

Effective dermatomal blockade after subcostal transversus abdominis plane block

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ABSTRACT

INTRODUCTION: The ultrasound-guided transversus abdominis plane (TAP) block is used to treat postoperative pain after abdominal surgery. Abdominal wall sensory nerves are anaesthetised by injecting local anaesthetics into the neurofascial plane between the internal oblique and the transversus abdominis muscles. Sensory assessment of a TAP block may guide the decision on the extent of the block. The purpose of this study was to investigate if the dermatomal extent of sensory blockade after injection of 20 ml 0.5% ropivacaine bilaterally into the TAP can be assessed using cold and pinprick sensation.

MATERIAL AND METHODS: Subcostal TAP block was performed bilaterally in 20 awake patients scheduled for elective abdominal surgery. Sensory change in dermatomes T4-L4 was tested with pinprick using a blunt needle and cold disinfectant swabs after 10, 20 and 30 minutes.

RESULTS: Data from 20 patients (40 blocks) were analysed. Eighteen patients registered sensory change after subcostal TAP block, and dermatomes T10-T12 were blocked after 30 minutes in all of these patients. Spread of sensory change to dermatomes T5-L3 was variable.

CONCLUSION: This study confirmed that the dermatomal extent of a sensory blockade after a single-shot subcostal TAP block can be assessed using cold and pinprick sensation.

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TRIAL REGISTRATION: The study was registered at clinicaltrials.gov with the registration number NCT01024868.

The transversus abdominis plane (TAP) block is a regional block used for postoperative pain treatment after abdominal surgery. The anterolateral abdominal wall is innervated by peripheral nerves of spinal roots T6-L1. The purpose of the TAP block is to anaesthetise these sensory nerves by injecting 20-40 ml of local anaesthetics into the neurofascial plane between the internal oblique and the transversus abdominis muscles.

The TAP block was first described by Rafi in 2001 [1]. The clinical effect of the landmark technique was investigated in several trials [2-4]. Hebbard studied the use of ultrasound (US)-guided TAP block in 2007 [5]. Subcostal, oblique subcostal and posterior (triangle of Petit) approaches to TAP block are described in the

literature [5, 6]. Evaluation of the TAP block has shown promising results as part of multimodal postoperative pain management after various abdominal surgical procedures [7].

Barrington, Tran and McDonnell assessed the spread of local anaesthetics in cadavers [8-10]. Only one study has investigated the distribution of dermatomal sensory blockade after different TAP block approaches [11]. Another study included assessment of the TAP block sensory change with pinprick, but evaluated the effect in no more than three patients [10]. The ability to assess sensory change after the TAP block may guide the clinician's intervention by helping him or her to determine the extent of the block, or if a surgical incision is within the area of the TAP block. It is important to ascertain if sensory change after a TAP block can be monitored by cold or pinprick test before these tests can be correlated to assessment of clinical analgesia in future studies. The purpose of this study was therefore to investigate if the sensory extent of a TAP blockade after injection of 20 ml ropivacaine 0.5% bilaterally can be assessed by using cold and pinprick sensation.

MATERIAL AND METHODS

The local ethics committee was consulted about the study and decided that no ethics committee approval was needed since the study was regarded as a quality assurance study. The TAP block as described in this study is part of routine care for patients undergoing gynaecological and abdominal surgery at Herlev Hospital.

