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Original Article

Cutaneous sensory block area of the laparoscopic-assisted transversus abdominis plane block

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ABSTRACT

INTRODUCTION. Different approaches and techniques are used to apply a transversus abdominis plane block (TAP), but their characteristics are poorly described. Precise injection of local anaesthetic is considered crucial to achieving the desired block effect. Laparoscopic-assisted TAP (L-TAP) is a blind technique and potentially less reliable than ultrasound (US)-guided techniques. This study assessed the cutaneous sensory block area (CSBA) after an L-TAP adopting a subcostal dual block approach.

METHODS. Thirty elective laparoscopic cholecystectomy patients received bilateral L-TAPs. The CSBA was mapped 150 min. after block application using cold sensation and a sterile marker, photo-documented and transferred to a transparency sheet from which the area was calculated.

RESULTS. The median CSBA of the subcostal bilateral dual L-TAP was 161 cm^2 (interquartile range: 131-217 cm^2; range: 67-408 cm^2). In all patients, the CSBA mainly covered the skin over the epigastrium, whereas 23% also had an infraumbilical component. In none of the patients did the CSBA cover the abdominal wall laterally to a vertical line through the anterior superior iliac spine.

CONCLUSION. The subcostal bilateral dual L-TAP produces a heterogeneous non-dermatomal CSBA of varying size and distribution across the medial epigastric abdominal wall, similar to the CSBA described in the existing literature on US-guided subcostal TAP.

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The laparoscopic-assisted transversus abdominis plane block (L-TAP), unlike the ultrasound-guided block (US-TAP), is a blind technique [1].

The transversus abdominis plane block (TAP) is used to achieve opioid-sparing analgesia after surgery [2]. Several approaches to TAP are adopted: subcostal [3], lateral [4] and posterior TAPs [5, 6], including dual TAPs in which two of the approaches are combined in the same block application [7].

L-TAP was first described in 2011 in laparoscopic nephrectomies [1]. L-TAP has several benefits, including ease of performance, less dependency on specialised skills and equipment, and avoidance of intraperitoneal

infiltration with local anaesthetics (LA) [1]. Though the TAP was initially performed using a blind technique, the implementation of ultrasonography has garnered an increased focus on applying the TAP in the "correct plane". However, confirmation of LA deposition in the fascial plane is impossible for the L-TAP technique, as it is applied without US guidance [8]. Though this would be considered a disadvantage, the laparoscopic technique is widely used in the clinical setting and appreciated for its practical application.

Considering the variations in approaches and techniques used in TAP application, some discourse persists concerning the mechanism producing the desired analgesic effect [8]. Dermatological coverage is often used to evaluate different approaches to the TAP. The TAP has been described to cover the dermatomes T6 to L2, depending on the approach [8]. Two studies have previously described the cutaneous sensory block area (CSBA) of the subcostal US-TAP [9] and the posterior US-TAP [6]. Both studies showed a heterogeneous non-dermatomal effect with significant variation between the two approaches. To our knowledge, CSBA mapping has never been done for the L-TAP technique.

This study describes the CBSA after L-TAP using the subcostal approach with a medial and lateral injection (dual L-TAP), corresponding to what Børglum et al. described as the medial intercostal TAP and the lateral intercostal TAP [7], and Hebbard et al. referred to as the upper subcostal TAP and lower subcostal TAP [10]. Using cold sensation to measure the CSBA, we hypothesised that the dual L-TAP would result in more block failures and a smaller CSBA than the subcostal US-TAP due to the blind application of the technique.

