Assessment of procedural skills in residents working in a research and training institute: An effort to ensure patient safety and quality control

ABSTRACT

Background: To ensure patient safety, it is important to regularly assess the knowledge and practical skills of anesthesia trainees. This study was conducted to evaluate the competency of the residents and the impact of various corrective measures in the form of didactic lectures and clinical skill demonstrations on the conduct of various procedural skills by the residents.

Materials and Methods: Ninety-five junior residents were enrolled in this study. Assessment of competency of 1st, 2nd, and 3rd year residents in performing various procedure skills of anesthesia was done in two stages using procedure specific checklist (PSC) and Global Rating Scales (GRSs). Preliminary results of the first assessment (Score 1) were discussed with the residents; deficiencies were identified and corrective measures suggested by didactic lectures and clinical skill demonstrations which were followed by a subsequent assessment after 3 months (Score 2).

Results: There was a statistically significant improvement in the PSC and GRS scores after corrective measures for all the procedural interventions studied. Percentage increase in scores was maximum in 1st year (42.98 ± 6.62) followed by 2nd year (34.62 ± 5.49) and minimum in 3rd year residents (18.06 ± 3.69). The percentage increase of scores was almost similar for all subset of procedural skills; low, intermediate, and high skill anesthetic procedures.

Conclusion: For assessment of procedural skills of residents, use of PSC and GRS scores should be incorporated and the same should be used to monitor the impact of various corrective measures (didactic lectures and clinical skill demonstrations) on the conduct of various procedural skills by the resident.

Key words: Assessment; checklist; Global Rating Scales; procedural skills; residents

Introduction

The practice of anesthesia is challenging and dynamic. The anesthesiologist is often faced with time sensitive situations which demand critical decision-making and high-quality surgical interventions. It is thus important to regularly assess the knowledge and practical skills of the trainees to ensure patient safety.[1-3]

Our hospital is a tertiary care referral hospital. The Department of Anesthesia and Intensive Care is one of the largest with 90–100 junior residents (students enrolled in MD Anesthesia for a period of 3 years). The teaching faculty consists of approximately thirty consultants and forty senior residents (anesthesiologists recruited for a period of 3 years after completion of MD). They are responsible
for the training of these residents and monitoring of their clinical and academic activities. The aim of this prospective observational study was to incorporate a combination of previously validated checklists and Global Rating Scales (GRSs)\(^4\) for the evaluation of the competency of the residents during the performance of various procedural skills. This was to ensure better quality of health-care delivery by identifying deficiencies and initiating corrective measures in the form of didactic lectures and clinical skill demonstrations. A reevaluation of the residents done after a period of 3 months was used to assess the impact of the corrective measures.

**Materials and Methods**

The study was conducted after informed consent from the junior residents and approval by the institutional ethics committee. Assessment of a particular procedural skill was done only if the log book of the resident showed more than twenty independent, successful performances of the skill in the past. Any resident with less than this number was excluded from the study. Three subsets of residents were identified based on number of years of admission in the residency program: 1\(^{st}\) year (1\(^{st}\) and 2\(^{nd}\) semester), 2\(^{nd}\) year (3\(^{rd}\) and 4\(^{th}\) semester), and 3\(^{rd}\) year (5\(^{th}\) and 6\(^{th}\) semester; each semester comprises 6 months duration).

The trainees were assessed for competency in six different procedures which were grouped in three subsets based on the level of skill needed for successful completion of the same.

1. Low skill procedures
   a. Endotracheal intubation
   b. Subarachnoid block.

2. Intermediate skill procedure
   a. Lumbar epidural block
   b. Arterial line cannulation (radial artery).

3. High skill procedure
   a. Central line (internal jugular vein) cannulation
   b. Nerve stimulator-guided supraclavicular brachial plexus block.

Assessment of each procedural skill was done by the consultant anesthetist (second and third investigator) using two evaluation tools:

a. Procedure-specific checklist (PSC) (Appendix A): A resident’s score was calculated at the completion of the procedure based on the proportion of items done correctly in the checklist

b. GRS (Appendix B): It consists of seven dimensions, each related to some aspect of procedure performance. Each dimension was graded on a 5-point scale with the middle and extreme points anchored by explicit descriptors. Each 5-point item was scored from 0 (poor performance) to 4 (good performance). A resident’s score for a given station was determined by summing the marks on the seven dimensions and dividing by 28 to obtain a percentage score. Items on the GRS were developed in accordance with the procedure planned/evaluated.

