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Anatomy of abdominal anterior cutaneous intercostal nerves with respect to the pathophysiology of anterior cutaneous nerve entrapment syndrome (ACNES): A case study

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ABSTRACT

Introduction: Anterior Cutaneous Nerve Entrapment Syndrome is allegedly caused by entrapment of an intercostal nerve in a fibrous ring in the rectus abdominis muscle leading to neuropathic pain. Surgical release of the strained nerve (neurectomy) obtains adequate pain relief in 70% of patients. Standard anatomy texts and previous research however might underestimate the complex network of nerve branches in the abdominal wall, leading to suboptimal treatment results and misguided pathophysiology.

Material and methods: One fresh frozen cadaver with no gross previous pathology was dissected to map the course of intercostal nerves from the lateral abdominal wall to their nerve terminals in the subcutis of the anterior abdominal wall. Histology was performed to differentiate between nerve tissue and fascia. Special attention was payed to fibrous ring like structures.

Results: Five major neurovascular bundles were identified (T8-T12). Fibrous rings were not found intramuscularly but in the posterior rectus sheath, if present. Multiple neural interconnections at the lateral border of the posterior rectus sheath were found. Per dermatome several small branches perforated the rectus abdominis muscle.

Conclusions: The trajectory of nerves in the abdominal wall appears to be more complex than previously suggested, which should be addressed when for instance a neurectomy is performed.

1. Introduction

A frequently overlooked cause of chronic abdominal wall pain is the anterior cutaneous nerve entrapment syndrome (ACNES). This syndrome is characterized by an exceedingly painful peripheral neuropathy, allegedly caused by entrapped sensory cutaneous terminal branches of abdominal intercostal nerves innervating the skin of the lateral and anterior abdominal wall [1,2]. Entrapment may occur at various anatomic sites, for instance where the nerve passes through fibrous or osseofibrous structures or penetrates muscles as also observed in carpal tunnel syndrome and sciatic nerve entrapment [3,4]. In the case of ACNES this concerns the 6 lowest intercostal nerves (T7–T12) which are anchored (1) to the spinal cord, (2) to the dorsal branch of the spinal nerve, (3) at the level where the lateral cutaneous branch originates, (4) at the entering point of the anterior cutaneous branch into the posterior rectus sheath and (5) to the skin. (Fig. 1).

According to one previous microanatomy study the most likely anatomical site of entrapment is the point where the neurovascular bundle enters the posterior rectus abdominis sheath it makes a nearly 90° turn, piercing through the rectus muscle, eventually reaching the skin (Fig. 2). The author of this study claimed that the neurovascular bundle is encircled at this level by a fibrous ring, located intramuscular just anterior from the posterior rectus sheath (Fig. 3). He suggested that connective fat tissue is able to herniate within this ring once changes in intraabdominal pressure occur. This chain of events would result in neural ischemia causing pain [5,6].

ACNES can therefore occur in each dermatome of the trunk that is innervated by the lower six intercostal nerves. Patients typically complain of abdominal pain at a one-finger-tip specific point projecting over the rectus abdominis muscle. Pain is often severe requiring

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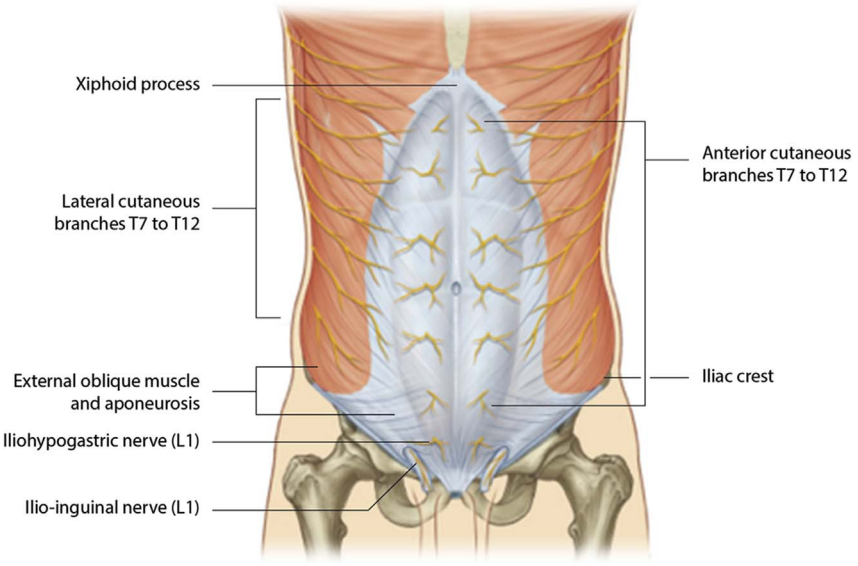

Fig. 1. Lateral and anterior cutaneous nerve branches of the abdominal wall.
Source: Drake et al.: Gray's Anatomy for Students, 2nd edition Copyright 2009 by Churchill Livingstone, an imprint of Elsevier, Inc., chapter 44; The Abdomen, page 259.