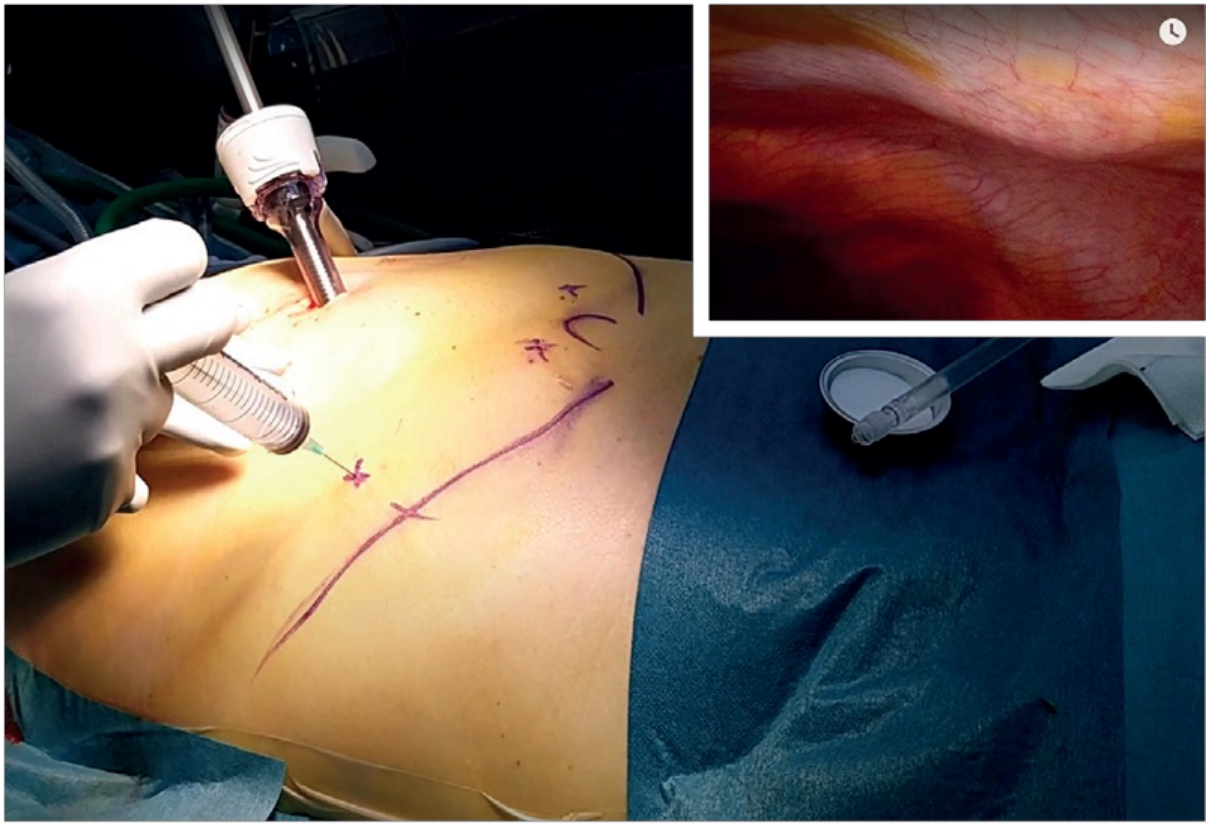
METHODS

The Regional Committee on Health Research Ethics and the Danish Health and Medicines Authority confirmed that no study approval was required because of its explorative observational nature. As part of assessing the effect of changing our analgesic standard practice from US-TAP to L-TAP, we collected prospective data from 30 patients undergoing elective laparoscopic cholecystectomy in a day-surgery setting. Oral and written informed consent were collected from thirty patients between 15 February 2022 and 31 December 2022. The exclusion criteria were age ≤ 18 years, prior surgery to the upper abdominal wall, known sensory deficits of the abdominal or thorax wall, allergy to LA or pregnancy. Surgery was performed or supervised by a surgical specialist following department guidelines for laparoscopic cholecystectomy.