**Data collection**

Assessment of competency was done in two stages. Preliminary results of the first assessment (Score 1) were discussed with the residents and corrective measures suggested by didactic lectures and clinical skill demonstrations which was followed by a subsequent assessment after 3 months (Score 2).

Paired t-test was used to compare the score before and after didactic lectures and clinical skill demonstrations. Percentage change in score for different subset of residents (1\(^{st}\), 2\(^{nd}\), and 3\(^{rd}\) year) was compared within the group and between the group using one-way ANOVA and post hoc analysis with Bonferroni corrections, respectively. All tests were considered two tailed with 95% confidence interval and statistical significant \(P < 0.05\).

**Results**

We enrolled 95 junior residents in this study. The distribution of residents based on years of experience is summarized in Figure 1.

**Comparison of scores (procedure-specific checklist and Global Rating Scale) of residents for various procedural skills**

There was a statistically significant improvement in the PSC and GRS scores after corrective measures for all the procedural interventions studied [Table 1].

![Figure 1: Distribution of residents based on years of experience](image)
Comparison of percentage increase in scores (procedure-specific checklist and Global Rating Scale) of residents based on complexity of the procedure

The percentage increase of scores was almost similar for all subset of procedural skills; low, intermediate, and high skill [Table 2].

Comparison of scores (procedure-specific checklist) of residents based on years of training

The PSC scores of residents in the three subsets based on the duration of residency are summarized in Table 3. Percentage increase in performance of PSC was maximum in 1st year (42.98 ± 6.62) followed by 2nd year (34.62 ± 5.49) and minimum in 3rd year (18.06 ± 3.69). The difference was statistically significant (P = 0.00) for all comparisons between 1st, 2nd, and 3rd year.

Comparison of percentage improvement in scores for all procedures performed by residents

Detailed intergroup comparison was done for all procedures performed by residents of either of the six semesters [Figure 2a and b]. Improvement of PSC score of 1st semester residents was significantly more compared to improvement of 5th and 6th semester residents in all anesthetic procedures. Compared to 4th semester residents, 1st and 2nd semester residents showed significantly more improvement in performing subarachnoid block, and for other procedures, the percentage improvement was not statistically significant (P > 0.05). When improvement was compared among 1st, 2nd, and 3rd semester residents, for central line insertion and supraclavicular brachial block, 1st semester residents showed significantly more improvement compared to 2nd and 3rd semester, and for all other procedures, no statistically significant difference in percentage improvement was seen among them. Improvement of 3rd semester residents was significantly more compared to 4th semester in arterial and central line insertion. Improvement of 4th semester residents was significantly more compared to 6th semester for all procedures. Compared to 5th semester residents, 4th semester residents showed significantly more improvement in performing subarachnoid and epidural block and arterial line insertion. Improvement of 5th and 6th semester residents was comparable for all procedures.

Discussion

In our study, regular assessment of procedural skills of residents and corrective measures in the form of didactic lectures and clinical skill demonstrations led to a statistically significant improvement in the performance of the procedural skills which were evaluated using PSC and GRS scores. The values of the percentage increase in the cumulative scores however did not differ significantly based on the complexity of the procedure which we graded as low, intermediate, and high in our study. The percentage increase in score of PSC and GRS for all procedures was maximum in 1st year residents and minimum in 3rd year residents, and the differences were statistically significant. This reemphasizes the fact that residents are more susceptible to change during early years of training.
The cumulative value of the GRS scores for all residents (Table 1) decreases as the complexity of the procedure increases. The previous study has also reported that complex procedures such as peripheral nerve blocks, central line insertion, and epidural block are more difficult to learn than basic manual skills (e.g., endotracheal intubation). This point needs to be considered when formulating the contents of the residency program. Early exposure to complex procedural interventions may lead to failures and protocol violations, but introduction of residents at a very late stage makes them less susceptible to changes and improvements. Thus, the 2nd year of residency may be considered as the “golden period” and should be utilized for improvement of complex procedural skills.

