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RESEARCH ARTICLE

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Learning curve for spinal anesthesia as a basic skill in the training program of the anesthesia resident in faculty of medicine, Cairo University

(Observational study)

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ABSTRACT

Background and Aim: Spinal anesthesia, as a basic skill, needs to have a consideration in the design of the learning process in any training program. This study aimed to follow up on the learning curve of the junior resident during their training program to know the duration and the number of cases needed by the trainee to be skillful in spinal anesthesia.
Methods: for six months, the trainee were monitored to check their ability and excellence to achieve optimum spinal anesthesia using a checklist, learning curve, and strict crystal clear endpoint to achieve a 90% success rate
Results: The learning curve indicated a rapid improvement of skills, 50 attempts (cases), done over about 100 days with approximately 13 hours of residency work per day is enough for a trainee to achieve a success rate of 90%, as set by the criteria in this study.
Conclusions: By using learning curves, it is possible to generate the minimal numbers of each manual procedure required to achieve an adequate success rate

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Spinal anesthesia; learning curve; skills; training program

1. Introduction

The ability to successfully administer spinal anesthesia is a basic skill that is frequently utilized in the operating room by all anesthetists. Spinal anesthesia is easy and safe and allows for solid and reliable anesthesia in surgeries of the lower half of the body. It is sometimes the preferred choice of anesthesia, such as when caesarian sections are performed. It is also clearly ideal in surgeries where it is best if patients would remain conscious. The use of spinal anesthesia reduces the incidences of deep venous thrombosis, bleeding, and post-operative pain [1,2].

In order to design a proper learning program for anesthesiology trainees, one should be mindful of the comparative difficulty in acquiring the manual skills necessary to perform regional anesthesia compared with general anesthesia. This comparative difficulty lead program planners to attempt to decipher what minimum number of “live” training sessions and what total number of hours are needed for a trainee to acquire the skills necessary to properly administer spinal anesthesia. Evidently, planning for such training should be guided by a pre-set and clear definition of a successful administration and conduction of spinal anesthesia [3–6].

The application of the learning curve to the acquisition of the basic skill of anesthesia shows great variability, especially with regards to skills pertaining to spinal anesthesia. Unknown is the number of exposures to the technique, the amount of practice and minimal number of attempts needed for a trainee to become skillful at administering anesthesia. Few studies have considered the effect of these factors on the skillfulness of an anesthesiologist. Existent training programs seemed to have been designed without definitive scientific parameters [7–9].

The Cairo University Teaching Hospital (CUTH) is one of the largest hospitals in the Middle East. It is a 3000-bed hospital with 62 operating rooms and around 300 anesthesia training program trainees per year. It is visited by approximately 2 million out-patients per year. These parameters make the anesthesia training program at CUTH a cornerstone of anesthesia education in Egypt [10].

The present study aimed to detail the learning process during the first six months of an anesthesiology residency at CUTH and to define the minimum required number of cases of spinal blocks a trainee needs participate in before gaining enough skills to minimize failures during regional anesthetic procedures.

1.1. Methodology

All newly assigned (first year) anesthesiology residents at CUTH at the time of the conduction of this study

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were recruited (15 residents). During a period of six months, a standardized self-evaluation questionnaire provided to the 15 residents was used for self-assessment of the development of skills required for proper administration of spinal anesthesia. Successes or failures at administering spinal anesthesia were documented with each training day by an assigned senior staff member (mentor) during the 6-month period. To encourage compliance and accurate completion of the questionnaires, data collection and analysis were conducted anonymously. All clinical duties of the residents were supervised by a senior staff member (mentor). No restrictions were set for the type of patients to be involved in this study; the ASA classification of anatomical difficulties was not used to conduct pre-selections of patients.

