PERIODICUM BIOLOGORUM
VOL. 113, No 2, 203–206, 2011

UDC 57:61
CODEN PDBIAD
ISSN 0031-5362

Original scientific paper/new guidelines

Large volume dye spread in transversus abdominis plane block via three injection sites: a cadaveric study

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Abbreviations:
TAP – transversus abdominis plane
EO – external oblique
IO – internal oblique
LTOP– lumbar triangle of Petit
MAL – midaxillary line
SC – subcostal region

Received March 21, 2011.

Abstract

Background: *Transversus abdominis plane (TAP) block is a recently described regional anaesthesia technique that provides analgesia for the abdominal wall. Three access points for injection have been described: via the lumbar triangle of Petit (LTOP), via the midaxillary line and via the subcostal region (SC). This study aimed to investigate the spread of dye following injection via all 3 sites with a large volume injectate.*

Materials and Methods: *24 hemiabdomens were injected with 40 mL 25% black food dye: 8 via the LTOP) 4 via the MAL, 4 via the SC. Dissection was performed to reveal the extent of nerve involvement and dye spread.*

Results: *Variation in the size and shape of the LTOP was found between cadavers. Mean areas of dye spread (range of nerve involvement) in the remaining 16 hemiabdomens for LTOP, MAL and SC were 77.9 cm^2 (T10-ilioinguinal), 50.3 cm^2 (T10-ilioinguinal) and 91.3 cm^2 (T7-ilioinguinal) respectively. Communications were seen between nerves within the TAP in one dissection. Dye staining was seen to involve nerves outside the TAP.*

Conclusion: *Subcostal injection gives more superior dye spread, with a greater area and a wider range of nerve involvement. This should perhaps be the preferred injection site, and could have broader indications.*

INTRODUCTION

Transversus abdominis plane (TAP) block is a recently described regional anaesthesia technique, rapidly growing in popularity, involving the injection of local anaesthetic into the TAP. This is the space between the internal oblique (IO) and transversus abdominis (TA) muscle layers of the anterolateral abdominal wall, containing the thoracoabdominal nerves T7-L1. By targeting these nerves, TAP block provides superficial, unilateral anaesthesia to the abdominal wall, and is most commonly used to provide postoperative pain relief following lower abdominal or gynaecological surgery. It is an alternative to epidural anaesthesia where this technique is contraindicated or refused by the patient.

TAP block was first described in 2001 *(1)* as a safer alternative to abdominal field blocks, which involved multiple injections of higher doses of local anaesthetic. The first method of accessing the TAP utilised the lumbar triangle of Petit (LTOP), bounded by latissimus dorsi medially, external oblique (EO) laterally, and the iliac crest inferiorly. A landmark based technique was used, palpating the borders of these muscles to locate the triangle; and a 'double pop' technique, feeling for two pressure changes as the needle passed through the EO and IO fascia to reach the TAP, was also described. With time, ultrasound was suggested to guide the needle into the correct plane, *(2)* allowing injections to be made via other access points, the midaxillary line *(3)* and the subcostal region *(4)*.

There have been few anatomical studies into TAP block. In 2004, McDonnell *et al.* found that the double pop technique reliably deposited dye into the TAP *(5)*; while two separate studies in 2009 used ultrasound to inject dye into cadaveric TAP, one via the MAL *(6)* and the other via the SC *(7)*. MAL injection involved T11-L1, and T10 50% of the time; while SC injection targeted T9-T11. Further study revealed that the LTOP was more posterior than previously described, and was highly variable in shape and size *(8)*. To date, there are no studies comparing all 3 injection sites. The current study aimed to build on this small literature base, comparing shape and extent of dye spread, as well as nerve involvement, following injection via the 3 access points described. A large volume of dye would be injected, since larger volumes of local anaesthetic have been used clinically by some anaesthetists.