We used two different assessment tools because each has its merits and demerits. An advantage of checklists is that they have intrinsic content validity. The use of checklists has been shown to be inappropriate in higher levels of experience and more complex skills. Another problem with checklists is that as all steps of procedure are weighted equally regardless of clinical importance, a trainee might obtain a high score, despite omitting important steps of procedure. Advantage of GRS is that they are not confined to one procedure but can be used for different procedural skills. As the GRS has a gradation of response in each category, it is less objective than a checklist, although this allows the assessment to be more qualitative. Potential pitfalls with GRS include the “halo effect,” when good or bad performance in one domain unduly influences the grading of performance in other domains.

Basic science and clinical knowledge are examined on a routine basis using written and oral examinations, but assessment of procedural skill is often neglected. Lack of a uniform objective method could be one of the factor. Task-specific checklists and GRS when used for assessment of residents performing an interscalene brachial plexus block and axillary block have reliably discriminated between different levels of training and are thus valid measures of performance. Cumulative sum analysis has been found to be an effective tool for measuring the competence of anesthetic trainees for practical procedures. All above-mentioned studies have emphasized on assessment of procedural skills, but in our study, we have also shown the improvement in performance after training using the above-mentioned assessment tools.

Cumulative sum analysis is an alternative tool to assess an individual’s performance during the conduct of various procedural skills. Problems with using cumulative sum analysis (CUSUM) analysis is that it is a statistical method that looks at the outcome rather than at the process of performing procedural skills and there are no nationally agreed definitions for success or failure for a given procedure, and those used in the literature vary greatly.

We recruited residents after the performance of minimum twenty procedures because Konrad et al. have demonstrated that the learning curves reveal a marked improvement of skill after twenty attempts. Learning manual skills is a multimodal function depending on many variables and varies from individual to individual. Attaining a prescribed number of procedures lacks validity and may not guarantee competence as trainees might have learnt incorrect technique and could continually perform techniques incorrectly. It is clear, though, that there is a wide spectrum of learning curves, and consequently, the only way to guarantee competency is to tailor training to the individual rather than to focus on minimum numbers.

One of the limitations of our study was that the data collection was done from only one center; the learning situation can vary greatly from institute to institute and thus the components of checklist for various procedures may not be the same. We assessed the residents only one time both before and after training; ideally, residents should have been assessed three times and final score would have been mean of the three scores.
**Conclusion**

Use of PSC and GRS scores should be incorporated for the assessment of procedural skills of residents. The same should be used to monitor the impact of various corrective measures on the conduct of a procedural skill by the resident. Intensive supervision and quality control are least effective for residents in the last years of residency. Periodic review of the curriculum of the residency program and necessary changes can be done based on the results of assessment using PSC and GRS.

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**Conflicts of interest**

There are no conflicts of interest.

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Appendix A

A(1): Checklist for endotracheal intubation

| Item                                                                 | Yes | No |
|----------------------------------------------------------------------|-----|----|
| Ensures that all necessary parties are present and ready to begin procedure |     |    |
| Correctly identifies appropriate size of endotracheal tube (ETT) and laryngoscope blade based on age and weight of patient |     |    |
| Equipment checked to ensure working properly (laryngoscope light, etc.) |     |    |
| Ensures suction in place and working properly                         |     |    |
| Any other necessary equipment gathered if required, for example, stylet, LMA |     |    |
| If anticipated difficult airway, difficult airway cart kept ready     |     |    |
| Patient’s head positioned properly                                    |     |    |
| Suctioning done if required                                           |     |    |
| Laryngoscope blade inserted properly                                 |     |    |
| Laryngoscopy done in proper way                                       |     |    |
| ETT inserted to appropriate depth and stylet removed (if used)         |     |    |
| Correct placement of ETT confirmed using capnography/auscultation/chest rise |     |    |
| I will pass the resident regarding this competence                    |     |    |