A single straightforward standard procedure was chosen for the purposes of training the residents, irrespective of the type of patient. At the start of the training program, residents were given a complete description of the procedure by their mentors followed by a demonstration of the procedure on real patients. The procedure called for spinal anesthesia to be performed in the sitting position using a 22-gauge Quincke spinal needle (Abbott Co., Chicago). A midline approach was to be initially attempted; the resident changing to a paramedian approach if he/she faced difficulties.

Objective criteria of success for the administration of spinal anesthesia were sought and detailed. The aim of these criteria was to enhance the quality of the training program and the objectivity of the study at hand with clearly defined endpoints. To consider the administration of spinal anesthesia to be successful, **all of** the following had to be evident:

(1) The appearance of the cerebrospinal fluid in all four quadrants (360-degree needle rotation).
(2) Less than 10 minutes elapsing between skin puncture and needle removal.
(3) An adequate depth of anesthesia where only conscious sedation was required.
(4) No physical assistance from the mentor (only verbal assistance).
(5) A maximum of three attempts within the ten minutes mentioned in number 2.

For the purposes of this study, a trainee was considered to have acquired the necessary skills to properly administer spinal anesthesia if he/she had achieved an overall success rate of 90% after multiple attempts during the six-month training period. After each attempt, a checklist and an assessment sheet (Figure 1) was filled by the assigned mentor. For every consecutive 10 sheets, one collective score of 1 to 10 was calculated. The score was then plotted on a learning curve as a percentage of 10. With each new set of 10 attempts, a new collective score was given and plotted (again as a percentage) on the learning curve. This continued until the trainee had achieved a 90% success rate.

By the end of the six-month training period, a learning curve had been plotted for each trainee. In addition, a collective learning curve representing the learning progress of the entire trainee group was also mapped out.

1.2. Sample size and type

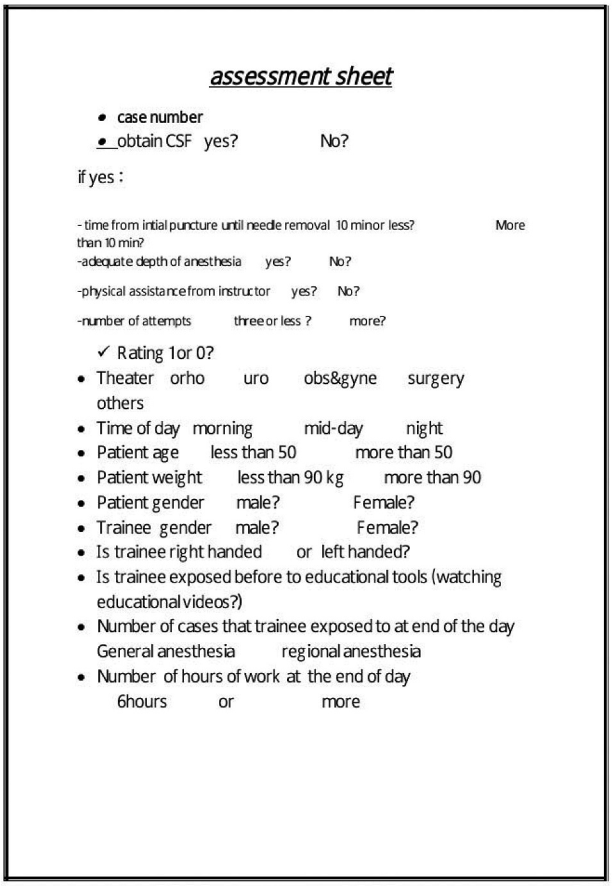
The nature of this study required that all participates be fresh medical graduates with no clinical experience apart from the year of internship. To properly attribute any acquired skills to the training program being assessed, trainees needed to have had no previous experience with administering spinal anesthesia. This set a limit on the number of anesthesiology residents who could participate in the study. To maximize the number of participants, all new residents assigned to the anesthesiology department at the time of the study (15 residents) were asked to participate in the study from day one of their residencies and for the subsequent 6 months.