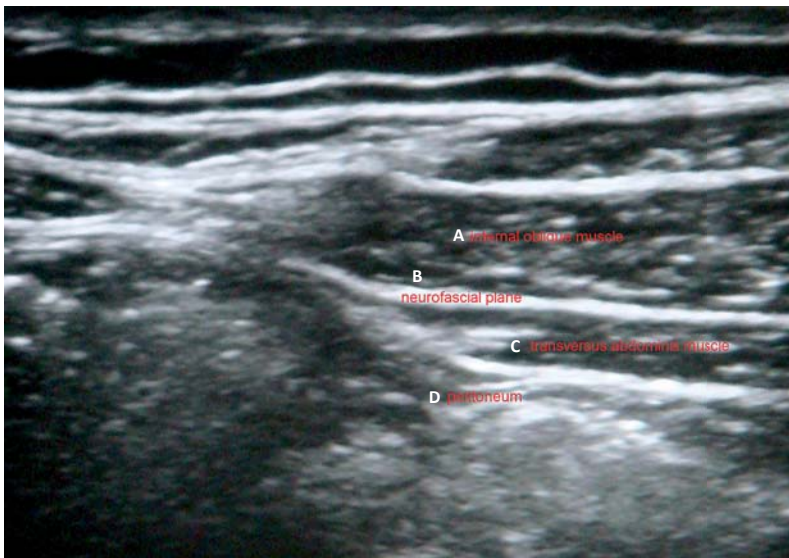
Patients scheduled for elective abdominal or gynaecological surgery under general anaesthesia combined with TAP block were included in the study from December 2009 to March 2010. Written informed consent was obtained from the patients before their enrolment in the study. Patients with known allergies to local anaesthesia, patients less than 18 years old or with a body mass index (BMI) of less than 17 or more than 40 were excluded.

Patients were brought to the anaesthetic room one hour before operation. Standard monitoring with electrocardiogram, non-invasive arterial pressure and pulse oximetry was performed. Prior to the TAP block, normal

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Ultrasound identification of transversus abdominis plane (neurofascial plane) between internal oblique muscle and transversus abdominis muscle. A = internal oblique muscle; B = neurofascial plane; C = transversus abdominis muscle; D = peritoneum.

sensation in dermatomes T4-L4 was established by using a cold disinfectant and a blunt needle bilaterally in the midclavicular line.

The two clinical investigators used the same TAP block approach. The insertion site, 5-8 cm lateral to the sagittal plane at the level of the umbilicus, was identified and correct injection into the neurofascial plane between the internal oblique and the transversus abdominis muscles, lateral to the rectus sheath, was visualised using US, GE Medical Systems Logiqe. For facilitation of the TAP-block, 4 ml of lidocaine 1% was administered subcutaneously at the insertion site. Afterwards, the TAP-block was performed under US-guidance in the awake patient, with injection of 20 ml ropivacaine 0.5% bilaterally via Braun Stimuplex needles. We chose a common clinical method, i.e. assessment of pinprick and cold sensitivity. The patient was asked to register a prick or coldness, respectively, on the upper extremity. Sensory change was then assessed bilaterally in the midclavicular line, starting above dermatome T4, moving caudally to dermatome L4. Pinprick was tested with a blunt needle with minimal skin deformation and cold with cold disinfectant swabs at 10, 20 and 30 minutes after ropivacaine injection. The patient notified the examiner as soon as he perceived a change

in sensation. Variability of pressure was further limited as only two investigators were involved. As testing with cold was carried out with wet disinfectant swabs, the evaporation during the test was minimal. We used a standard dermatome chart where the xiphoid process corresponded to T6, umbilicus to T10 and the inguinal ligament to L1. Thereafter patients were anaesthetised and operated as scheduled. Postoperatively, the patients followed routine care and were not investigated further.

Data are described by median and range. Difference in sensory changes between pinprick and cold and difference in symmetrical spread were tested with Wilcoxon signed-rank test. The difference in spread over time for pinprick and cold, respectively, was tested with Friedman's test. Correlation of spread and demographic data such as age, height and weight were assessed by Spearman's rho. We used SPSS 18 for statistical analyses.

Trial registration: The study was registered at clinicaltrials.gov with the registration number NCT01024868.