A(2): Checklist for subarachnoid block

| Item                                                                 | Yes | No |
|----------------------------------------------------------------------|-----|----|
| Makes proper preparations in the anesthetic and operating rooms      |     |    |
| Informs and guides patient appropriately regarding the procedure and positioning |     |    |
| Washes and/or decontaminates hands, wears gloves, and gown by sterile technique |     |    |
| Correct positioning of patient, sitting or lateral position, with assistance from staff |     |    |
| Correct preparation of utensils and check of drugs and instruments   |     |    |
| Proper identification of insertion level appropriate for the planned operation |     |    |
| Uses proper sterile technique - sterile cleaning and draping of skin  |     |    |
| Discuss choice of local anesthetic for skin and choice of median or paramedian approach |     |    |
| Local analgesia established at desired site and patient told of impending needle stick |     |    |
| Correct insertion of spinal needle                                   |     |    |
| Loss of resistance appreciated                                       |     |    |
| Free flow of cerebrospinal fluid checked                             |     |    |
| Drug given properly                                                  |     |    |
| Performs procedure fluently                                           |     |    |
| Discuss and defend choice and dose of anesthetic for the spinal block |     |    |
| Disposes of waste appropriately                                     |     |    |
| Determines block level – with indication of dermatomes               |     |    |
| Initiates proper measures to support cardiovascular function          |     |    |
| Describes indications and contraindications for spinal anesthesia     |     |    |
| Describes at least three important complications, describes how to prevent and treat these |     |    |
| Communicates effectively with the patient and team members           |     |    |
| Documents procedure correctly and completely                          |     |    |
| I will pass the resident regarding this competence                    |     |    |
A(3): Checklist for lumbar epidural block

| Yes | No |
|-----|----|
| Makes proper preparations in the anesthetic and operating rooms | |
| Informs and guides patient appropriately regarding the procedure and positioning | |
| Washes and/or decontaminates hands, wears gloves, and gown by sterile technique | |
| Correct positioning of patient, sitting or lateral position, with assistance from staff | |
| Correct preparation of utensils and check of drugs and instruments | |
| Proper identification of insertion level appropriate for the planned operation | |
| Uses proper sterile technique - sterile cleaning and draping of skin | |
| Discuss choice of local anesthetic for skin and choice of median or paramedian approach | |
| Local analgesia established at desired site and patient told of impending needle stick. | |
| Correct insertion of epidural needle | |
| Correct identification of epidural space – loss of resistance | |
| Correct insertion of epidural catheter | |
| Performs procedure fluently | |
| Gives test dose to check catheter position - can explain the reason and procedure for testing | |
| Discuss and defend choice and dose of anesthetic for the epidural block | |
| Disposes of waste appropriately | |
| Determines block level – with indication of dermatomes | |
| Initiates proper measures to support cardiovascular function | |
| Describes indications and contraindications for epidural anesthesia | |
| Describes at least three important complications, describes how to prevent and treat these | |
| Communicates effectively with the patient and team members | |
| Documents procedure correctly and completely | |

I will pass the resident regarding this competence

A(4): Checklist for radial arterial line cannulation

| Yes | No |
|-----|----|
| Obtains informed consent | |
| Performs Allen test | |
| Positions forearm and wrist | |
| Have pressure bag and tubing for connection ready | |
| Washes hands | |
| Applies cap, mask, sterile gown, sterile gloves | |
| Opens kit and organizes procedure material | |
| Paints and drapes the site | |
| Injects local anesthetic (2% lidocaine) at site of procedure | |
| Palpates radial pulse with nondominant index finger | |
| Inserts needle tip into radial artery pulse site | |
| Bevel up, enters artery at 30° to 40° | |
| Watches for flash of bright red blood (flashback) | |
| Uses dominant hand thumb to slip guide wire into artery | |
| Slips plastic catheter over wire into the artery | |
| Gently removes the needle and wire | |
| Applies pressure immediately proximal to puncture site to prevent loss of blood from hub | |
| Places plastic coupler to pressure transducer | |
| Dresses with transparent sterile dressing | |
| Dispose of needle and guide wire in sharps container | |
| Cleans up | |
| Writes procedure note in appropriate space | |