MATERIALS AND METHODS

12 embalmed cadavers, aged 71–93 years at the time of death, were injected bilaterally with 40 mL solution. The injectate used was black food dye, containing carmoisine red, quinoline yellow, and Green S, diluted to 25% with water. Two cadavers were used as pilot studies, to trial the double pop technique. This was carried out by a consultant anaesthetist and regional expert in the field, but reliable deposition into the TAP could not be achieved. Ultrasound scans of embalmed cadavers are also unable to clearly delineate the fascial layers. For our study, therefore, limited dissection was performed prior to injection. An initial attempt exposed a small portion of the TAP, into which the dye was injected, but this led to spillage and significant dye loss. A more satisfactory solution was to expose an area of IO through which the needle could be inserted to reach the TAP. This resulted in much smaller volumes of spillage, approximately 2–5 mL. Having exposed the LTOP for injection, the dimensions of the triangles and their distance from the vertebral column were recorded.

All cadavers were injected via the LTOP on one side, and either the MAL or SC on the other, to compare the original technique with the more modern, ultrasound guided procedures. Having allowed the cadavers to rest supine for 45 minutes to mirror clinical practice, further dissection was performed, which revealed that this technique consistently placed dye within the correct layer. Of

TABLE 1

Area and nerve involvement of 8 cadavers.

Cadaver		LTOP	MAL	SC
1	Area (cm^2)	44	29	
	Nerves	T12	T11-T12	
2	Area (cm^2)	126	51	
	Nerves	T11-T12	T11-iliohypogastric	
3	Area (cm^2)	77	36	
	Nerves	T10-T12	T11-T12	
4	Area (cm^2)	99	85	
	Nerves	T11-ilioinguinal	T10-ilioinguinal	
5	Area (cm^2)	77		109
	Nerves	T12-ilioinguinal		T8-iliohypogastric
6	Area (cm^2)	69		132
	Nerves	T11-ilioinguinal		T9-ilioinguinal
7	Area (cm^2)	89		43
	Nerves	T10-iliohypogastric		T9-iliohypogastric
8	Area (cm^2)	42		81
	Nerves	T11-T12		T7-T11
	Mean area (cm^2):	77.9	50.3	91.3
	Range of nerves:	T10-ilioinguinal	T10-ilioinguinal	T7-ilioinguinal

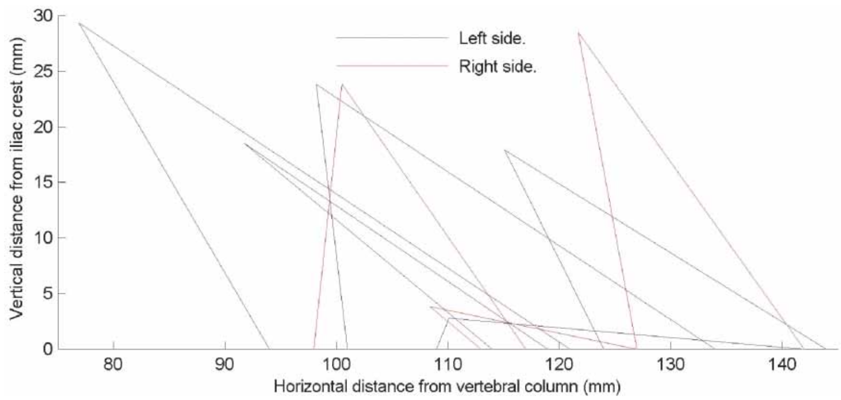

Figure 1. *Graph displaying shapes of LTOP.*

the remaining 10 cadavers, 8 had dye in the correct planes on each side. 2 cadavers were dissected in detail, reflecting each muscle layer of the abdominal wall anteriorly and tracing the nerves found back to their ingress to the TAP. The remaining 6 cadavers were dissected to expose the extent of dye spread and note the nerve involvement in the dye.

The outline of the dye stain from each cadaver was traced on to clear plastic. Digital photographs of these tracings could then be taken, and the Matlab computer programme used to digitize the outline of the dye spread using a piecewise cubic spline. This could be plotted on to graphs, with the anterior superior iliac spine as a landmark.

