second effort may be successful, possibly using ultrasound guidance. However, even unsuccessful rectus sheath blocks do not necessarily result in futile surgery. The value of this important risk factor must be discussed with each potential patient before embarking on surgery.

A fourth risk factor associated with an unsuccessful result after an anterior neurectomy is the presence of paravertebral tender points. This finding suggests a spread of abnormal stimulation over

the entire sensory nerve trunk.²³ In essence, ACNES is an entity involving intercostal nerves, or portions thereof. One may speculate that the severity of the intercostal nerve dysfunction is reflected by the extension of the painful area. In other words, a subgroup of ACNES patients having pain in the abdominal flank and the back area (along all portions of the intercostal nerve) are more likely to suffer from a more severe form that may be refractory to an anterior neurectomy. It is advised to standardly check for trigger points along the flank and back because their presence may be used in the counselling of preoperative patients. Conversely, paravertebral PRF treatment or dorsal root ganglion stimulation may possibly be more beneficial in these patients.²⁴

Identifying risk factors associated with an anterior neurectomy fuels the discussion on the etiology of this intriguing syndrome. Although entrapped end twigs of intercostal nerves traversing the rectus muscles are supposedly the culprit in this peripheral neuropathy, anatomical findings show that the anterior ventral branches of intercostal nerves seem to travel rather freely over the muscles toward the skin.²⁸ Neuroma formation, a feared complication after neurectomies such as Morton's neuralgia, may potentially also be found in "postsurgical" ACNES. However, neuroma formation is seldom demonstrated during ACNES surgery.²⁵ Histological hallmarks of entrapment, such as perineural fibrosis or edema, are also only incidentally encountered. These findings suggest that other than pure mechanistic pathways may be responsible for the pain in a large portion of patients. The role of segmental relations between intercostal nerves and viscera via splanchnic chains explaining pain in some patients is also unclear.^{26,27}

In conclusion, the results of this study will prove valuable to surgeons and pain specialists who consider performing a neurectomy for ACNES but primarily find clinical application in counselling patients before surgical intervention who have 1 or multiple risk factors. There are no better treatment options at this point, and clear harm–benefit considerations are lacking as postdissection pain, hematoma, seroma, infection, or other permanent complications are scarce.¹² Thus, a neurectomy could always be explored. But the chance of increased risk of failure should be explicitly addressed.

Conflicts of interest

The authors have indicated that they have no conflicts of interest regarding the content of this article.

