# Electromagnetic navigation bronchoscopy (ENB) – how fast can it be learned?

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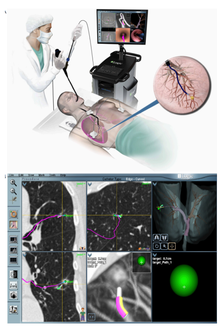
## Introduction



ENB is a relatively new and technical demanding procedure for the guidance of bronchoscopic biopsy of small lung lesions. The results in experienced hands are relatively well described. However, we do not know the results in unexperienced hands

– in other words, how fast you can learn the procedure?

## Aim

The aim of the present study was to draw the learning curves for four beginners in ENB.


## Conclusion

For two of the operators (Operator 1 and 4), at least 25-30 procedures were necessary to obtain competency whereas Operator 2 and 3 demonstrated more horizontal learning curves indicating an overweight of successful procedures from the beginning.

The lesions biopsied by operator 3 were more often located in the central – or middle 1/3 of the thorax when compared to the other three operators, which may have influenced the results, but data are too sparse to draw a conclusion concerning this

## Methods

Four operators from three Danish hospitals without prior ENB experience were enrolled. The outcome of each ENB procedure performed from May 1st 2018 to June 31th 20 was assessed and classified as either diagnostic or non-diagnostic based on sample adequacy.

Learning curves were drawn based on diagnostic yield.

The outcome of each ENB procedure was classified as either success or failure based on sample adequacy.
Adequate samples (= success) were defined as follows: a) samples with malignant cells at cytopathological evaluation or b) samples showing a non-malignant diagnosis at cytopathological and/or microbiological evaluation.
All other procedures were considered failures (= inadequate samples).

## Results

### Understanding learning curves using CUSUM scores

- An **upward** projection indicates a failure (=non-diagnostic procedure)
- A **downward** projection indicates a success (=diagnostic procedure)
- A **horizontal or downward course** of the curve indicates obtained competency
- **Decision intervals** are shown as horizontal lines and the curve is said to signal meaning that at this given time point, the operator has "crossed a line" by having too many failures when balanced against successes.