RESULTS

8 hemiabdomens were injected via the LTOP, 4 via the MAL, and 4 via the SC. Table 1 gives the areas of dye spread, and details the nerve involvement, for each injection. Figure 1 shows the variation in size and shape between the 8 LTOP exposed prior to injection. All 16 dye outlines were plotted on to graphs. Figure 2 displays 3 outlines from different cadavers on the same set of axes, which illustrates the major differences in position between the injection sites: dye spread from MAL injection was more anterior than following injection through the LTOP, while dye injected into the SC spread more superiorly. Dye spread through muscle, as well as within the TAP, staining nerves outside this fascial layer, including branches of T12 and L1 between EO and IO. In addition to the spread of dye within the TAP, in one of the fine dissections performed communications were discovered between adjacent thoracoabdominal nerves at every level (Figure 3). This is in contrast to the descriptions given in standard textbooks of single, segmental nerves, and has been described only once before *(9)*.

DISCUSSION

This anatomical study found that injection of the same volume of dye via 3 sites produced marked variation in spread of dye, the area covered within the TAP, and the nerves involved. Subcostal injection produced more superior dye spread, and so it is perhaps unsurprising that it tended to involve more superior thoracoabdominal nerves, with the greatest range of nerve involvement of the 3 sites. Across the 4 cadavers injected via this route, all the thoracoabdominal nerves, from T7 to the ilioinguinal nerves, were involved, although not all were involved in any one cadaver. Subcostal injection also gave the greatest area of dye spread, with a mean of 91.3 cm^2, compared with 77.9 cm^2 and 50.3 cm^2 for LTOP and MAL, respectively. These findings support the use of SC TAP block for postoperative pain relief following a wider range of surgical procedures, including those involving subcostal incisions.

The anatomical finding of communications between nerves within the TAP is interesting, since it has been described only once before *(9)*. It is also relevant to TAP block, since these communications mean that the dermatome of a nerve blocked proximally may not be entirely anaesthetised, if some afferent fibres travel via a different nerve. Figure 2, illustrating the wide variation in shape and size of the LTOP between cadavers, supports the previous suggestion of Jankovic *et. al (8)* that the use of a landmark based technique to locate this triangle is unlikely to be accurate.

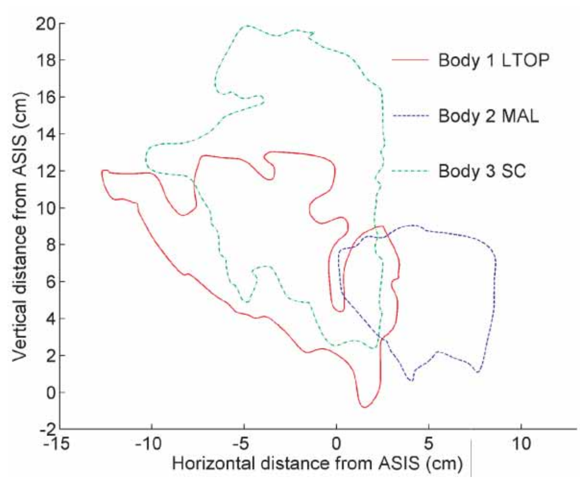

Figure 2. *Graph of dye spread from 3 cadavers.*

Figure 3. *Communications between nerves within the TAP, digitally altered in colour. Turquoise = T9, red = T10, purple = T11, yellow = T12, green = iliohypogastric.*

Limitations of this study include the use of embalmed cadavers, since this is likely to influence the way in which fluid passes through fascial planes; the altered technique used to access the TAP; and the small sample size. There is a wide scope for further research in this area, both clinical and anatomical. Data is needed on the safety of larger volumes of local anaesthetic in TAP block, with serial serum measurements; and on the dermatomes anaesthetised following injection via the various access points. Further anatomical studies are required to support the limited data pool, perhaps with fresh, frozen, or Thiel embalmed cadavers to mirror the spread of injectate in life more closely.

CONCLUSION

This study has shown that subcostal injection gives more superior dye spread, with a greater area and a wider range of nerve involvement. Subcostal approach should perhaps be the preferred injection site, and could have broader indications.

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