2021

All epidural needle bevels are not the same

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INTRODUCTION

Unintentional dural puncture continues to occur despite advances in epidural analgesia and anaesthesia for over a century.[1-5] Several risk factors have been implicated as aetiologies.[6,7] Our institution has been using Arrow® FlexTip Plus® Epidural Catheterisation kits (Teleflex, North Carolina, USA) for over 25 years. However, on one occasion, there was an abrupt change in the supply chain of epidural sets, necessitating the acquisition of kits from a different manufacturer. This change led to an observational increase in difficulty in threading the epidural catheter and dural puncture incidence requiring a blood patch. No study has analysed the physical characteristics of epidural needles. Our *in vitro* study attempted to address this void.

METHODS

This study was performed at the Brigham and Women's hospital during the period January 1st to 30th January 2018. The Ethics Committee of the institution waived the ethical approval requirement as our study did not involve any patients. Six 17-gauge epidural needles in clinical use for epidural placement were obtained for this study [Table 1, Figure 1a]. All needles, with their stylet removed, were placed on a level platform with bevels facing upwards. A Canon® REBEL T3i digital SLR camera with a macro lens was used to obtain magnified images of the epidural needle bevels. Photographs of the front and lateral views of the bevel and lateral views of the bevel with an epidural catheter threaded at select distances were obtained. Adobe Photoshop®CC measurement scale was used to measure length, width, area of the epidural bevel, and angulation of the catheter exiting the bevel. The minimum length of the bevel (MLB) required for the catheter to physically exit the epidural needle was analysed [Table 1, Figure 1a].

Exit characteristics of the catheter were studied using an *in vitro* elastic band model [Figure 1b]. The needle was secured horizontally with a clamp affixed to a stand. The elastic band was placed vertically between two clamps with minimal stretch. The needle was positioned against the elastic band so that the tip of the epidural bevel facing upwards contacted the elastic band. The epidural catheter was introduced in 0.5 cm increments until 2.5 cm of catheter exited the epidural needle tip [Figure 1c]. At each increment, a lateral photograph was taken and the distance of movement of the elastic band from the epidural needle tip was measured using Adobe Photoshop® [Table 1]. The process was repeated for each needle using the same type of epidural catheter (Arrow® FlexTip Plus® Epidural Catheter, Teleflex, North Carolina, USA).

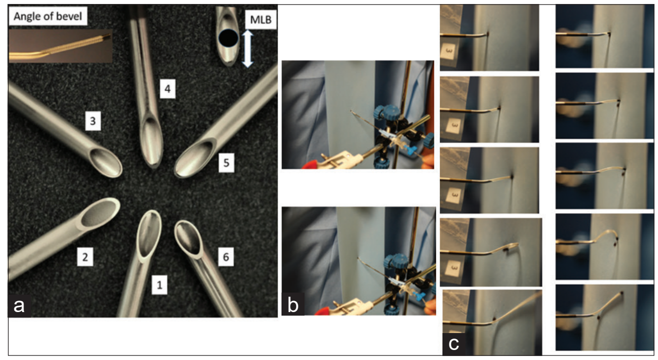

Figure 1: (a) Epidural needles, angulation of catheter protrusion and minimum length of the bevel (MLB). (b) The elastic band and the epidural needle are positioned such that the tip of the epidural needle and catheter touches the band. (c) Movement of the elastic band and catheter behaviour as the catheter exits the needle bevel

RESULTS

The bevel length varied from 2.26 mm to 3.26 mm, width from 1.20 mm to 1.34 mm, area from 2.26 mm^2 to 3.80 mm^2, angulation of catheter from 12.4° to 16.4°, and MLB from 1.07 mm to 1.63 mm. Weiss-1 has the largest area and shortest MLB. Tuohy-4 has the longest bevel and MLB compared to others. The angulation of catheter protrusion varied from 16.4° with the Hustead-6 to 12.4° with the Tuohy-4. Table 1 shows the distance of elastic band displacement while threading the catheter. After 2.5 cm of catheter was threaded, the tip of the catheter flipped upwards on exit. Catheter exit characteristics varied considerably due to variations in physical characteristics among needle bevels [Figure 1c]. The elastic band was displaced to a greater extent without the catheter curving upwards (Table 1, Hustead-6 at 2 cm).

DISCUSSION

This analytical study demonstrates that the bevels of all epidural needles are not the same. The differences in physical characteristics of the bevel may affect tactile perception during the epidural placement and

Table 1: Epidural needles and physical characteristics. Movements of the elastic band in mm at various lengths of catheter insertion are also shown.