References

- McGarrity TJ, Peters DJ, Thompson C, McGarrity SJ. Outcome of patients with chronic abdominal pain referred to chronic pain clinic. *Am J Gastroenterol*. 2000;95:1812–1816.
- Srinivisan R, Greenbaum DS. Chronic abdominal wall pain: a frequently overlooked problem. Practical approach to diagnosis and management. *Am J Gastroenterol*. 2002;97:824–830.
- van Assen T, Boelens OB, Kamphuis JT, Scheltinga MR, Roumen RM. Construction and validation of a questionnaire distinguishing a chronic abdominal wall pain syndrome from irritable bowel syndrome. *Frontline Gastroenterol*. 2012;3:288–294.
- Lindsetmo RO, Stulberg J. Chronic abdominal wall pain—a diagnostic challenge for the surgeon. *Am J Surg*. 2009;198:129–134.
- Carnett JB. Intercostal neuralgia as a cause of abdominal pain and tenderness. *Surg Gynecol Obstet*. 1926;42:8.
- Applegate WV, Buckwalter NR. Microanatomy of the structures contributing to abdominal cutaneous nerve entrapment syndrome. *J Am Board Fam Pract*. 1997;10:329–332.
- Carnett JB, Bates W. The treatment of intercostal neuralgia of the abdominal wall. *Ann Surg*. 1933;98:820–829.
- Boelens OB, Scheltinga MR, Houterman S, Roumen RM. Management of anterior cutaneous nerve entrapment syndrome in a cohort of 139 patients. *Ann Surg*. 2011;254:1054–1058.
- Maatman RC, Steegers MAH, Boelens OBA, Lim TC, van den Berg H, van den Heuvel SAS, Scheltinga MR, Roumen RMH. Pulsed radiofrequency or anterior neurectomy for anterior cutaneous nerve entrapment syndrome (ACNES) (the PULSE trial): study protocol of a randomized controlled trial. *Trials*. 2017;18:362.
- Boelens OB, van Assen T, Houterman S, Scheltinga MR, Roumen RM. A double-blind, randomized, controlled trial on surgery for chronic abdominal pain due to anterior cutaneous nerve entrapment syndrome. *Ann Surg*. 2013;257:845–849.
- van Assen T, Boelens OB, van Eerten PV, Scheltinga MR, Roumen RM. Surgical options after a failed neurectomy in anterior cutaneous nerve entrapment syndrome. *World J Surg*. 2014 Dec;38(12):3105–3111.
- van Assen T, Boelens OB, van Eerten PV, Perquin C, Scheltinga MR, Roumen RM. Long-term success rates after an anterior neurectomy in patients with an abdominal cutaneous nerve entrapment syndrome. *Surgery*. 2015;157:137–143.
- Dworkin RH, et al. Interpreting the clinical importance of group differences in chronic pain clinical trial: IMMEDIATE recommendations. *Pain*. 2009;146:238–244.
- Stahmer SA, Shofer FS, Marino A, Shepherd S, Abbuhl S. Do quantitative changes in pain intensity correlate with pain relief and satisfaction. *Acad Emerg Med*. 1998;5:851–857.
- Filligim RB, King CD, Ribeiro-Dasilva MC, Rahim-Williams B, Riley III JL. Sex, gender, and pain: a review of recent clinical and experimental findings. *Pain*. 2009;10:447–485.
- Pickering G, Jourdan D, Eschalier A, Dubray C. Impact of age, gender and cognitive functioning on pain perception. *Gerontology*. 2002;48:112–118.
- Khimich S. Level of sensitivity of pain in patients with obesity. *Acta Chir Hung*. 1997;36:166–167.
- Dunn KM, Croft PR. The importance of symptom duration in determining prognosis. *Pain*. 2006;121:126–132.
- Siawash M, R Maatman, Tjon a Ten W, van Heurn E, Roumen R, Scheltinga M. Anterior neurectomy in children with a recalcitrant anterior cutaneous nerve entrapment syndrome is safe and successful. *J Pediatr Surg*. 2017;52:478–480.
- Wandner LD, Scipio CD, Hirsh AT, Torres CA, Robinson ME. The perception of pain in others: how gender, race and age influence pain expectations. *J Pain*. 2012;13:220–227.
- Roeckel LA, Le Coz GM, Gaveriaux-Ruff C, Simonin F. Opioid-induced hyperalgesia: cellular and molecular mechanisms. *Neuroscience*. 2016;338:160–182.
- Edwards RR, Dworkin RH, Sullivan MD, Turk DC, Wasan AD. The role of psychosocial processes in the development and maintenance of chronic pain. *J Pain*. 2016;17(9 Suppl):T70–T92.
- Marchettini P, Lacerencia M, Mauri E, Marangoni C. Painful peripheral neuropathies. *Curr Neuro Pharm*. 2006;175:175–181.
- Cohen SP, Sireci A, Wu CL. Pulsed radiofrequency of the dorsal root ganglia is superior to pharmacotherapy or pulsed radiofrequency of the intercostal nerves in the treatment of chronic postsurgical thoracic pain. *Pain Physician*. 2006;9:227–235.
- Ferkel E, Davis WH, Ellington JK. Entrapment neuropathies of the foot and ankle. *Clin Sports Med*. 2015;34:791–801.
- Luz LL, Fernandes EC, Sivado M, Kokai E, Szucs P, Safronov BV. Monosynaptic convergence of somatic and visceral C-fiber afferents on projection and local circuits in lamina I: a substrate for referred pain. *Pain*. 2015;156:2042–2051.
- Roumen RMH, Vening W, Wouda R, Scheltinga MR. Acute appendicitis, somatosensory disturbances ("head zones"), and the differential diagnosis of anterior cutaneous nerve entrapment syndrome (ACNES). *J Gastrointestinal Surg*. 2017;21:1055–1061.
- Mol FMU, Lataster A, Scheltinga MR, Roumen RM. Anatomy of abdominal anterior cutaneous intercostal nerves with respect to the pathophysiology of anterior cutaneous nerve entrapment syndrome (ACNES): A case study. *Submitted*.