RESULTS

Twenty-one patients scheduled for elective abdominal or gynaecological surgery under general anaesthesia combined with TAP block were included in the study. One patient felt uncomfortable during subcutaneous needle insertion prior to local anaesthetic injection. She did not want to continue with the awake TAP block on insertion of the TAP block needle and was excluded. Data from 20 patients (40 TAP blocks) were analysed. Baseline patient characteristics are shown in **Table 1**. All but one patient had normal sensitivity tested before TAP block application. That patient had previously undergone abdominal surgery and reported reduced sensitivity to pinprick but not to cold in dermatomes T11-L1.

Oxygen saturation, blood pressure and pulse rate remained stable throughout the observation period for 19 of the patients. One patient had a 33% drop in mean arterial blood pressure ten minutes after injection of 2.4mg/kg ropivacaine. There was a normal pulse rate and the patient was not clinically affected. Blood pressure remained at the lower value. The investigators achieved US visualisation of needle insertion and spread of local anaesthetic in all patients, although fascial plane separation on injection was not always clearly visible.

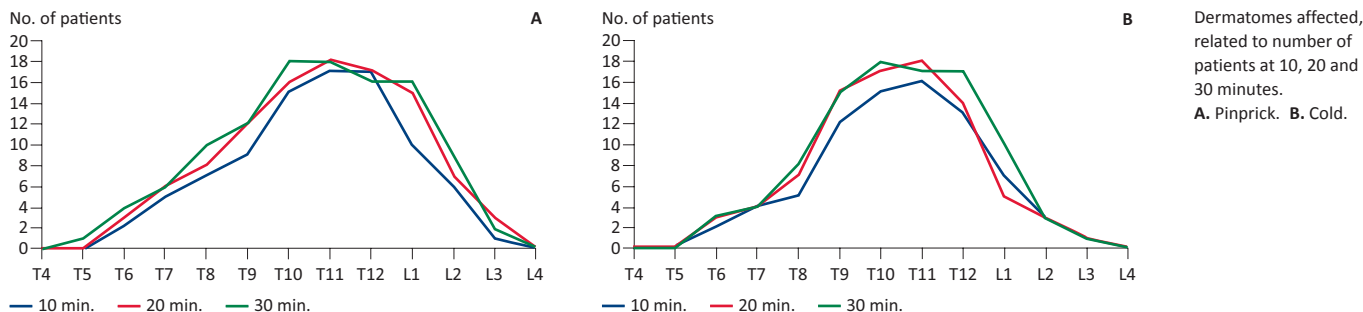
The dermatomes affected by sensory change over time, tested with pinprick and cold at 10, 20 and 30 minutes, are illustrated in **Figure 1** and **Figure 2**. Out of the 20 patients, 18 (90%) registered bilateral sensory change after the TAP block. The two remaining patients re-

TABLE 1

Baseline patient characteristics for the 20 patients completing the study.

Age, median (range), years	53 (32-81)
Sex ratio, M:F, n	9:11
Weight, median (range), kg	76 (48-106)
Height, median (range), cm	174 (160-196)
Body mass index, median (range), kg/m ²	25.4 (16.5-37.6)

FIGURE 1



ported no sensory change on either side after the TAP block had been performed. Each investigator had one failed block. One patient reported altered sensation to cold and pinprick from T5/6-L3, and one patient from T6-L2 bilaterally already ten minutes after ropivacaine injection, whereas only dermatomes T9-L1 were affected in the majority of patients.

The extent of sensory change increased significantly from 10 to 30 minutes (Figure 1), with p-values of 0.00006 for pinprick and 0.0006 for cold. The median number of dermatomes blocked after 30 minutes was six (interquartile range (IQR) 4-9) for pinprick and five for cold (IQR 4-6.75) (Figure 2). **Figure 3** shows the median upper and lower extent of sensory blockade of the affected dermatomes. No significant difference in sensory change between pinprick and cold after 30 minutes ($p = 0.17$) was observed. Asymmetrical extent of sensory change comparing left and right was insignificant for both pinprick and cold. Mean values for right and left were therefore calculated and used for further statistical analysis.

