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Accuracy in estimating the correct intervertebral space level during lumbar, thoracic and cervical epidural anaesthesia

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Background: Even in the absence of factors concealing anatomical landmarks, high failure rates in correctly determining a given lumbar interspace have been reported.
Methods: Therefore, it was the aim of the present study to compare the assessed and factual level (determined by computed tomography) of epidural puncture in attending a regional anaesthesia cadaver workshop. Eighty-two anaesthetists performed 117 punctures.
Results: Vertebral interspaces between T8–L4 were correctly identified more often than those between C3–T5 ($P < 0.05$). Identification of an arbitrarily chosen vertebral interspace was excellent in both the cervical/high thoracic and thoracic/lumbar regions.
Conclusion: As previously conjectured only for the lumbar region, we could confirm the tendency of anaesthetists to perform neuraxial puncture more cranially than expected also for the thoracic and cervical regions. The large majority of punctures (93.7%) was performed within one interspace of the predicted level.

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The extent of blockade after induction of epidural as well as spinal anaesthesia is correlated to the spinal level of injection of the anaesthetic agent. Levels are traditionally determined prior to puncture by means of inspection and palpation of anatomical landmarks. However, the validity of these landmarks in the correct determination of lumbar interspaces has been repeatedly put into perspective (1, 2). Furthermore, high failure rates in correctly determining a given lumbar interspace have been reported even in the absence of factors concealing anatomical landmarks (3). Therefore, it was the aim of the present study to evaluate the accuracy of anaesthetists attending a regional anaesthesia cadaver workshop in determining vertebral interspaces.

Methods

For the present study, 82 consultants, or residents near the end of training, attending a regional anaesthesia workshop utilizing human cadavers, were surveyed. Three cadavers preserved in a mixture of alcohol and glycerol were randomly allocated to test persons. Important landmarks on these cadavers were palpable (e.g. vertebra prominens, scapula, iliac crest).

Participants were requested to perform one to three epidural punctures at arbitrary vertebral levels on a cadaver in the prone position and to subsequently state their assumed level of puncture after palpation of landmarks. Needle position was recorded, and the cadaver was scanned using a Synergy (General Electrics, Munich, Germany) computer tomography (CT) device at a power of 120 kV/80 mA and a slice thickness of 10 mm without overlap in axial-scan mode. Levels of actual puncture were determined on the scout graph and plotted against assumed levels after palpation. After the study was finished, data were arbitrarily grouped according to the puncture area: C3–T5 representing upper thoracic and cervical EDA, and T8–L4 representing thoracic and lumbar EDA, and spinal anaesthesia.

Data were analyzed using the chi-square test to show differences in the agreement rate between the

two areas. Inter- and intra-observer reliability between anaesthetists' judgement and computed tomography was analyzed using intraclass correlation coefficient (ICC). Scores for statistical measurements with the ICC range from 0 to 1, where the former shows no reliability and the latter perfect reliability. A reliability score of <0.4 is graded as poor, scores between 0.4 and 0.75 as fair to good, and a score of >0.75 is graded as excellent (4). After adjustments for multiple comparisons with the use of Bonferroni's procedure, *P*-values of less than 0.01 were considered to indicate statistical significance. SPSS for Windows 11.0 software (Chicago, IL) was used for all analyses.

Results

Participants performed 56 punctures between C3 and T8, and 61 punctures between T8 and L4. The detailed number of punctures at the different levels was: C3/4: 2, C5/6: 1, C6/7: 2, C7/T1: 3, T1/2: 3, T2/3: 5, T3/4: 13, T4/5: 14, T5/6: 13, T8/9: 10, T9/10: 4, T10/11: 8, T11/12: 6, T12/L1: 2, L1/2: 7, L2/3: 9, L3/4: 9, L4/5: 6. Sites of puncture located between T8 and L4 were more likely to be correctly classified than those between C3 and T5 ($P = 0.013$). Of punctures in the lower area, 49.2% were correctly classified, but only 26.8% of those located between C3 and T5 ($P < 0.05$). Of the punctures, 93.7% were performed within one interspace of the presumed location.

For a detailed depiction of puncture level accuracy, refer to Table 1. In brief, the marked space was correctly identified in 26.8%; 53.6% were assumed to be at a lower space than shown at the CT. Markers were one space higher than palpated in seven cases. In 5.4% cases markers were two spaces higher, and in 1.8% case markers were three spaces higher than predicted.

