# Perforator-guided drug injection in the treatment of abdominal wall pain

**Running title**

Perforator-guided drug injection

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**ABSTRACT**

**Background:** Pain from the abdominal wall can be caused by nerve entrapment, a condition called abdominal cutaneous nerve entrapment syndrome (ACNES). As an alternative to surgery, ACNES may be treated with injection of local anesthetics, corticosteroids or botulinum toxin at the point of maximal pain.

**Method:** The point of maximal pain was marked on the abdominal skin. Using color Doppler ultrasound, the corresponding exit point of perforating blood vessels through the anterior fascia of the rectus abdominis muscle was identified. Ultrasound-guided injection of botulinum toxin in close proximity to the perforator's exit point was performed below and above the muscle fascia.

**Results:** The technique was used from 2008 to 2014 on 15 patients in 46 sessions with a total of 128 injections without complications. The injection technique provided safe and accurate administration of the drug in proximity to the affected cutaneous nerves. The effect of botulinum toxin on ACNES is beyond the scope of this article.

**Conclusion:** Perforator-guided injection enables precise drug administration at the location of nerve entrapment in ACNES in contrast to blind injections.

**KEY WORDS**

Abdominal wall pain, abdominal cutaneous nerve entrapment syndrome, ultrasound-guided injection, perforator anatomy

## INTRODUCTION

Chronic abdominal wall pain (CAWP) is a diagnostic challenge and the abdominal wall may be the source of CAWP in 10 to 30 % of patients presenting with abdominal pain (1). CAWP is often caused by nerve entrapment, a condition that has been more precisely named *anterior cutaneous nerve entrapment syndrome* (ACNES) (2). Carnett described a simple clinical test to differentiate abdominal pain that has its origin in the abdominal wall from abdominal pain caused by an intraabdominal cause (1, 2). A positive Carnett's test indicates that the pain comes from the abdominal wall. Pain relief after injection of a local anesthetic at the point of maximal pain gives further support to the diagnosis of ACNES (1).

There are different treatment options for ACNES ranging from surgery to injection of local anesthetics, corticosteroids or botulinum toxin at the location of nerve entrapment (2-4). Although such injections can be performed blindly, inaccurate placement of the needle tip may give suboptimal results. With blind injections there is also a risk of entering the abdominal cavity. Kanakarajan et al. used ultrasound-guided injections based on anatomical landmarks for optimal placement of the needle tip (5). However, their technique is limited to nerves in neurovascular bundles perforating the lateral part of the rectus muscle. The pain in ACNES has been associated with nerve entrapment at the level of the exit point through the anterior fascia of the abdominal rectus muscle (6). Anatomical studies show that cutaneous nerves follow perforating vessels on their course

through this fascia (7). Nerves supplying cutaneous sensation can travel with both medial and lateral vascular perforators (8). Color Doppler ultrasound enables us to visualize the exit points of perforating vessels through the anterior muscle fascia, not only in the lateral part, but also at other locations where pain may be associated with entrapment of a perforating nerve. We describe a new approach in treatment of ACNES using ultrasound-guided injection based on perforator anatomy.

## METHOD

All patients referred for injection treatment of ACNES with botulinum toxin in the period 2008 to 2014 were included in the study. The study was performed in agreement with in-house ethical guidelines and the Helsinki Declaration.

In the supine position, points of maximal tenderness were localized by the patient using one finger and marked on the skin with a permanent marker. The abdominal skin was sanitized. The marked points were examined with color Doppler using a General Electric Logiq 9 or E9 ultrasound machine with a 9 MHz linear transducer (General Electric, Milwaukee, Wisconsin, USA). The exit points of perforator vessels were localized in proximity to each point marked on the skin (figure 1). To avoid compression of the perforating vessels, care was taken to avoid excessive pressure on the skin. The exit points of the perforating vessels through the anterior muscle fascia were identified.