A significant correlation was seen between age and spread of sensory change, with a correlation coefficient (r_s) for age and pinprick of 0.56 ($p = 0.01$), and for age and cold of 0.46 ($p = 0.04$) after 30 minutes. The correlation coefficient for height and pinprick was significant ($r_s = 0.47$, $p = 0.04$), but not for height and cold ($r_s = 0.43$, $p = 0.06$).

We used a fixed volume of 0.5% ropivacaine. The ropivacaine dose in mg/kg did not influence the sensory change as there was no correlation between weight and the extent of sensory change of the TAP block assessed with both pinprick and cold ($r_s = -0.06$, $p = 0.81$ and $r_s = -0.05$, $p = 0.82$, respectively).

DISCUSSION

The basic finding of the present study was that bilateral US-guided subcostal TAP block produced a sensory blockade to pinprick as well as cold test in 18/20 patients, and that the distribution of this blockade varied

between patients with 75% of patients reporting a sensory change from T10 to L1 to pinprick, and from T9-T12 to cold after 30 minutes (Figure 1).

Some studies investigating sensory change after epidural analgesia indicated that there is a correlation between the number of dermatomes affected by epidural analgesia, tested with cold and pinprick, and pain during and after surgery [12-14]. The extent of the sen-

FIGURE 2

Median (solid black line), interquartile range (coloured), minimum and maximum spread of sensory blockade of dermatomes (vertical line) over time (red circles are outlying patients). A. Pinprick. B. Cold.

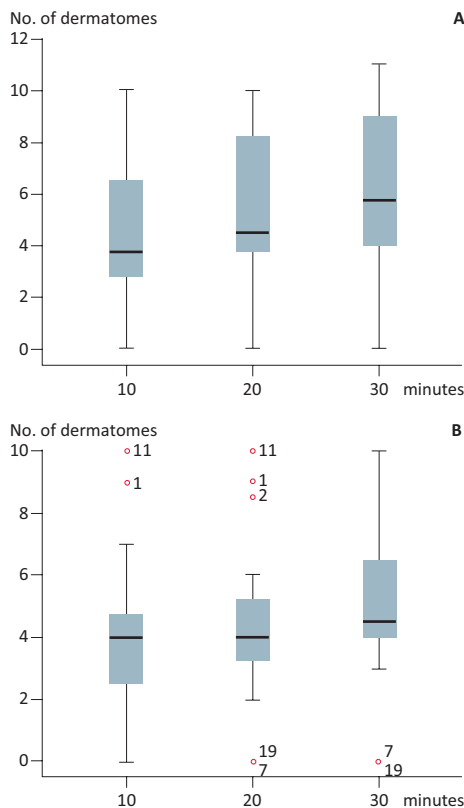
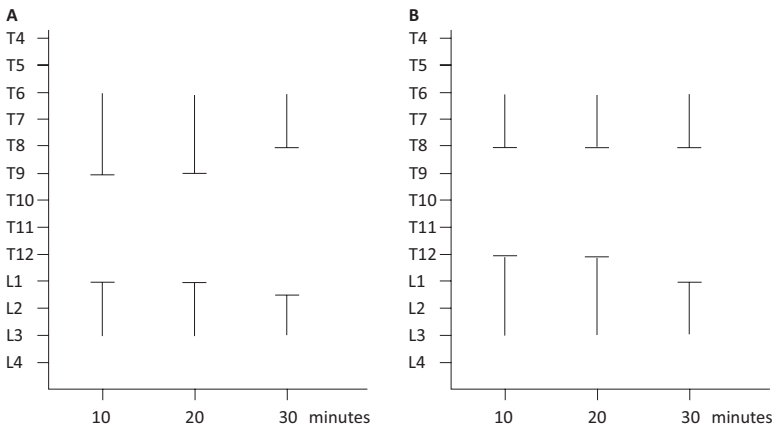



FIGURE 3

Median upper and lower spread of sensory blockade of dermatomes (T4-L4) over time. A. Pinprick. B. Cold.