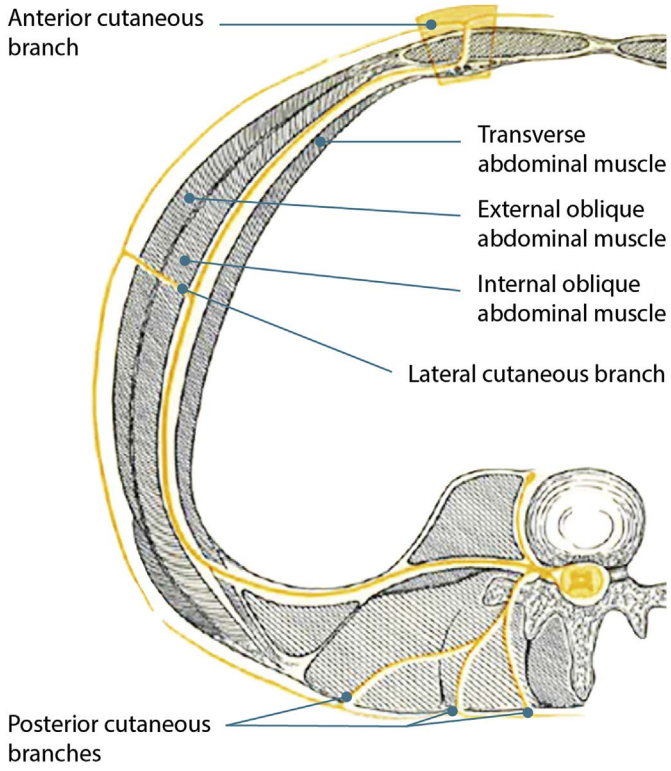

Fig. 2. Anchoring points of the intercostal nerve from back to abdominal wall. The anterior branch makes a sharp 90° turn through the rectus muscle. Illustration from Applegate WV, Abdominal cutaneous nerve entrapment syndrome. Am Fam Physician. 1973 Sep; 8(3):132–3.

selective nerve blocks or even a surgical intervention [7]. A neurectomy appeared to be an effective treatment modality as demonstrated in a double blind randomized setting [8]. The rationale of this procedure is to remove the pain generating nerve terminals and to release the entrapped nerve. Two types of procedures are performed. The first approach focuses on the nerve terminals at the site of the *anterior* fascia of the rectus abdominis muscle and obtains adequate pain relief in some 70% of operated patients [9]. Patients who experience insufficient pain relief after this procedure are eligible for a second operation. During this procedure, the neurovascular bundle is identified and removed at the posterolateral border of the muscle. The success rate of this secondary procedure is between 50 and 60% [10].

Observations based on approximately 150 secondary neurectomy procedures performed by the two senior authors (RR and MS) indicate that the anatomy of these intercostal nerve terminals is more variable and complex than suggested in standard anatomy texts. The aim of the present study was to take a first step in exploring and delineating the topography of the intercostal nerves at the level of the rectus muscle through cadaveric dissection and to relate the observed anatomical patterns to clinical aspects of ACNES.

2. Materials and methods

A fresh frozen cadaver was dissected at the Department of Anatomy and Embryology, Faculty of Health, Medicine Life Sciences of Maastricht University, Maastricht, the Netherlands by two experienced surgeons (RR and MS) who also perform neurectomy procedures. The cadaver was of an 84-year old female without gross pathology, previous surgical procedures or traumatic lesions to the abdomen or pelvis. The dissection procedure started with a 20 cm longitudinal incision some 15 cm lateral to the midline xyphoid process-umbilicus-symphysis. The left external and internal oblique abdominal muscles were dissected, exposing the left transverse abdominal muscle and the fascia transversalis. Five major neurovascular bundles (T8-T12) were identified within this plane and were followed proximally and distally. Tissue samples were collected and processed for histology at the Department of Anatomy and Embryology using standard Hematoxylin & Eosin (HE) staining to differentiate nerve tissue from fascia connections and blood vessels and confirm the presence of neural tissue and Osmium Tetroxide (OsO_4) staining more specifically for myelin.

During dissection, images were recorded with a Panasonic Lumix digital camera (model: DMC-FZ3). Specific attention was payed to nerve interconnections, plane of penetration and branches that penetrated the fascia of the anterior rectus sheath.

3. Results

Five major neurovascular bundles were exposed using a latero-medial approach (Fig. 4). Histology confirmed the presence of multiple separate nerve fibers in all bundles (Fig. 5), (Table 1). T11 (black) and T10 (red) were traced distally to where they enter the posterior rectus muscle sheath. At this point, a network of interconnections was observed before the remaining anterior bundles branched into several minor perforators disappearing into the rectus muscle (Fig. 6). A fibrous