A 21G 80 mm injection needle was inserted through the skin at the short side of the transducer's footprint in the direction of each perforator's exit point (figure 2). The tip of the needle was continually kept within the tissue plane visualized by the transducer. The tip was advanced through the anterior muscle fascia in close proximity to the exit point of the perforator. Typically, patients report a short period of sudden pain exaggeration in relation to the injection of botulinum toxin in proximity to the nerve. After aspiration to rule out intravascular position of the needle, botulinum toxin 40 IU/mL in saline solution (Botox; Allergan Inc., Irvine, CA, USA) without addition of local anesthetic was distributed evenly below and above the anterior muscle fascia around the perforator's exit point (figure 3). The concentration of 40 IU/mL was chosen to obtain high tissue concentration locally. Lower concentration would require higher injection volumes with a risk for increased diffusion away from the nerve with possible inadvertent effects such as muscle denervation.

**RESULTS**

The technique was used from 2008 to 2014 on 15 patients (8 females and 7 males) with mean age 42.5 years (range 19-81) in 46 sessions with a total of 128 injections (table 1). The average number of tender spots treated per session was 2.7 (range 1-8) and the average dose of botulinum toxin 40 IU/mL was 42 IU per tender spot (range 12.5-100). No patients received more than 200 IU in one session. In all patients, color Doppler visualized a perforator with an exit point in close proximity to each overlying mark on the skin. The points of maximal pain could be positioned over both the lateral and medial part of the rectus abdominis

muscle. While vessels could be identified with color Doppler, we could not clearly identify individual nerves on the ultrasound images. The injection technique provided safe and accurate administration of the drug in close proximity to the affected cutaneous nerves.

On evaluation during follow-up none of the patients had complications in relation to the injections. The effect of botulinum toxin on ACNES is beyond the scope of this article. Almost all patients responded well with considerable pain reduction after injection. Therefore most patients also returned for repeated treatment when the effect of botulinum toxin had subsided.

## DISCUSSION

Injections of local anesthetics, corticosteroids or botulinum toxin are promising alternatives to surgical treatment of ACNES (1, 2, 4). As ACNES is related to nerve entrapment at the exit point of the anterior muscle fascia, it is important that the needle tip is properly placed at this level. Although it is possible to perform this injection blindly, there is no guarantee that the injected substance is placed in the most optimal position. Such may influence the effectiveness of the treatment. Visualization of a perforator at the exit point in proximity to the mark on the skin ensures that the drug is delivered in the right place. We noticed that an exaggeration of pain occurred as the needle was placed in proximity to the perforator's exit point. This pain had a similar character as the pain experienced due to ACNES, which provides indirect confirmation that the drug was injected close to the point of nerve entrapment. A further indirect confirmation is

obtained from the fact that the patients without knowledge on the anatomy pointed directly at the exit points of perforators. These findings indirectly support the diagnosis of ACNES.

Some authors have reported on the use of ultrasound-guided injections in the treatment of ACNES based on visualization of anatomical landmarks without using color Doppler (5, 9). These techniques rely on anatomical landmarks and only visualize lateral neurovascular bundles as they perforate the rectus muscle. In the same way as these authors we could visualize the neurovascular bundle with ultrasound and the individual vessels could be identified with color Doppler. However, we were unable to identify individual nerves on the ultrasound images, which is the reason why we rely on color Doppler visualization of the vascular structures.

Plastic surgeons have contributed significantly to the knowledge on perforators of the abdominal wall, as these perforators are frequently used for blood supply of transposed tissue in reconstructive surgery (10). The perforator complex normally consists of a perforating artery, one or two comitant veins and a cutaneous nerve (7). The technique is a spin-off from our experience with sensate perforator flaps (11-13) and deep inferior epigastric perforator (DIEP) flap breast reconstruction (10). During dissection of perforator flaps we regularly see how the cutaneous nerves follow the path of perforating vessels as they travel through or between muscles (figure 4).

Our new approach for perforator-guided injection in the treatment of ACNES is based on this anatomical knowledge. Taylor et al. documented in their anatomical studies that cutaneous nerves emerge in conjunction with perforating blood vessels in both the medial and lateral part of the abdominal rectus muscle (7). Yap et al. performed dissections of neurovascular bundles in the rectus muscles and showed that sensory nerves can travel with both medial and lateral vascular perforators (8). Histological examinations confirmed the presence of nerve tissue in 94 % of cadaveric and 93 % of clinical specimens. Other authors also support these findings.

