Vulnerability of Different Nerves to Intrafascicular Injection with Different Needle Bevel Types and Needle Angles: A Mathematical Model

Olga C. Nin, M.D*., Margarita Sanromán Eng. Ph.D. @, André P. Boezaart, M.D., Ph.D. **, Yury Zasimovich M.D. *, Xavier Sala-Blanch, M.¶., José De Andrés M.D., Ph.D. @, Miguel A. Reina, M.D., Ph.D§

*Acute and Perioperative Pain Medicine, Department of Anesthesiology, University of Florida College of Medicine, Gainesville, Florida, USA @Sales Representative Unit, Abbott Medical España, Madrid, Spain

** The Alon P. Winnie Research Institute, Gainesville, Florida and Still Bay South Africa ¶ Human Anatomy and Embryology Unit, Faculty of Medicine, Universitat de Barcelona, Barcelona, Spain

@Department of Anesthesiology, Critical Care and Pain Management, School of Medicine, and the Department of Anesthesiology, Madrid-Montepríncipe University Hospital, Madrid, Spain

§ CEU San Pablo University School of Medicine, Madrid, Spain

Background

- Intra-fascicular injection of a local anesthetic, its toxicity, and direct needle trauma to nerve tissue are generally considered the primary reasons for nerve injury after intraneural injection.¹
- We hypothesize that local anesthetic can enter the fascicle if at least 80% of the distal needle orifice is inside the fascicle. The aim of this study was to calculate the theoretical vulnerability of nerve fascicles given their actual sizes and that of different needle openings.

Methods

- We superimposed microscopic images of two routinely used nerve block needles (a 22-G, 15° “Stimuplex® D” needle and a 22-G, 30° “Stimuplex® Ultra 360®” needle) over seven microscopic images of four nerve types taken at the same magnification. (Figure 1a&b)
- We calculated the chances of distal needle orifice overlap of the fascicles and assigned 80%, 90%, and 99% overlap as significant for fascicle vulnerability to intra-fascicular injection.
- We assigned a color for the amount of overlap (vulnerability) to demonstrate this graphically. (Figure 2)

Results

- The ECO 30° needle was found within the fascicles more frequently than the NE 15°needle because the area of the distal orifice of the ECO 30° needle (0.31mm ²)was smaller that of the NE 15° needle (0.64mm²).
- In brachial plexus roots, the entire distal orifice of the needles were found inside the fascicles more frequently because the fascicles are larger at that level.
- None of the fascicles accommodated 99% of the distal needle orifices.

Figure 1a&b:

Typical regional block needle superimposed on a typical nerve at the same magnification. **a.** Block needle superimposed over a brachial plexus nerve root (C7) to show overlap or occupation calculated percentage of the nerve fascicle by the needle distal orifice. **b.** Fascicle overlap or occupation by the distal needle opening assigned a color for graphical representation.

Figure 2: The percentage of needle distal orifice overlap for different nerves and needles. **a.** Median nerve and 22-G, 30° “Stimuplex® Ultra 360®” needle. **b.** Median nerve and 22-G, 15° “Stimuplex® D” needle. **c.** Brachial plexus root nerve at the interscalene level and 22-G, 30° “Stimuplex® Ultra 360®” needle. **d.** Brachial plexus root nerve at the interscalene level and 22-G, 15° “Stimuplex® D” needle. **e.** Popliteal sciatic nerve and 22-G, 30° “Stimuplex® Ultra 360®” needle. **f.** Popliteal sciatic nerve and 22-G, 15° “Stimuplex® D” needle. **g.** Subgluteal nerve and 22-G, 30° “Stimuplex® Ultra 360®” needle. **h.** Subgluteal nerve and 22-G, 15° “Stimuplex® D” needle.

Group	Nerve	Needle type	Average fascicle sizes	Area size	Number values	Values (%) occupied at ≥80%	Values (%) occupied at ≥90 %	Values (%) occupied at ≥99%
A	Median nerve at wrist	ECO 30°	0.25 mm ²	22.79 mm ²	3175	94 (3.0%)	28 (0.9%)	0
B		NE 15°			4119	11 (0.3%)	0	0
C	Brachial plexus nerve roots C5, C6 & C7 within common circumneurium	ECO 30°	0.98 mm ²	33.48 mm ²	4560	579 (12.7%)	397 (8.7%)	0
D		NE 15°			5746	244 (4.2%)	96 (1.7%)	0
E	Brachial plexus nerve roots of C5	ECO 30°	1.16 mm ²	5.11 mm ²	739	113 (15.3%)	67 (9.1%)	0
F		NE 15°			758	28 (3.7%)	4 (0.5%)	0
G	Brachial plexus nerve roots of C6	ECO 30°	1.82 mm ²	8.85 mm ²	1142	231 (20.2%)	163 (14.3%)	0
H		NE 15°			1200	115 (9.6%)	59 (4.9%)	0
I	Brachial plexus nerve roots of C7	ECO 30°	0.73 mm ²	19.52 mm ²	2401	239 (10.0%)	164 (6.8%)	0
J		NE 15°			2596	95 (3.7%)	29 (1.1%)	0
K	Sciatic nerve at popliteal level	ECO 30°	0.25 mm ²	71.44 mm ²	8670	235 (2.7%)	80 (0.9%)	0
L		NE 15°			10049	14 (0.1%)	0	0
M	Sciatic nerve at subgluteal level	ECO 30°	0.20 mm ²	68.63 mm ²	8721	109 (1.2%)	32 (0.4%)	0
N		NE 15°			10600	0	0	0

Figure 3: Sample and Results. The average fascicle size is the result of analyzing the samples used in each group. Value (%) inside fascicles at ≥80%/90%/99% estimating the relative risk that the orifice of the needle was inside fascicular tissue by 80%, 90%, or 99%. ECO 30° = 22-G, 30° “Stimuplex® Ultra 360®” needle (B Braun, Melsungen AG, Germany). ECO 15° = 22-G, 15° “Stimuplex® D” needle (B. Braun, Melsungen AG, Germany).

Conclusion

- The analysis of partial to full occupation of the distal needle orifices inside the nerve fascicles allowed us to document and visually demonstrate how the different microanatomic architecture of each nerve type affects its vulnerability to intra-fascicular injection.

References

1. Brull R, Hadzic A, Reina MA, et al. Pathophysiology and etiology of nerve injury following peripheral nerve blockade . *Reg Anesth Pain Med* 2015; 40:479-90.

Acknowledgements

The authors sincerely thank Corey Astrom, ELS, of the University of Florida (Gainesville, FL) for her help with the preparation of this manuscript. We would also like to thank Javier Moratinos-Delgado, technician, Virginia García-García, technician, and Paloma Fernández, Ph.D., of the CEU San Pablo University School of Medicine (Madrid, Spain) for their assistance in the histology laboratory.