The ICC between the punctured lumbar interspace determined by CT and the anaesthetists' judgements was 0.79 in the area C3–T5, and 0.94 between T8 and L4.

Discussion

The principal result of our study is that determination of segmental level by trained anaesthetists as assessed by ICC is excellent within both investigated intervals. Out of the 117 punctures, 93.7% were located within one interspace of the predicted level.

The extent of epidural blockade is directly related to the level of injection. Furthermore, haemodynamic compromise during epidural anaesthesia is equally related to injection level (5, 6). Traditional diagnostic procedures preceding EDA most importantly include inspection and palpation to determine vertebral levels. Even though bony landmarks are most often used to determine levels, the results are not always in concordance with objective measures of segmental determination such as imaging methods. Studies on different aides in the determination have not provided anaesthetists with a definitive yet workable method to accurately determine a given vertebral interspace (5).

Similarly, studies on the reproducibility of bony anatomical landmarks, e.g. the iliac crest, as markers of vertebral levels have not provided consistently positive results (1, 2). Broadbent et al. (3) enrolled 97 patients subjected to magnetic resonance (MRI) scans. Anaesthetists were asked to determine the levels of lumbar interspaces by attaching a marker to the patients' skin. Actual position of the marker and

Table 1

Number of punctures in the two measurement intervals plotted against interspace error. *P*-value (significance after Bonferroni's correction assumed at $P < 0.01$) indicates statistical difference between the two groups.

			Group		Total	*P*-value
			C3–T5	T8–L4		
Location of factual puncture site compared with subjective estimate	One space lower	n =	30	17	47	0.005
		% of group	53.6%	27.9%	40.2%	
	Correctly identified	n =	15	30	45	0.013
		% of group	26.8%	49.2%	38.5%	
	One space higher	n =	7	11	18	0.452
		% of group	12.5%	18.0%	15.4%	
	Two spaces higher	n =	3	3	6	1.000
		% of group	5.4%	4.9%	5.1%	
	Three spaces higher	n =	1	0	1	0.479
		% of group	1.8%	0.0%	0.9%	
Total		n	56	61	117	
		% of group	100.00%	100.00%	100.00%	

distance to the presumed vertebral level was recorded. Accuracy of segmental determination was stated as being impaired by patient obesity. Our study, in contrast, used epidural needles advanced, as in clinical routine to mark segmental levels. This eliminates the possibility of marker movement after palpation, which may, in part, explain the high level of disparity between the predicted puncture level and the corresponding findings on MRI scans in obese test persons. One notable result of the study conducted by Broadbent was the tendency of doctors to locate the desired interspace more cranially than was the case. This is undesirable since, e.g. moving up only two interspaces from the classical L3/L4 interspace in spinal anaesthesia would locate the puncture site in the vicinity of the spinal cord. Gessel et al. similarly reported a tendency of anaesthetists to perform neuraxial puncture at higher levels than assumed (7) and ascertained inadequate clinical determination of lumbar vertebral levels in 59%. Hogan et al. found that more than half of investigated lumbar epidural catheters had been placed one interspace higher than anticipated (8). However, to our knowledge, imaging studies investigating needle placements during neuraxial anaesthesia have only been conducted at the lumbar level, but not at cervical and thoracic levels. Results from our study therefore confirm and considerably widen these findings, in as much as the tendency to locate the site of puncture more cranially than previously described only in the lumbar region (3, >7) was also confirmed for different levels, i.e. the upper thoracic and cervical spinal column. Sites of puncture located between T8 and L4 were more likely to be correctly classified than those between C3 and T5, although after Bonferroni's correction, this difference was not statistically significant.

Finally, one limitation of the present study should be addressed. Cadavers conserved in alcohol and glycerol are more flexible than those conserved in formaldehyde, but are still more rigid than live subjects. Therefore, the results of the present study are indeed even more encouraging, as actual palpation of landmarks may be considered easier in average adults.

In conclusion, identification of an arbitrarily chosen vertebral interspace was excellent in both the cervical/high thoracic and thoracic/lumbar regions. The vast majority of punctures (93.7%) was performed within one interspace of the predicted level. As previously conjectured only for the lumbar region, we could confirm the tendency of anaesthetists to perform neuraxial puncture more cranially than expected also for the thoracic and cervical regions.

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