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ORIGINAL RESEARCH REGIONAL ANESTHESIA

Evaluation of the effectiveness of an advanced airway simulation workshop through pre- and post-course assessments in a low-resource setting

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ABSTRACT

Background: Effective airway management is critical in anaesthesia, yet many trainees have limited exposure to high-stakes airway emergencies in real clinical settings. Simulation-based training (SBT) offers a safe environment to practise technical skills before applying them to patients.

Methodology: We conducted a single-centre, one-day SBT workshop on advanced airway management for 15 anaesthesia trainees, stratified by experience into < 2 years (n = 8) and ≥2 years (n = 7). Participants completed a standardized 20-mark MCQ exam before and after the workshop, hands-on stations (including cricothyroidotomy, video laryngoscopy and rigid bronchoscopy), and post-workshop feedback on 0–5 Likert scales. A structured 4-step cricothyroidotomy assessment (stab, twist, bougie, tube; total score 0–4) was repeated at 6 months to evaluate retention. Descriptive statistics and paired-samples tests were used, with $P < 0.05$ considered significant.

Results: Both less experienced and more experienced trainees showed statistically significant improvements in total MCQ scores following the workshop, with larger gains in the more experienced group and greatest improvements seen in high-acuity procedural components. Participants rated all stations highly on satisfaction and perceived usefulness. At 6-month follow-up, 13/15 trainees completed the cricothyroidotomy assessment; the majority achieved scores ≥3/4 and no trainee scored <2/4, indicating retention of basic procedural competence.

Conclusion: A structured, low-cost SBT workshop in advanced airway management significantly improves anaesthesia trainees' knowledge and procedural skills and is associated with high self-reported satisfaction. Such simulation programs are feasible in resource-limited settings and should be more widely integrated into anaesthesia training curricula.

Keywords: Simulation-based training, Airway management, Anesthesia education, Clinical skills, Medical simulation, Low-resource settings

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1. INTRODUCTION

Anesthesiologists are required to handle life-threatening events without making errors, requiring both theoretical knowledge and clinical skills. Failure to properly manage the difficult airway results in significant morbidity and mortality; therefore, training for the anesthesiologist is essential to improve patient outcomes by reducing medical errors.[1] Traditionally, anesthesiologists have relied on non-simulation-based training (NSBT) methods, such as didactic lectures, lecture-based learning (LBL), and problem-based learning (PBL) to develop skills. However, they often lack sufficient hands-on experience in managing critical events and struggle with effective teamwork.

The traditional "see one, do one, teach one" model is no longer accepted in current medical education. The reason for this is that it leads to poor outcomes as it results in inadequate education and a lack of appropriate hands-on exposure during residency training. While theoretical instruction and practical demonstrations in airway management are provided during anaesthesia training, these maneuvers are often inconsistent, unstandardized, and untested before being applied to patients.

Simulation-based training (SBT) can help fill these gaps in skill development. Simulation provides a controlled, reproducible environment, allowing trainees to practice advanced and risky procedures without the concerns of practicing on real patients.[2,4] It allows trainees to test their knowledge, receive structured feedback, and identify shortcomings in their skillset. Furthermore, simulation strengthens participants' cognitive, emotional, and psychomotor skills, leading to positive changes in attitude and behavior in clinical practice.[3]

Literature review demonstrates that SBT has a significant impact on knowledge, attitude, and practice, providing updated evidence to inform future anesthesia educational designs. With this we conducted out study with the aim of evaluating the impact of a structured SBT workshop on knowledge, procedural performance and 6-month skill retention in advanced airway management among anaesthesia trainees at a tertiary cancer center.

2. METHODOLOGY

We conducted a single-center, pre–post, simulation-based educational study in the Department of Anaesthesiology at Shaukat Khanum Memorial Cancer Hospital and Research Centre, Lahore, Pakistan after acquiring IRB Exemption (EX-07-08-25-01). The intervention consisted of a one-day structured workshop on advanced airway management that combined didactic lectures with hands-on practice on simulation models, with a follow-up practical examination on cricothyroidotomy performed 6 months later to assess skill retention. All anaesthesia trainees (residents in years 1–4 of training and fellows) working in the department at the time of the workshop were eligible to participate, in which 15 trainees participated; No formal randomization was used; they were stratified into two groups based on clinical experience (<2 years, n = 8; ≥2 years, n = 7). Participation in the workshop and all associated assessments was entirely voluntary, had no impact on trainees' formal evaluations, progression, or employment, and completion of the pre- and post-course assessments was considered as implied consent.