sory block may be an indicator of the clinical efficacy of the epidural block [15], but it does not necessarily show if the patient has reduced levels of pain after surgery [12-14]. Only one investigation to date has assessed sensory change to pinprick and cold after TAP block and studied analgesia requirements after surgery [11]. Lee et al compared the subcostal and posterior TAP block approach in 50 patients. Among their patients 98% had some degree of sensory block compared with 90% in our study. Lee et al assessed morphine consumption in a multimodal analgesic regime without a control group. TAP block has demonstrated promising effects on pain and opioid requirements after various surgical procedures [7], with rare side effects [16, 17]. The target for the TAP blockade seems to be at the level of the abdominal wall including the skin, whereas a potential effect on visceral pain has not been systematically investigated. The spread of the TAP block has been described in three cadaver studies [8-10]. In one of the studies by McDonnell JG et al, the spread of the TAP block was also investigated in three volunteers by computed tomography imaging and magnetic resonance imaging. This showed the deposition and reduction of injectate in the transversus abdominis plane which correlated with findings of sensory block from T7 to L1 to touch and pinprick after lidocaine 0.5% injection in these volunteers [10].

Different injection sites have been used, depending on the dermatomes that needed to be anaesthetised. Various names have been used to differentiate between the injection sites, such as posterior TAP block, lateral rectus abdominis block, subcostal TAP block and subcostal oblique TAP block [6, 18, 19]. The US-guided ilioinguinal and iliohypogastric nerve block may also be considered a low TAP block [20]. The pos-

terior TAP block has been the most frequently used and is either placed US-guided or as landmark technique. It has not yet been shown if different injection sites can reliably block nociception in the respective different dermatomes, even if they produce some difference in the pattern of dermatomes affected by sensory change [11]. Lee et al achieved a median sensory block of three dermatomal segments with the posterior approach, the most cephalad dermatome being T10. When using the subcostal approach, four dermatomes were blocked, the most cephalad dermatome being T8.

Although the number of patients was limited, our study showed that dermatomes T9-L1 were commonly affected by a single-shot subcostal TAP block with insertion into the parasagittal plane 5-10 cm laterally to the umbilicus. This approach appears easily reproducible, simple and effective.

Our finding of a correlation between age and sensory block spread is new and requires further investigation. There could be a change of the ability to contain local anaesthetic within the neurofascial compartment of the TAP with increasing age. Further imaging studies could help to clarify this.

We found an increasing extent of sensory blockade with time, comparing results at 10 and 30 minutes (Figure 1 and Figure 2). The assessment period for observation of the sensory extent and regression of TAP blockade should be extended to help characterise this block in future studies.

Our study could have benefited from the inclusion of more patients. Another limitation is the technical nature of our study which does not correlate sensory findings with postoperative pain perception. A skin-folding test may have been useful to address if deep tissues are at all affected by the TAP-block and could be incorporated into future studies. Further studies with a blinded controlled design should be used to confirm if sensory blockade can be assessed reliably by using pinprick and cold sensation and be correlated to a reduction in analgesic requirements. Studies using the landmark technique seem to indicate an extensive analgesic blockade [2-4]. Possible differences in the spread of the TAP block between landmark and different US approaches should be investigated.

Our study found that two patients had no change in sensory perception despite the US visualisation of needle insertion into the TAP. The failure of the block may have been due to insufficient spread of local anaesthetic in the interfascial plane, which may be identified with US. This finding was also described in the paper by Lee et al [11].

Further studies are required to shed light on the distribution of the various TAP block approaches, correlating visualisation of spread of local anaesthetic in the

interfascial plane with sensory blockade and the clinical effect on pain.

The TAP block has not yet been commonly applied preoperatively in awake patients. We found that it was well tolerated by most patients, as only one patient dropped out of the study due to discomfort.

CONCLUSION

This study confirmed that the dermatomal extent of a sensory blockade after the subcostal TAP block can be assessed using cold and pinprick sensation.

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