Procedure

Laparoscopic technique [1] and a variation on the dual-TAP approach described by Børglum et al. [7] were used. With the patient in general anaesthesia, the surgeon attained pneumoperitoneum and placed surgical ports. Besides ropivacaine used for L-TAP application, no LA infiltration was applied before, during or after surgery. Immediately after placing the umbilical port, the surgeon applied the dual subcostal L-TAP. Four injections were made with 10 ml of ropivacaine 2.5 mg/ml at each injection site using a 21-gauge, 2.5-inch needle. The injection sites were a medial subcostal infiltration between the midclavicular and central sternal lines and a lateral subcostal infiltration between the midclavicular and anterior axillary lines bilaterally (**Figure 1**). The needle tip was visualised laparoscopically, passing into the preperitoneal fat without perforating the parietal peritoneum. The needle was then withdrawn until the tip was assumed to be located between the posterior rectus sheath and the transversus abdominis fascia (approximately 2-3 mm, more in obese patients), and injection was performed. Confirmation of the "correct" plane can be visualised by the formation of Doyle's bulge [1] covered by the transversus abdominis muscle (Figure 1). However, no direct visual confirmation of fascial separation is possible for this technique. All blocks were performed by a surgeon familiar with the procedure and supervised by the primary investigator (CBS).

FIGURE 1 Injection points for the dual subcostal laparoscopic-assisted transversus abdominis plane block with a laparoscopic view of Doyle's bulge – representing the transversus abdominis muscle covered by the abdominal wall fascia and parietal peritoneum lifted by local-anaesthetic bolus injection.



Assessment of the cutaneous sensory block area

As in our previous publication [9], the CSBA was assessed 90 min. after the end of general anaesthesia, corresponding to approximately 150 min. after block application (T150). Since surgery took 45-75 min., there was a 135-165 min. time range from application to CSBA testing. The assessment was performed within the duration of the cutaneous sensory effect of the L-TAP, which, for ropivacaine, was reported to be approximately 10 h [6]. Testing was done using gauze dipped in alcohol. The gauze was tapped on the skin of the abdominal wall from the midsagittal line, adopting a star-shaped approach with its centre at the umbilicus to indicate cutaneous sensory changes in cold perception. The same investigator performed the CSBA mapping in all patients. Before the examination, the test conditions were thoroughly explained to the patients. The patients were asked to distinguish between an immediate cold sensation and a sensation of heat or numbness. The test was performed without the patient looking at the test area (their abdomen). In case of doubt, the area was reassessed before concluding the examination. The demarcation lines were marked on the skin, confirmed twice, and a connecting line was drawn to determine the CSBA. A ruler was placed next to the marked CSBA, which was then documented by a digital photo. The photo was transferred to a REDCap database [11, 12]. The marked CSBA was

then transferred to transparencies for later reference when calculating the total CSBA. The total area was calculated from the transparencies using SketchAndCalc software [13].

All data were managed according to the General Data Protection Regulation of the European Union and Danish legislation. The regional data protection agency approved the database (P-2020-920).

Statistical analysis

In this observational study, assuming a normal distribution of data, a sample size of 30 participants was chosen to achieve an estimation of the mean value. Continuous data are presented as median, range and interquartile range (IQR) and categorical data as proportions. Descriptive statistics were used, and all analyses were conducted using R statistical software, V.4.2.3 [14].

Trial registration: not relevant.

RESULTS

Thirty patients, eight male (26%), undergoing elective laparoscopic cholecystectomy were included in the study. All 30 received dual bilateral L-TAP and CSBA assessments. The baseline characteristics (median (min.-max)) were: age, 49 (30-72) years; height, 170 (155-191) cm; body weight, 80 (50-106) kg; and BMI, 26 (18-35) kg/m^2. All except two dual L-TAP applications recorded a cutaneous sensory effect at T150 evaluated by cold sensation.

Individual mappings of CSBAs at T150 are depicted in **Figure 2**. The median CSBA was 161 cm^2 (IQR: 131-217 cm^2, min.-max 67-408 cm^2). In all patients, the CSBA covered parts of the abdominal wall between the epigastrium and the umbilicus, whereas 23% also had an infraumbilical component. A solely infraumbilical location of the CSBA was not observed. In none of the patients did the CSBA cover the abdominal wall lateral to a vertical line through the anterior superior iliac spine.

FIGURE 2 A visual presentation of the 30 participants after mapping the cutaneous sensory block area.

DISCUSSION

L-TAP is not a new technique [1]. However, to our knowledge, the dermatomal effect of the block had not been described previously. A recently published study visually presented the subcostal US-TAP and found a heterogeneous non-dermatomal CSBA [9]. In the present study, we also found a non-dermatomal effect for the subcostal dual L-TAP with a CSBA similar to the effect of the US-TAP regarding size and location. This is surprising, considering that precise injection in the facial plane is believed to be crucial for achieving the desired block effect.

