ORIGINAL ARTICLE

Three different approaches to Transversus abdominis plane block: a cadaveric study

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ABSTRACT

Aim The transversus abdominis plane (TAP) block is a new technique for providing analgesia to the anterior abdominal wall. There is ongoing debate regarding access point for TAP block. The aim of this cadaveric study was to compare the spread of 40 mL of dye using three different approaches to TAP: subcostal , via the mid-axillary and via the lumbar triangle of Petit (LTOP).

Methods Injection of black dye into the TAP was performed for each hemi-abdominal wall of 13 embalmed human cadavers by using 3 different access points: subcostal (9 hemi-abdomens), mid-axillary (9) and LTOP (8). This was followed by dissection to determine the extent of dye spread and nerve involvement in the dye injection. The shapes of the dye were traced onto clear plastic, which was then photographed. These digital photographs were loaded into the mathematical software programme Matlab, and the outline of the dye spread was digitised using a piecewise cubic spline, enabling the shapes to be plotted on a graph and the areas to be calculated.

Results The area of the dye spread for subcostal, mid-axillary and LTOP was 85.1 (T7-L1), 58.9 (T10-L1) and 77.9cm^2 (T10-L1), respectively. There was statistically significant difference between area of dye spread between subcostal and mid-axillary approach ($p<0.01$).

Conclusion This dye injection study in a cadaver model indicates that subcostal approach is associated with a larger area of spread of dye than the mid-axillary approach. Dye injected through subcostal, mid-axillary and LTOP approaches demonstrated different nerve involvement.

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INTRODUCTION

The transversus abdominis plane (TAP) block is a new technique for providing analgesia to the anterior abdominal wall as a part of multimodal analgesic regimen (1). Since it was first introduced 10 years ago, the technique has been refined and modified several times (2). It was first described through the lumbar triangle of Petit (LTOP), and then through the mid-axillaryiy line, with the use of ultrasound scanning to ensure correct positioning of the needle between the internal oblique (IO) and transversus abdominis (TA) muscle layers (3,4). A subcostal injection technique has also recently been described, with the aim of achieving a higher level of analgesia (5). As recent meta-analysis demonstrated a relatively large difference in morphine sparing between two TAP block technique favouring mid-axillary approach over LTOP (6), the clinicians raised the question whether three different techniques may have different spread of injectate and different segmental nerve involvement.

The aim of this study was to compare the surface area and the number of nerves "covered" by a single injection of 40ml of dye using three different previously described approaches to TAP: LTOP, mid-axilary and subcostal.

MATERIALS AND METHODS

A total of 13 embalmed cadavers, age 71-93 years were injected with dye. The cadavers were preserved using 75 liters of embalming fluid (consisting of 756 mL industrial methyl, 125 mL phenol, 40 mL formaldehyde, 22 ml glycerol and 57 mL water per liter of fluid) introduced into the common carotid artery by gravity feed and were then refrigerated for at least 4 weeks.

A small portion of the internal oblique was reflected to expose the TAP. A 20G needle was then placed into the TAP under direct vision. Because a small area of the IO was reflected, spread of dye was not completely confined to the TAP. Approximately 2-5 mL of dye was observed to leak from this defect in subsequent experiments.

A 40 mL of black food dye containing carmoisine red, quinoline yellow, and Green S, diluted to 25% with water, was injected. Although most clinical and cadaveric studies report use of 20 mL of local anaesthetic (6-8), we have chosen larger volume, 40 mL, because our clinical experience supports usage of larger volumes of local anaesthetic.

Eight hemi-abdomens were injected in the TAP plane via subcostal approach, nine via lumbar triangle of Petite and nine via mid-axillary line.

Following injection in prone position, all cadavers were left supine for 45 minutes, to mimic clinical practice, before further dissection was carried out. For 2 cadavers, detailed dissection was carried out on both sides. Skin, external oblique and then internal oblique were reflected anteriorly to expose the TAP. Nerves within this plane were cleaned and traced back to their intercostal spaces or perforation of the TA for identification. One of these cadavers was bisected longitudinally, and one hemiabdomen was dissected internally to expose the thoracoabdominal nerves from their origin at the intervertebral foramina. Nerve involvement in the dye was recorded. The remaining 11 cadavers were dissected exposing the dye within the TAP without identifying each nerve. Following this rapid dissection, more fine dissection was carried out on the subcostally injected hemiabdomens to locate the thoracoabdominal nerves and acquire nerve involvement data.

The shapes of the dye were traced onto clear plastic, which was then photographed. These digital photographs were then loaded into the mathematical software programme Matlab, and the outline of the dye spread was digitised using a piecewise cubic spline, enabling the shapes to be plotted on a graph and the areas to be calculated.

A Student-t test was used to determine whether there was any significant difference in the area of dye spread between three different injection techniques. A p value of <0.05 was regarded as statistically significant.