1.3. Statistical analysis

Data were statistically described in terms of mean standard deviation (SD), median and range, frequencies (number of cases) and percentages when appropriate. A comparison of numerical variables between the study groups was done using the Mann Whitney U test for independent samples. For the purposes of comparing categorical data, Chi-square tests were performed. Alternatively, the Exact test was used when the expected frequency was less than 5. *P* values of less than 0.05 were considered statistically significant. All statistical calculations were done using computer program IBM SPSS (Statistical Package for the Social Science; IBM Corp, Armonk, NY, USA) release 22 for Microsoft Windows.

2. Results

Following the approval of our departmental scientific committee, all 15 residents belonging to the rotation that had started at the time of the study were monitored during their first 6 months of residency. They were enrolled in our training program for the administration of spinal anesthesia and evaluated for skills gained over the six-month duration of the study. The total number of attempts (cases) needed for each resident to reach the 90% success rate delineated by our study was 50 attempts (cases). During this six-month period, the average number of attempts that trainees conducted per surgical theater were; 21 attempts



assessment sheet

- case number
- obtain CSF yes? No?

if yes :

- time from intial puncture until needle removal 10 minor less? More than 10 min?
-adequate depth of anesthesia yes? No?
-physical assistance from instructor yes? No?
-number of attempts three or less ? more?

✓ Rating 1or 0?

- Theater orho uro obs&gyne surgery others
- Time of day morning mid-day night
- Patient age less than 50 more than 50
- Patient weight less than 90 kg more than 90
- Patient gender male? Female?
- Trainee gender male? Female?
- Is trainee right handed or left handed?
- Is trainee exposed before to educational tools (watching educational videos?)
- Number of cases that trainee exposed to at end of the day General anesthesia regional anesthesia
- Number of hours of work at the end of day 6hours or more

Figure 1. Assessment sheet.

(cases) in the obstetric theaters; approximately 16 cases in orthopedic theaters; 7 cases in the urology theaters; and 5 in the general surgery theaters (see Table 1).

The learning curve indicated a rapid improvement of skills after the first 20 attempts (cases) with an average success rate of 40%, rising to an average of 70% after 30 cases and to 80% after 40 cases.

All of the residents reached our target of a 90% success rate during the six-month duration of the study (see Figures 2 and 3).

Work hours per resident during the study period averaged 13 hours of work per day. In addition, the average duration needed for a resident to achieve the target 90% success rate was 100 days per resident.

Patient characteristics we considered that would have added difficulty and interfered with the success rates of trainees included an age of 60 years or older and a body weight above 90 (due to resultant anatomical difficulties). Thus, the majority of cases in the first part of the study were selected to be less than 60 years of age with a body weight less than 90 kg, allowing for an initial steep progress in trainee learning curves. At the end of the study, each trainee had attempted the administration of spinal anesthesia to an average 33 cases below 60 years of age, and an average of 34 cases weighing less than 90 kg, (see Tables 2, 3 and 4).

Table 1. Average number of cases (attempts) per trainee in the orthopedics, obstetrics, general surgery and urology theaters.

	Orthopedics	Obstetrics	General Surgery	Urology
Mean	15.73	20.93	5.33	7.33
Median	10.00	15.00	3.00	6.00
SD	15.187	17.429	6.079	14.710

Data presented as means, medians and standard deviations (SD).

2.1. Discussion

This study aimed to add to our understanding of proper training program design. We attempted to set clear endpoints with objective criteria for the successful attempt at administering spinal anesthesia. Such exact set of criteria were essential to the aim of determining what number of cases, work hours per day and overall training period a trainee needs to achieve our set the goal of a 90% success rate.

Our results suggest that approximately 50 attempts (cases), done over a period of about 100 days with approximately 13 hours of residency work per day is enough for a trainee to achieve a success rate of 90%, as set by the criteria in this study.