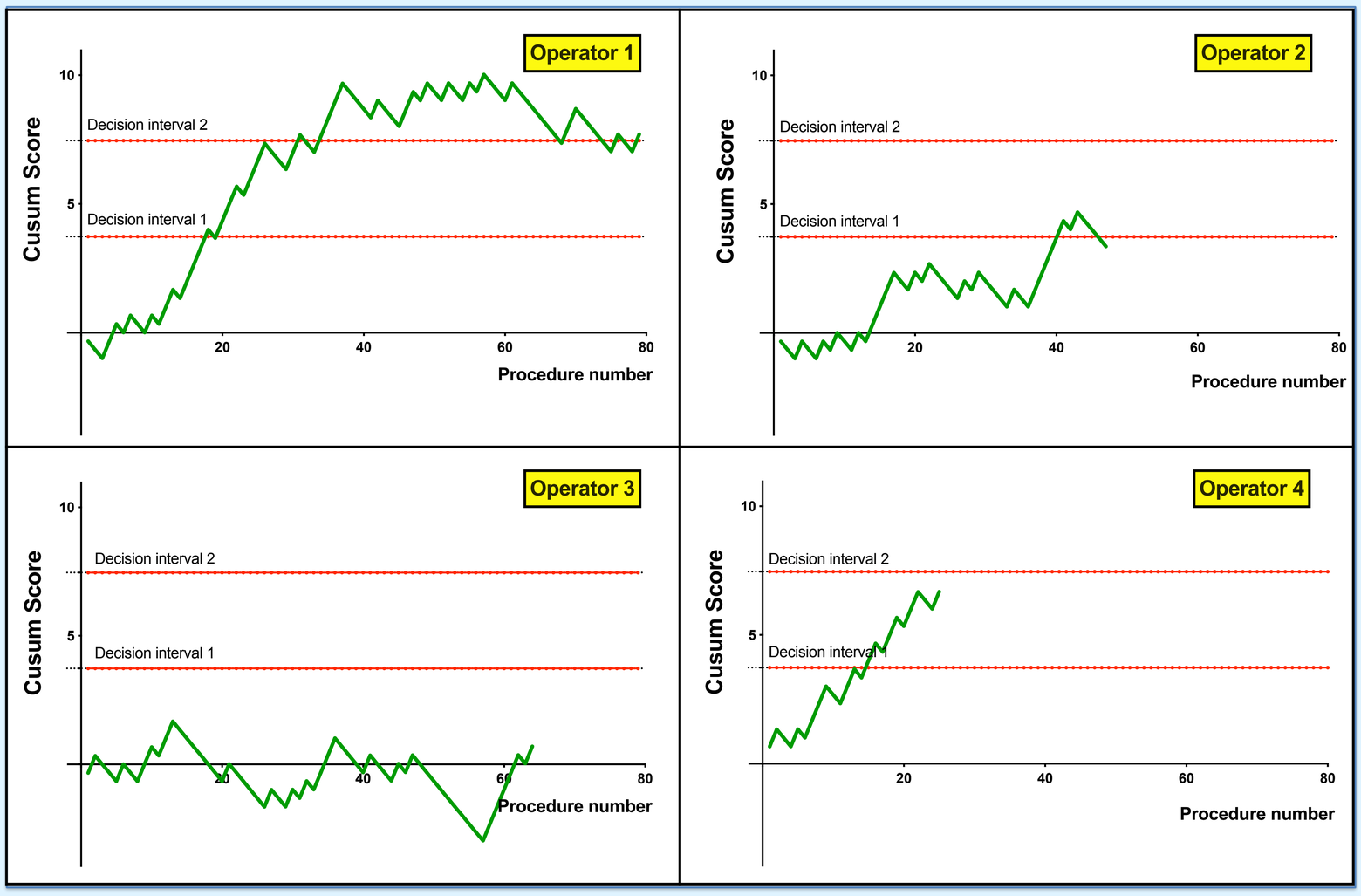



**Figure 1**: Learning curves illustrated as cusum plots for the four operators.

**CUSUM scores and learning curves**
Cumulated Sum (cusum) analysis is a method for quantitative evaluation of the learning curve for surgeons and anaesthesiologists.
A cusum plot is a graphical representation of the trend in the outcome of a series of consecutive procedures.
The cusum score for a given procedure is the running sum of a mixture of increments (with each failure) and decrements (with each success).
The decrease in the cusum plot with each successful procedure is denoted '*s*' and the increase in the plot with each unsuccessful attempt is '*1–s*'. To determine the value of *s*, one must set an *acceptable failure rate* which is the level of error that one will expects if the procedure is carried out correctly, and an *unacceptable failure rate* for the particular procedure being assessed.
In the our studycase of ENB, we have designated the acceptable and unacceptable failure rates as 0.27 and 0.40, respectively, based on findings from previous studies of diagnostic yield in ENB. Based on the formulas for calculating custom scores, s = 0.33 and 1–s = 0.66.
The reward for a successful procedure (*s*) is thereby less than the penalty for a failed procedure (1–s).

### Table 1. Subject, lesion, and procedural details

| | Operator 1 | Operator 2 | Operator 3 | Operator 4 | p-value |
|---|---|---|---|---|---|
| **No. of procedures** | **79** | **47** | **64** | **25** | |
| **Lesion size (mm)**, (median [range]) | 25 [2-74] | 25 [8-55] | 26 [8-58] | 18 [10-53] | 0.51 |
| **Lesion location (no, % within the operators)** | | | | | ***<0.001** |
| Peripheral 1/3 of the lung | 64 (81) | 40 (87) | 17 (27) | 5 (20) | |
| Middle 1/3 of the lung | 14 (18) | 5 (11) | 28 (44) | 19 (76) | |
| Central 1/3 of the lung | 1 (1) | 1 (2) | 19 (30) | 1 (4) | |
| **Lesion distance to pleura (mm), (median [range])** | 14 [0-63] | 14 [0-60] | 26 [0-70] | 25 [0-78] | ***0.01** |
| **Lesion distance to fissure (mm), (median [range])** | 25 [0-94] | 29 [0-100] | 33 [0-123] | 14 [0-94] | 0.21 |
| **PET pos (no. %)** | 77 (99) | 40 (93) | 60 (94) | 23 (92) | 0.3 |

### Table 2. Diagnostic yield and final diagnose

| | Operator 1 | Operator 2 | Operator 3 | Operator 4 |
|---|---|---|---|---|
| **Diagnostic yield** | | | | |
| No. of ENB procedures with a diagnostic sample (no. (% of total no. of procedures)) | 45 (57) | 28 (60) | 42 (66) | 10 (40) |
| No. of ENB procedures with a non-diagnostic sample (no. (% of total no. of procedures)) | 34 (43) | 19 (40) | 22 (34) | 15 (60) |
| **Final diagnose of samples** | | | | |
| Malignant (no. (% of total)) | 54 (68) | 32 (68) | 44 (69) | 15 (60) |
| Non-malignant (no. (% of total)) | 25 (32) | 15 (32) | 20 (31) | 10 (40) |
| Total no. of ENB procedures | 79 | 47 | 64 | 25 |