In our material we observed that in the same patient ACNES can be caused by entrapment of several nerves. The pain locations were located not only along the lateral part of the rectus muscle as frequently has been reported by others (3, 5, 14), but our results also show pain locations in relation to perforators emerging through the medial part of the rectus muscle. Although ultrasound does not visualize the nerve directly, color Doppler visualizes the perforating vessels accompanying the nerve. The technique thereby permits precise administration of botulinum toxin in proximity to the location where nerve entrapment is anticipated to occur that is at the exit point through the fascia. We have routinely used this technique in our university hospital since 2008 and have not registered any complications.

## CONCLUSION

Perforator-guided injection enables precise drug administration at the location of nerve entrapment in ACNES in contrast to blind injections.

## CONFLICT OF INTEREST STATEMENT

None of the authors has any financial interest, and none of the authors has any conflicts of interest.

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| Patient | Sex | Age | Sessions | Injections |
|---|---|---|---|---|
| 1 | F | 32 | 6 | 12 |
| 2 | F | 21 | 13 | 35 |
| 3 | F | 43 | 2 | 5 |
| 4 | M | 49 | 7 | 23 |
| 5 | F | 20 | 1 | 4 |
| 6 | M | 32 | 3 | 7 |
| 7 | M | 48 | 3 | 10 |
| 8 | F | 63 | 3 | 7 |
| 9 | M | 37 | 1 | 4 |
| 10 | F | 19 | 1 | 8 |
| 11 | M | 53 | 2 | 2 |
| 12 | F | 45 | 2 | 6 |
| 13 | F | 32 | 1 | 1 |
| 14 | M | 81 | 1 | 2 |
| 15 | M | 64 | 1 | 2 |

**Table 1**

Patient age (average in cases with multiple sessions), sex, sessions per patient and total number of injections per patient.