RESULTS

Surface area

On average, subcostal injection resulted in the greatest area of dye stains, followed by lumbar triangle injection. Mid-axillary line injection resulted in the smallest areas of dye stains (Table 1). There is statistically significant difference

Table 1. Surface area of dye stains following different sites of injection

Site of injection	Mean area (cm^2)	Standard deviation (cm^2)	Number of measurements
Subcostal	85.1	11	9
Mid-axillary	58.9	8.4	9
Lumbar Triangle of Petite	77.9	27.8	8

between subcostal injection area and mid-axillary injection area. The spread of dye following mid-axillary line injection was more anterior than following lumbar triangle injection, while dye injected subcostally spread more superiorly than both (Figure 1).

Nerve involvement

Nerve involvement was the greatest following subcostal injection, in average 5.5 (T7-T12) . T10 and T11 were strongly involved in all cadavers.

Following mid-axillary line injection, on average 3.75 nerves were involved, T10-L1.T11 and T12 were strongly involved and the iliohypogastric nerve was partially involved.

For lumbar triangle injection, on average 3 nerves were involved (T10-L1). T12 was strongly and T11 was partially involved.

There was no statistically significant difference in number of nerves involved between subcostal, mid-axillary and LTOP approach.

DISCUSSION

The main finding, which is expected in-line with previous data (7,8) is that subcostal approach is associated with a more cephaled spread of dye than the mid-axillary and LTOP approach. Subcostal injection of 40 mL of dye produced both the largest areas of dye and the greatest nerve involvement (85.1±11 cm^2 and 5.5 nerves involved, T7-T12) compared with injection via the LTOP (77.9±27.8 cm^2 and 3 nerves involved, T10-L1) or via the mid-axillary line (58.9±8.4 cm^2 and

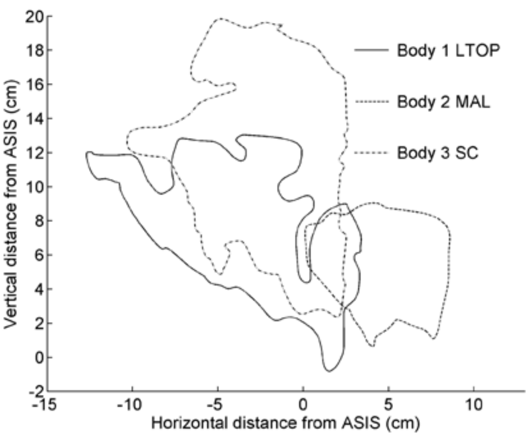

Figure 1. The spread of dye following subcostal, mid-axillary and lumbar triangle of Petit injection from 3 cadavers* (ASIS, anterior superior iliac crest; LTOP, Lumbar triangle of Petit injection; MAL, mid-axillary injection, SC, subcostal injection)

3.75 nerves involved, T10-L1). The difference between subcostal and mid-axillary area was statistically significant.

We must emphasize that these differences were observed in cadavers. There is already evidence that TAP block is associated with a significant increase in serum concentration of local anaesthetic (9). We would assume that in patients at least some of the local anaesthetic would be absorbed within the first 45 minutes after injection. Therefore, the observed difference could be larger, smaller or non existing in patients where substantial amounts of injectate might be absorbed before spreading within the TAP space.

In a previous cadaveric study, which used an equivalent to the mid-axillary ultrasound guided approach (the probe was placed on the anterolateral abdominal wall between the iliac crest and costal margin and the needle advanced from an anterior and medial location in a posterolateral direction) to inject 20 mL of dye, identified that the thoracolumbar nerves T11, T12 and L1 were most commonly affected by the dye (7). This is in line with our findings in the present study, although T10 was also involved in half of our cadavers. We can explain this finding with larger volume of dye used in our study.

Another cadaveric study, single injections of 20 mL dye subcostally (7), spread the mean area of 60 cm^2, with the range of nerve involvement from T9 to T12 and multiple injections involved area of dye of 90 cm^2 and a range of nerve involvement from T7 to T12. This illustrates that a single injection of a double volume of dye gives an area and range of nerve involvement similar to multiple injections of smaller volumes of dye. Our finding suggests that subcostal block with 40 mL of local anaesthetic can achieve analgesia up to the T7 level and therefore can be used for analgesia for supraumbilical and possibly even for subcostal incision.

Because the TAP block has been shown to be associated with a significant increase in serum local anaesthetic (LA) concentration and use of total volume of 40 mL (20 mL per side) concentrated LA (eg 0.5% ropivacaine) is often near the maximum recommended dose, increasing the total LA volume to 80 mL (40 mL per side) may not be advisable. Reducing concentration of LA may reduce the risk of LA systemic toxicity. However, the efficacy of lower concentrations of LA for TAP block has not been established. Additional studies comparing efficacy of small-volume TAP blocks using concentrated LA solutions to high-volume TAP blocks using more diluted LA solutions are needed.

In conclusion, this dye injection study in a cadaver model indicates that subcostal approach is associated with a more cephaled spread of dye than the mid-axillary and LTOP approach. Dye injected through subcostal approach demonstrated significantly larger surface spread when compared to mid-axillary approach.

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