We conducted this study to visualise the cutaneous effect of the subcostal dual L-TAP. Though the L-TAP is frequently compared to other techniques/approaches to TAP application, such as the posterior US-TAP [15, 16], one major caveat is that it is impossible to confirm that the LA has been placed in the TAP plane and not just intramuscularly. Thus, we consider a visual presentation of the laparoscopic technique important in the ongoing discourse about TAP and its clinical relevance.

Although we found that the L-TAP results in a non-dermatomal CSBA, we have shown that the L-TAP provides a CSBA that generally covers the upper medial abdominal wall with a varying distribution. In two of the 30 patients, the dual blocks covered only one side. This might be due to block application beneath the deep abdominal facia and thus have no effect on the cutaneous nerves. Eight patients had a very localised CSBA close to the point of LA application, probably due to superficial LA injection. However, a CSBA was reproducible in 58 out of 60 (97%) unilateral block applications. These results are very similar to our findings regarding the subcostal US-TAP and, therefore, question whether direct injection in the TAP plane is necessary to achieve block-related analgesia.

Compared with the subcostal US-TAP's CSBA [9], the addition of the lateral LA injection in the dual subcostal TAP did not seem to add any significant lateral effect to the CSBA. This may indicate a similar effect as the medial subcostal approach or that the distance between injection points was too small. Injecting LA further laterally, i.e., identical to the lateral or even posterior TAP, may have increased CSBA size.

This study has several limitations. Being an observational descriptive study, no randomisation or blinding was applied to compare the CSBA of the L-TAP with the CSBAs of other TAP approaches. Only cold sensation was assessed. Pinprick testing was not done to avoid interference with the findings from the cold sensation test. We aimed to achieve a simple and visual presentation of the CSBA. Though the pinprick test may show slight variations compared with the cold sensation test [17], visual documentation was the primary focus of this study. No baseline was established before block application, but patients with prior surgery to the upper abdominal wall were excluded. The study was conducted in a clinical setting with patients in general anaesthesia, which introduces a time factor from block application to CSBA testing. Also, testing after general anaesthesia may potentially introduce some uncertainty due to the residual effect of anaesthesia and opioids. We do not consider the uncertainty of the exact localisation of the LA injection a limitation as the idea of L-TAP is to avoid using US guidance, and the study aimed to describe the CBSA in a daily clinical setting.

The analgesic effect of the TAP and its clinical implications remain controversial [8]. Whether the analgesic effect of the block relates to the CSBA is uncertain. The muscle-relaxing effect described by Støving et al. [6] or the systemic effect of LA [18, 19] may significantly contribute to TAP-associated pain relief. However, we believe that knowledge of the different approaches is important to understand the potential effect of TAPs, and the present study provides new knowledge regarding the sensory distribution of the dual subcostal L-TAP. The distribution of the CSBA across the upper medial abdominal wall may potentially provide meaningful pain management for surgical procedures of the upper abdomen, e.g., laparoscopic cholecystectomies, right hemicolectomies and bariatric surgery. The L-TAP has been described as having a similar analgesic effect to the US-TAP [20]. However, the clinical relevance compared with placebo and local infiltration analgesia seemed negligible, with differences of 1-3 mg morphine equivalents in the first 24 postoperative hours. Considering the expediency and ease of performance, we consider L-TAP the superior technique for minimally invasive surgical procedures.

Randomised trials remain warranted to determine the clinical relevance of TAP. Further research may investigate whether injection of LA directly in the TAP plane is necessary to achieve opioid-sparing pain relief. Similarly, the variation in CSBA distribution between TAP approaches should be investigated in relation to pain management and the location of primary surgical incisions.

CONCLUSION

The dual subcostal L-TAP produces a heterogeneous non-dermatomal CSBA and seems to have varying size and distribution across the medial epigastric abdominal wall, similar to the subcostal US-TAP.

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