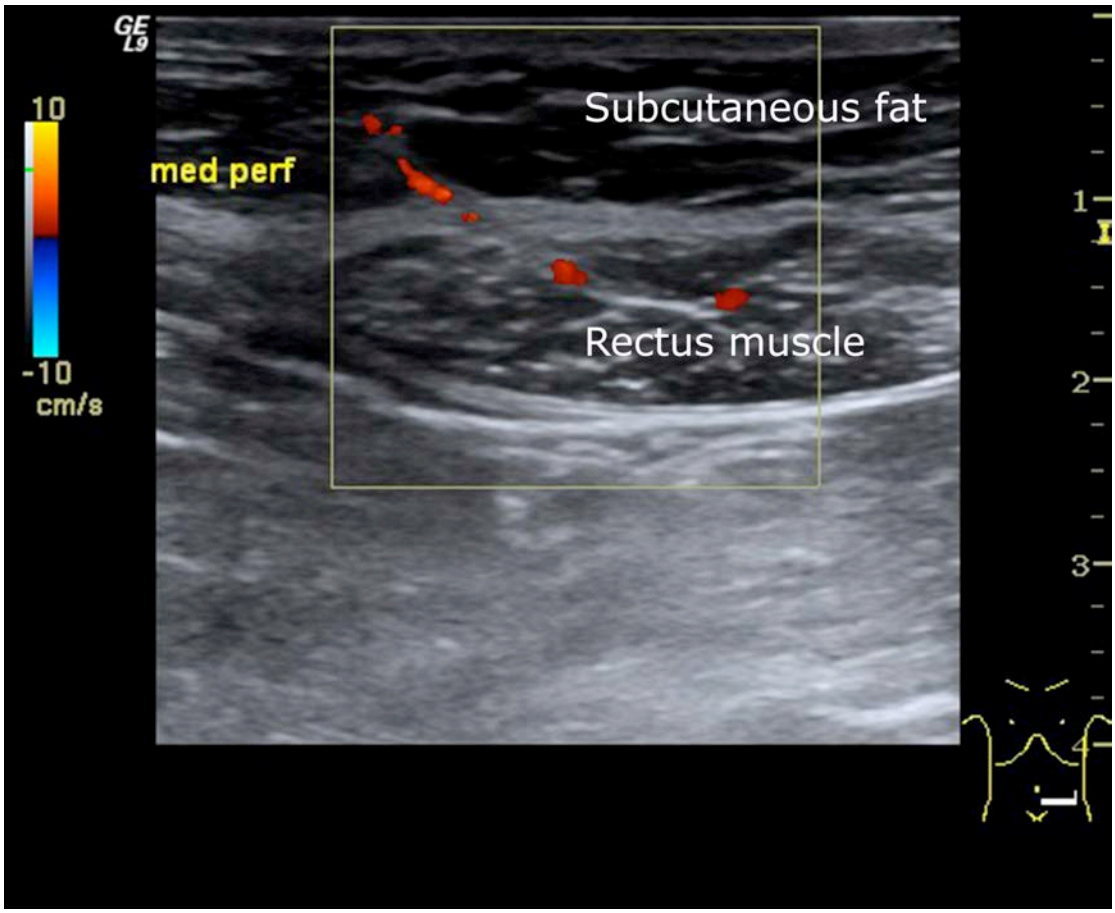


**Figure 1**

A medial perforator from the deep inferior epigastric artery visualized with color Doppler. As a part of the perforator complex, the cutaneous nerve follows the course of the vessels.

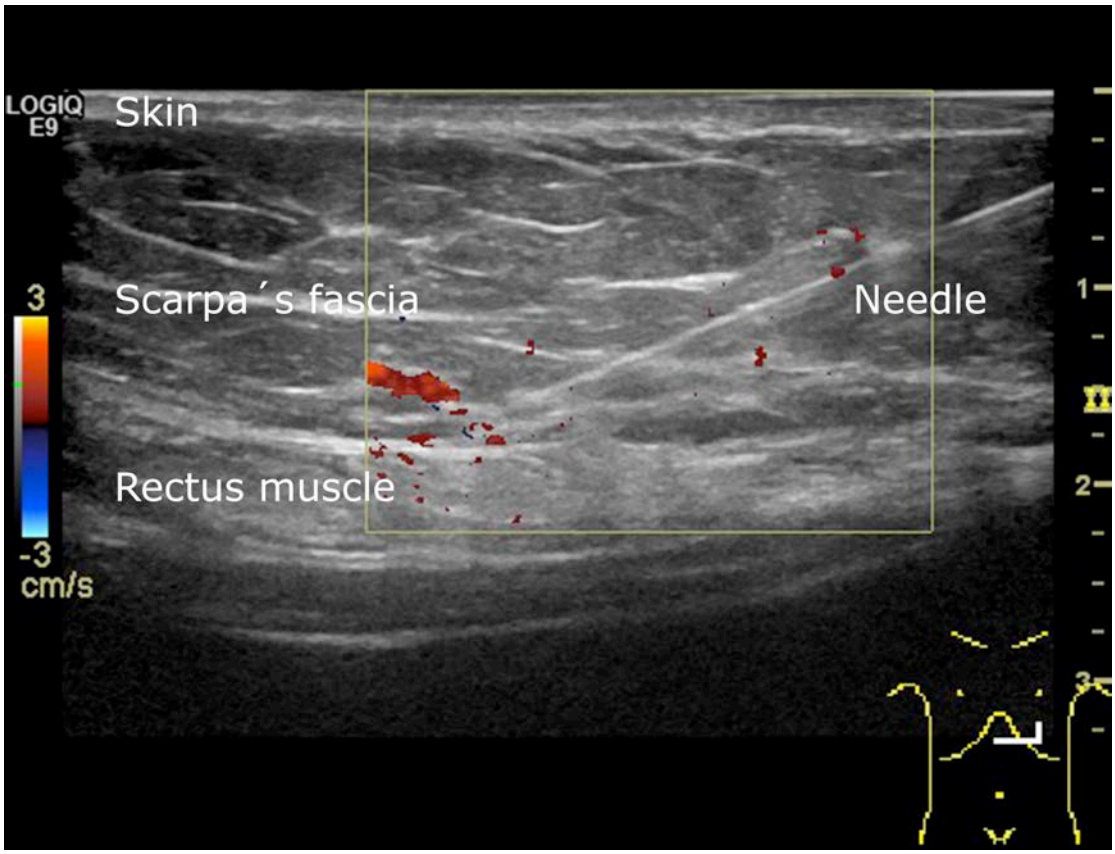


**Figure 2**

The needle tip is kept within the visualized plane toward the perforator´s exit point through the anterior fascia of the rectus abdominis muscle.