The learning curve revealed that there is a sharp increase to 40% in the success rate after the first 20 attempts (cases). Furthermore, results indicated rates reached the desired 90% when trainees had conducted 50 attempts on average. Before conducting the study, we

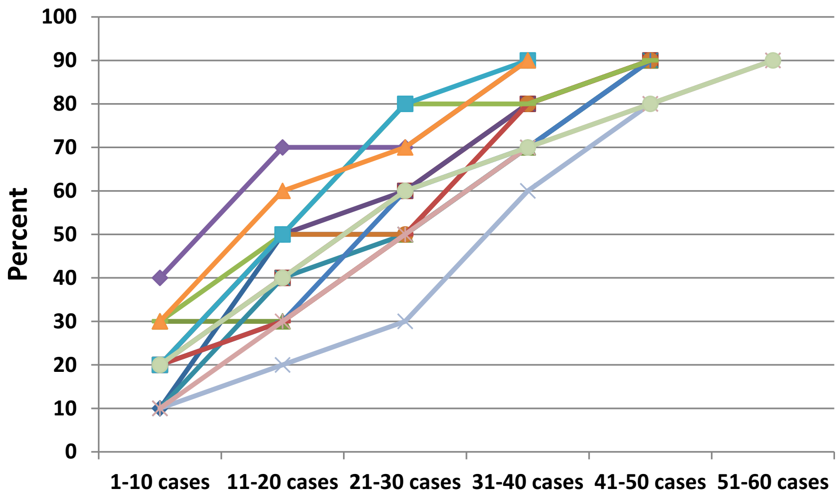


Figure 2. The learning curve for the included trainees.

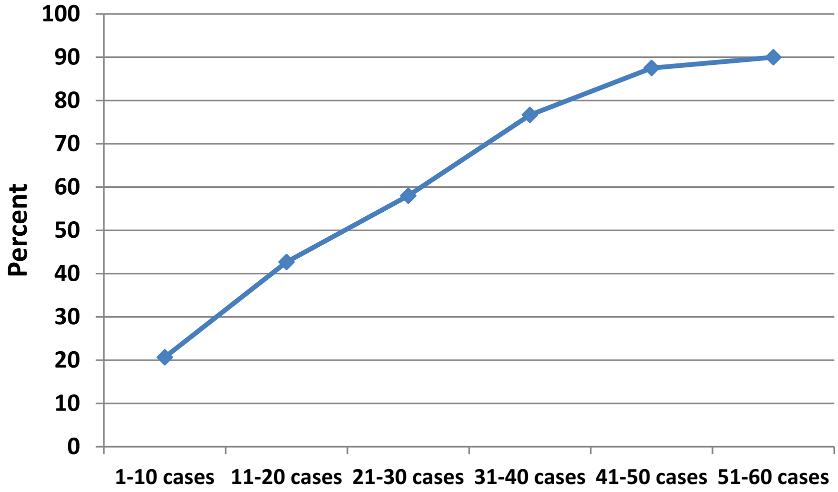


Figure 3. Learning curve of the average of all included trainees.

Table 2. Average workhours and workload needed to achieve the target 90% success rate.

	Number of spinal anesthesia cases to reach the target	Average daily working hours	Duration to Achieve 90% (Days)
Mean	49.33	12.80	99.93
Median	50.00	12.00	101.00
SD	4.037	1.014	23.560

Data presented as means, medians and standard deviations (SD).

Table 3. Average number of patients with age above and below 60 years old for each trainee.

	Patients above 60 years of age	Patients below 60 years of age
Mean	15.53	33.13
Median	16.00	32.00
SD	4.307	3.502
P-value	0.240	0.036

Data presented as means, medians and standard deviations (SD).

considered the multiple factors that might affect the learning curve of each trainee, including the type of theater of operation, patient age and body weight.

Table 4. Average number of patients weighing above and below 90 kg per trainee.