The workshop was structured with the following format: a pre-course MCQ exam followed by lectures on DAS (Difficult Airway Society) intubation and extubation guidelines, demonstration of airway anatomy on ultrasound, and high-flow nasal oxygenation, after which hands-on practical's were conducted on cricothyroidotomy, video laryngoscopy, and rigid bronchoscopy. The MCQ exam was repeated at the end of the session using an identical paper; each correct answer was awarded 1 point and incorrect or unanswered questions were scored 0 (no negative marking), and pre- and post-course scores were compiled to calculate a cumulative workshop score for each participant out of a total of 20. Feedback at the end of the workshop was obtained regarding each station using a Likert scale from 0 to 5, which was used solely to evaluate participants' satisfaction, confidence, and perceived usefulness of the workshop and not as a measure of objective knowledge or skills. A 6-month follow-up cricothyroidotomy exam was conducted to assess retention of knowledge and skills; participants were evaluated on key airway management steps (stab, twist, bougie, tube) in a structured practical assessment scored out of 4, with 1 mark awarded for each correctly performed step, as these four steps represent the essential sequence required to achieve procedural competency.

Descriptive statistics (means ± standard deviations for continuous variables and frequencies with percentages for categorical variables) were calculated. Pre- and post-workshop MCQ scores and cricothyroidotomy checklist scores were compared using paired-samples t-tests to assess within-participant changes. A p-value of <0.05 was considered statistically significant. All analyses were performed using SPSS version 27 (IBM Corp., Armonk, NY, USA).

3. RESULTS

The simulation-based airway management workshop included 15 anesthesia trainees stratified by clinical

experience: less than 2 years (n = 8) and more than 2 years (n = 7). Analysis revealed significant improvements in both groups following simulation training.

The less experienced group (< 2 years) demonstrated a mean total score improvement from 12.13 ± 3.31 to 15.75 ± 1.39 (Δ=+3.62 ± 2.83, P < 0.01). The more experienced group (>2 years) showed higher baseline scores (14.29 ± 2.63) and achieved close to perfect post-course performance (19.57 ± 0.79, Δ=+5.28 ± 2.69, P < 0.01).

Table 1: Performance Comparison Before and After Simulation Training

Component (Max)	Group	Pre-Course	Post-Course	Improvement (Δ)
DAS Guidelines (9)	<2 years	4.50 ± 0.93	5.63 ± 0.92	1.13
	>2 years	4.57 ± 2.07	5.71 ± 2.21	1.14
Cricothyroidotomy (2)	<2 years	1.50 ± 0.53	1.88 ± 0.35	0.38
	>2 years	1.57 ± 0.53	1.71 ± 0.49	0.14
HFNC (3)	<2 years	1.50 ± 0.93	2.25 ± 0.46	0.75
	>2 years	2.43 ± 0.79	2.71 ± 0.49	0.28
Ultrasound (2)	<2 years	1.63 ± 0.52	1.88 ± 0.35	0.25
	>2 years	1.86 ± 0.38	2.00 ± 0.00	0.14
Fiberoptic (2)	<2 years	1.50 ± 0.93	1.88 ± 0.35	0.38
	>2 years	1.86 ± 0.38	2.00 ± 0.00	0.14

Data presented as mean ± SD

Table 2: Performance Improvement by Participant Category

Experience	n	Pre-Course (Mean ± SD)	Post-Course (Mean ± SD)	Improvement (Δ)	p-value
<2 years	8	12.13 ± 3.31	15.75 ± 1.39	3.62 ± 2.83	<0.01
>2 years	7	14.29 ± 2.63	19.57 ± 0.79	5.28 ± 2.69	<0.01

Performance in knowledge based components of MCQ exam showed consistent gains across groups, with DAS Guidelines improving by approximately +1.1 points in both. Scores in MCQs comprising of practical skills development differed by experience: the < 2 years group showed substantially greater scores in critical hands-on procedures—Cricothyroidotomy (+0.38 vs +0.14 in >2 years), HFNO (+0.75 vs +0.28), and Fibroptic (+0.38 vs +0.14). Both groups achieved excellent post-training scores in Ultrasound (< 2 years: 1.88 ± 0.35; >2 years: 2.00 ± 0.00) and Fiberoptic (< 2 years: 1.88 ± 0.35; >2 years: 2.00 ± 0.00).

These results indicate that simulation-based training effectively enhances airway management skills across experience levels, with early career trainees benefiting most in high acuity procedural skills.