Epidural needle	Source of epidural kit
1. Weiss-1 epidural needle	Arrow FlexTip Plus Epidural Catheterisation Kit REF ASK-05400-BW
2. Weiss-2 epidural needle	BD Durasafe Combined Spinal and Epidural Needle Set REF 405139
3. Touhy-3 epidural needle	Design Options PERIFIX Epidural Anaesthesia Tray REF 552041
4. Touhy-4 epidural needle	FlexTip Plus Epidural Catheterisation Kit REF AK-05502
5. Touhy-5 epidural needle	Arrow FlexTip Plus Epidural Catheterisation Kit REF ASK-05401-NM
6. Hustead-6 epidural needle	Arrow FlexTip Plus Epidural Catheterisation Kit REF AK-05503

	Weiss-1	Weiss-2	Tuohy-3	Tuohy-4	Tuohy-5	Hustead-6
Length (mm)	2.84	2.50	2.32	3.26	3.14	2.26
Width (mm)	1.34	1.22	1.20	1.22	1.34	1.25
Area (mm^2)	3.80	2.32	2.26	3.24	3.44	2.40
Angulation of catheter protrusion	13.5°	14.2°	14.8°	12.4°	16.2°	16.4°
Minimum length of bevel (mm)[a]	1.07	1.50	1.25	1.63	1.48	1.25
Length of catheter threaded	**Weiss-1**	**Weiss-2**	**Tuohy-3**	**Tuohy-4**	**Tuohy-5**	**Hustead-6**
0.5 cm	5.10 mm	5.30 mm	4.60 mm	5.20 mm	4.40 mm	3.90 mm
1.0 cm	6.10	8.50	8.60	5.40	6.00	5.80
1.5 cm	8.20	6.10	2.30	0.30	4.40	8.00
2.0 cm	1.54	1.80	2.20	0.30	0.80	6.90
2.5 cm	N/A	N/A	N/A	N/A	N/A	2.20

feel of epidural catheter insertion. Tactile perception is the principal factor clinicians use while approaching the epidural space. In a study in piglets, it was found that the force required to penetrate ligamentum flavum with an 18G needle was about 7.754 N (68.3% confidence interval 5.45-11.03).[8] The penetrating force was variable depending upon the change in texture of the tissues.[8] Hence, it is conceivable that the force required to penetrate tissue will vary with the heterogeneity of epidural needles.

Drzymalski performed an *in vitro* study demonstrating that enough length of the epidural bevel must be in the epidural space to allow the catheter to exit.[9] If MLB is longer, more bevel length must be in the epidural space for the catheter to thread easily. Otherwise, catheter insertion through the epidural needle will encounter the bevel's mechanical barrier despite an appropriate loss of resistance to air or saline. This may be the causative reason for the increased difficulty observed by us in threading the catheter when we switched from the Weiss-1 epidural needle (shortest MLB).

The depth of the epidural space can range from 2 to 25 mm. Therefore, if a patient has a shallow epidural space or the dura is abutting the ligamentum, indentation of dura would be more likely with longer MLB needles. The Weiss-1 seems superior in this situation with a shorter MLB. The longer bevels, such as with the Tuohy-4, may run the potential risk of the tip of the bevel touching the dura when the depth of the epidural space is small and thus, theoretically increasing susceptibility for accidental dural puncture. Despite this theoretical risk, there is no evidence due to lack of studies randomising epidural needles for epidural placement.

The angulation of the epidural catheter as it exits the bevel adds another complexity to catheter threading. Our study is the first to evaluate the exit characteristics of the epidural catheter through a variety of epidural needles. There is one *in vitro* study that analysed the effect of Tuohy needle bevel on the deflection of a spinal needle as its tip exits the bevel.[10] Contrary to our analysis, this study neither evaluated the physical characteristics of a variety of epidural needles, nor the exit characteristics of an epidural catheter. Our analysis shows a tendency of the catheter to curve upwards before exiting when encountering resistance. An epidural needle with a higher angle of catheter exit could facilitate easier threading of the catheter because of less resistance encountered against an obstruction such as the dura.

There are limitations in our analytical study. We did not analyse forces required to move an epidural needle with bevels having different physical characteristics in clinical practice. Furthermore, this study does not predict difficulties experienced in threading epidural catheters into actual epidural space when the epidural catheter tip abuts the dura, fat and epidural contents, impeding the catheter movement. Catheter stiffness can also influence the catheter exit from the epidural bevel. However, our analysis demonstrates that epidural needles with different bevels' physical characteristics can influence catheter exit. Epidural needles with higher catheter angulation had less resistance to encountering the obstruction based on our *in vitro* observations of elastic band movement. Epidural needles have not undergone progressive changes since their initial introduction by the pioneers in the field of regional anaesthesia.[11]

To conclude, our *in vitro* study demonstrates that an epidural needle bevel with a small minimum length of bevel and larger catheter exit angle is more theoretically suited for ease of passage of an epidural catheter into the epidural space. Future studies should focus on redesigning epidural needles with such bevels and investigate them in clinical practice.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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Submitted: 27-Dec-2020
Revised: 11-Jan-2021
Accepted: 31-Jan-2021
Published: 15-Apr-2021

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Access this article online	
Quick response code	Website: www.ijaweb.org
	DOI: 10.4103/ija.IJA_1503_20

How to cite this article: Benhardt AC, Kodali BS. All epidural needle bevels are not the same. Indian J Anaesth 2021;65:328-30.