**Figure 3**

Using color Doppler the exit point of the perforator through the anterior rectus fascia is visualized. Ultrasound guided positioning of the needle tip near this exit point ensures precise drug administration.

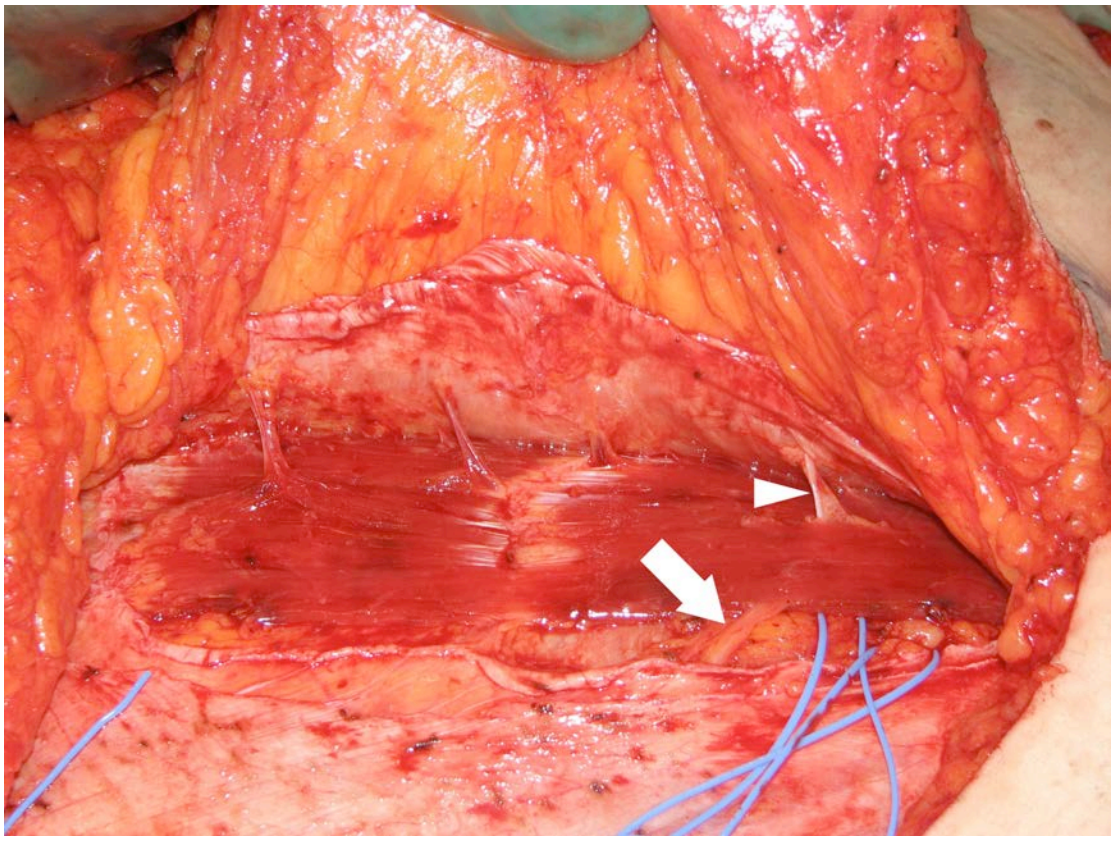

**Figure 4**

Dissection of a DIEP flap: Intercostal nerves (arrow) give off sensory branches (arrowhead) that follow vascular territories through the muscle towards the skin.