I will pass the resident regarding this competence
### A(5): Checklist for central line (internal jugular vein) cannulation

| Yes | No |
|-----|----|

- Patient is educated about the need for and implications of the central line as well as the processes of insertion and maintenance
- Patient’s anticoagulation therapy status assessed
- Obtain informed consent
- Washes and/or decontaminates hands, wears gloves, and gown by sterile technique
- Equipment assembled and verified — materials, medications, syringes, dressings, and labels
- Site assessed and marked
- Patient positioned for procedure
- Sterilize procedure site (chlorhexidine)
- Allow site to dry before puncture
- Use sterile technique to drape patient from head to toe
- Use local anesthetic and/or sedation
- Catheter prefilled and all lumens clamped except distal port
- Obtain qualified second operator after 3 unsuccessful sticks
- Aspirate blood from each lumen (to avoid air embolism and ensure intravascular placement)
- Transduce central venous pressure or estimate central venous pressure by fluid column (to avoid arterial placement)
- Clean blood from the site using antiseptic agent (chlorhexidine)
- Sterile dressing applied (gauze, transparent dressing)
- Dressing dated
- Disposes of waste appropriately
- Describes indications and contraindications for central line insertion
- Describes at least three important complications, describes how to prevent and treat these
- Communicates effectively with the patient and team members
- Documents procedure correctly and completely
- Verify placement by X-ray

I will pass the resident regarding this competence

### A(6): Checklist for nerve stimulator-guided supraclavicular brachial plexus block

| Yes | No |
|-----|----|

- Position patient supine and head up
- Turns head slightly to contralateral side
- Identifies the anatomical landmarks
- Infiltrates skin with local anesthetic
- Betadine skin preparation
- Palpates for subclavian artery and inserts needle posterolateral to artery
- Asks for nerve stimulator to be turned to level 1.0 to 1.5 mA
- Advances atraumatic needle no more than 1” relative to skin
- Remains perpendicular to all planes
- Needle-advanced slightly caudal
- Recognizes appropriate muscle group stimulation
- Asks for voltage on nerve stimulator to be turned down
- Readjusts needle to obtain maximal twitch response for lesser voltage
- Upon accepting twitch asks for aspiration for blood
- Asks for injection of 1-2 cc of local to r/o intravascular injection
- Asks for injection of 5 cc incremental dose of local anesthetic
- Respiration after each 5 cc dose to r/o blood
- Removes needle and applies pressure and massage to injection site
- Describes indications and contraindications for epidural anesthesia
- Describes at least three important complications, describes how to prevent and treat these
- Communicates effectively with the patient and team members
- Documents procedure correctly and completely

I will pass the resident regarding this competence
### Appendix B: Global rating scale

| Preparation for procedure | 1 | 2 | 3 | 4 | 5 |
|----------------------------|---|---|---|---|---|
| Did not organize equipment well. Has to stop procedure frequently to prepare equipment | Equipment generally organized. Occasionally has to stop and prepare items | All equipment neatly organized prepared and ready for use |
| Respect for tissue | Frequently used unnecessary force on tissue or caused damage | Careful handling of tissue but occasionally caused inadvertent damage | Consistently handled tissues appropriately with minimal damage |
| Time and motion | Many unnecessary moves | Efficient time/motion but some unnecessary moves | Clear economy of movement and maximum efficiency |
| Instrument handling | Repeatedly makes tentative or awkward moves with instruments by inappropriate use of instruments | Competent use of instruments but occasionally appeared stiff or awkward | Fluid moves with instruments and no awkwardness |
| Knowledge of instruments | Frequently asked for wrong instruments or used inappropriate instrument | Know names of most instruments and used appropriate instrument | Obviously familiar with the instruments and their names |
| Flow of procedure | Frequently stopped procedure and seemed unsure of next move | Demonstrated some forward planning with reasonable progression of procedure | Obviously planned course of procedure with effortless flow from one move to the next |
| Use of assistants | Consistently placed assistants poorly or failed to use assistants | Appropriate use of assistants most of the time | Strategically used assistants to the best advantage at all times |
| Knowledge of procedure | Deficient knowledge | Knew all important steps of operation | Demonstrated familiarity with all aspects of operation |
| Overall performance | Very poor | Competent | Clearly superior |