	Patients weighing 90 kg or more	Patients weighing less than 90 kg
Mean	15.53	33.80
Median	16.00	31.00
SD	4.172	8.046
P-value	0.805	0.030

Data presented as means, medians and standard deviations (SD).

Notably, there were no differences among the trainees with respect to these factors. Nevertheless, we recommend that only young fit patients be recruited for similar training programs in order to accelerate the learning process.

Part of the design of any training program should be continuous program evaluation and reassessment leading to improvement of delivery according to the highest standards possible. [4]

There is an inherent difficulty in any attempt to evaluate technical performance. Evaluations are invariably subjective and often unreliable and invalid. Studies of the same nature as the present study face difficulties in quantifying and objectively evaluating the outcome of a performance; we attempted to use objectively set success endpoints. Further improvements in reliability would be achieved by direct observation of each component step within the anesthetic procedure, and the evaluation of such component steps using detailed "sub-criteria" [11,12].

Our experience at the creation of objective criteria and clear endpoints for our trainees can be of value for other training programs at CUTH. Presently, logbooks for trainees in various residencies at CUTH simply focus on the number of procedures performed and neglect quality. Trainees usually fill in their logbooks retrospectively at the end of their training year, putting into the question the accuracy of what is being recorded. Therefore, exact endpoints with clearly defined success criteria, recorded through direct observation of a mentor (such as in our study) seem essential to both the validity and reliability of what are being recorded as completed training points.

A possible limitation of our study is that data were gathered from a single institution with a small class size of fifteen residents. One could submit that our smaller program within a large hospital offers residents more chances to practice per resident, thus they are able to improve relatively quickly.

Some additional studies examined the learning processes of basic practical skills in anesthesiology using statistical approaches. Kopacz et al. [13], using the pooled cumulative success rate at groups of 5 attempts, demonstrated that a 79.3% success rate at proper administration of spinal anesthesia was achieved after 41 attempts. This study included only 7 residents and the only set criterion of success was obtaining CSF. Konrad et al. [14], using a least-square fit model and Monte Carlo procedures, demonstrated that 90% success rates at proper administration of spinal anesthesia were achieved after a mean of 71 attempts. This second study included 11 residents who were observed for one-year duration. Kestin [15], using the CUSUM method, analyzed individual learning curves for obstetric epidurals and spinal anesthesia. Only 2 of 8 residents (25%) attained the 10% acceptable failure rate (p 0) for spinal anesthesia after 39 to 67 blocks, whereas only 5 of 12 residents (41%) attained the 5% acceptable failure rate for epidural anesthesia after 29 to 185 procedures. The author suggests that the acceptable failure rates, taken from consensus among experienced anesthesiologists, might have been too stringent in the context of the study. Our data are in agreement with those of Kopacz et al. [16], who reported that 40 attempts to perform regional anesthesia or orotracheal intubation are inadequate to achieve an acceptable success rate. There are numerous mannequins and computer simulations that aid the learning of anesthetic techniques, but the degree to which these methods aid the learning process is unknown. As consistently normal anatomy is depicted and dynamic clinical alterations are absent, these aids may be of limited usefulness. Performance on humans is eventually necessary.

2.1.1. In conclusion

We believe that, by using learning curves, it is possible to generate the minimal numbers of each manual procedure required to achieve an adequate success rate. Learning curves may be a useful tool for monitoring the learning process of members of a given institution or of individual learners.

Our study shows that although significant improvement compared with the baseline had occurred after only 20 spinal anesthetics, the attainment of a 90% success rate required an average of 50 attempts at administering spinal blocks.

2.1.2. Future studies

Similar studies from different institutions might help to delineate the average number of attempts (cases) a trainee needs to conduct for each procedure in order to ensure adequate training and to sharpen manual skills. This should aid in developing definite learning protocols for the administration of spinal anesthesia to difficult cases such as the obese and geriatric patients.

Disclosure statement

No potential conflict of interest was reported by the authors.

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