Spread of injectate with superficial cervical plexus block in humans: an anatomical study[†]

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Background. This study was undertaken to investigate why the superficial cervical plexus block for carotid endarterectomy is so effective. Initial consideration would suggest that a superficial injection would be unlikely to block all terminal fibres of relevant nerves. One possibility is that the local anaesthetic crosses the deep cervical fascia and blocks the cervical nerves at their roots.

Methods. Superficial cervical plexus blocks (injections just below the investing fascia) were performed using methylene blue (30 ml) in four cadavers. In one additional control cadaver, a deep cervical plexus injection was performed. In a second control cadaver, a subcutaneous injection (superficial to investing fascia) was performed at the posterior border of the sternomastoid muscle.

Results. Anatomical dissection showed that with superficial block there was spread of the dye to structures beneath the deep cervical fascia. In the first control, dye remained in the deep cervical space. In the second control, dye remained subcutaneous.

Conclusions. The superficial cervical space communicates with the deep cervical space and this may explain the efficacy of the superficial block. The method of communication remains unknown. Our findings also indicate that the suitable site of injection for the superficial cervical plexus block is below the investing fascia of the neck, and not just subcutaneous.

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Carotid endarterectomy is often performed awake, either under superficial cervical plexus block or using deep (more commonly a combined superficial and deep) block, and both appear equally effective.¹² This is surprising as blocking nerve roots (with the deep injection) should be more effective. A superficial injection would need to block all nerve terminal fibres to be equally effective and this would seem more difficult.

One possible explanation for the efficacy of superficial block is if the local anaesthetic crossed the deep cervical fascia to act on the nerve roots. However, the current view is that deep cervical fascia is an impenetrable barrier.³⁴ The purpose of this study was to investigate the spread of superficially injected solutions in human cadavers.

Methods and results

Six preserved cadavers were used. All injections were made using 30 ml methylene blue dye 0.01% and a 23 G needle. Two cadavers (CAD1 and CAD2) received a superficial cervical plexus block. In two cadavers (CAD3 and CAD4), the investing fascia was first exposed by dissection and injection made just deep to this fascia under direct vision. 'Control' cadaver CAD5 received a subcutaneous injection (i.e. superficial to investing fascia but below the skin). 'Control' cadaver CAD6 received a deep cervical plexus

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Fig 1 Diagrammatic cross-sectional drawing of the anatomy of the neck at vertebral level C4, showing the major relevant structures and the sites of the three injections used in the study.



Fig 2 Photograph of cadaver neck during process of dissection, after superficial injection in cadaver CAD1. The clavicle has been cut away. Dye (seen as dark areas of shading) is seen coating all structures deep to the deep cervical fascia (indicated with a D). In particular, dye can be seen extending deeply in the upper part of the deep cervical space, in the direction of the cervical nerve roots; and in the lower part of the neck, coating the anterior scalene muscle, and tracking along the brachial plexus towards the axilla.

block (single-injection method⁵). Figure 1 summarizes the methods.

Anatomical dissection showed that with superficial block (CAD1–4), dye was found in the deep cervical space, coating scalene muscles, phrenic nerve, and cervical nerve roots. Dye was also found within the brachial plexus and tracking down to the axillary sheath (Fig. 2).

With subcutaneous injection only (CAD5), there was no dye spread beyond the subcutaneous tissues. After deep cervical injection (CAD6), dye remained confined to the deep cervical space: there was no retrograde spread to the superficial space.

Comments

The main result of this study is that the injectate in the superficial cervical space also enters the deep cervical space. Previous work suggested that the deep cervical fascia is an impenetrable barrier to infections and abscesses (which consequently track down towards the mediastinum), and also to tumour spread.³⁴ One possible explanation of our novel finding is that the deep cervical fascia may be 'porous' and allow spread of local anaesthetic. The fascia may still, however, be impenetrable to infection or tumour because the associated inflammation might serve to block

the fascial 'pores'. In contrast, expansion of the superficial cervical space by local anaesthetic in a normal neck might stretch the uninflamed deep fascia, tending to open the pores and facilitating local anaesthetic spread. This hypothesis does not fully explain why injection of local anaesthetic in the deep cervical space (CAD6) does not also open the pores and allow retrograde spread of solution,⁵ although it is possible that deep injection does not cause as much expansion of the deep space as injection does of the superficial space. Anatomically, the 'pores' in the fascia might be associated with sites at which the cervical nerves pierce the deep cervical fascia to enter the superficial cervical space. While gross spread of tumour across the deep cervical fascia does not appear to have been described, microscopic perineural spread of tumour from the superficial cervical space to the cervical nerve roots can occur and might be of some relevance to our speculation.⁶

Conventional anatomical drawings suggest that the distance between the investing and deep cervical fasciae is large (Fig. 1). Another possible explanation of our result is that, in fact, the two fascial layers are in very close proximity (i.e. the superficial cervical space is a potential, rather than an actual, anatomical space). The two fascial layers are plausibly brought into greater contact by the act of turning the head for the block. Thus, when the injecting needle is placed deep to the investing fascia, it might at the same time and quite easily also pierce the deep cervical fascia.

Our result explains, at least in part, the equal efficacy of the superficial and deep/combined cervical plexus blocks for carotid endarterectomy.¹² The local anaesthetic enters the same anatomical (deep cervical) space containing the cervical nerve roots in both techniques. It has been suggested that the superficial block carries fewer risks to the patient than does the deep/combined block.⁷⁸ If this is so, the need to perform a deep cervical plexus injection as part of the block does not seem easily justified in the light of our anatomical finding.

Some authors describe the superficial block as a simple 'subcutaneous injection'.^{9 10} However, the result of our subcutaneous injection (CAD5) suggests that, in fact, this alone is unlikely to be clinically effective. A superficial

plexus block should properly involve injection below the investing fascia of the neck (Figs 1 and 2), and it is only then that the injectate enters the deep cervical space.

Our study indicates a number of areas for further research. First, radiological studies *in vivo* might add to our observations in cadavers. Secondly, clinical studies might examine whether simple subcutaneous injections are indeed ineffective as compared with superficial cervical plexus bocks (i.e. sub-investing fascia injections) for carotid endarterectomy. Thirdly, histological work in tissue specimens might define the ultrastructure and porous properties of the deep cervical fascia.

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