Instructor feedback was highly positive across all sessions as given by participants. Theoretical components averaged 4.91/5, with the DAS guidelines session rated highest (5.00), followed by HFNO and Intubation (both 4.93). Practical sessions also scored well, with USG hands-on rated 5.00, and FOB basics, FOB practical, and FONA each at 4.87. The lowest, yet still favorable, score was for Intubation hands-on (4.60).

Thirteen participants completed the structured practical exam after 6 months. The mean score was 2.77 ± 0.64 out of 4, with a median of 3. Scores ranged from 2 to 4, with 30.8% scoring 2, 46.2% scoring 3, and 23.1% scoring 4. No participant scored below 2, indicating maintenance of baseline competency.

4. DISCUSSION

Simulation-based training (SBT) has become a key component in anesthesia education, allowing learners to practice and improve skills in a safe, controlled environment while helping reduce medical errors.2 Our workshop findings support this approach, showing that simulation is especially effective when matched to the learner's level of experience. When we analyzed the results by experience level, we found that junior trainees (<2 years of experience) made significant improvements in high-risk procedures like high-flow nasal oxygen (HFNO) and cricothyroidotomy, with a 50% increase in scores. In contrast, senior trainees (>2 years) showed near-complete mastery in technical skills, scoring 100% in ultrasound and fiberoptic bronchoscopy (FOB). These results highlight the effectiveness of our low-cost SBT model, even within the resource limitations common in developing countries.5 They also support the idea that simulation training can bridge important skill gaps across different experience levels when guided by evidence-based practices.

The success of the training lies in its alignment with key airway management principles. Junior trainees performed well to the FOB simulation, reinforcing earlier research that simulation helps shorten the learning curve for complex procedures.7 Senior trainees achieved high-level performance in rare but critical techniques like cricothyroidotomy, consistent with studies showing simulation's benefit in high-stakes, low-frequency situations.8,9 Both groups improved in using HFNO and FOB, but gains in knowledge-based areas—like the Difficult Airway Society (DAS) guidelines were more limited. This may reflect the relatively short duration of the didactic session, the dense cognitive load of multiple guidelines delivered on the same day as several practical stations, and the absence of structured pre-reading. Future workshops can incorporate pre workshop distribution of guidelines, spaced repetition of DAS guidelines during the day, and brief case-based discussions to better integrate theoretical content with hands-on practice.

Participant feedback was another important factor in the success of the workshop. Existing literature has shown that quality feedback strengthens skill retention,3 and participants in our workshop also emphasized its value. This highlights the importance of developing standardized instructor training programs and curriculum based on guidelines, especially for junior trainees who benefit the most from detailed guidance. Our experience based analysis also shows how simulation supports different learning needs: it helps beginners build basic competence and supports experienced practitioners in refining their skills. Even with a limited evaluation scope, both groups consistently followed airway management protocols, showing that simulation effectively reinforces critical decision-making pathways.

Follow-up after six months showed that most participants retained a good level of skill (mean score 2.77 out of 4). However, only 23% achieved perfect scores, which aligns with available literature warning about skill decay without regular practice.6,10 This emphasizes the need for ongoing refresher sessions, long-term assessment, and tiered training programs that consider the learner’s experience level. Our study also highlights ongoing challenges, including a low instructor-to-learner ratio, limited facilities for complex scenarios, and the need for better tracking of skill retention over time.

Looking ahead, future programs should focus on structured instructor training, experience-based learning pathways, and affordable simulation tools such as the Oxford box for FOB practice in low-resource settings. In conclusion, our findings confirm that experience-tailored SBT provides clear benefits: it builds essential skills in early-career trainees and sharpens advanced techniques in more experienced clinicians. By addressing critical gaps in life-saving procedures, simulation training plays a vital role in improving airway management. However, its long-term success depends on improving instructor capacity, enhancing integration of theory and practice, and supporting continued learning through structured follow-up.

3. LIMITATIONS

This study is limited by its small sample size, single-center design, and voluntary participation, which may introduce selection and response bias and reduce generalizability. In addition, the short follow-up period of 6 months restricts our ability to draw conclusions about long-term retention of knowledge and skills.

6. CONCLUSION

Simulation-based training significantly enhances knowledge, confidence, and skills in airway management, even in low-resource settings. Our project shows that cost-effective, well-structured simulation programs can have a positive impact on trainees' learning and behavior in advance airway management. Most participants requested conducting frequent workshops to enhance and retain the skills required.

7. Availability of data

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

8. Competing interests

The authors declare that they have no competing interests.

9. Funding

This study is not funded by any funding agency.

10. Ethical considerations

This study was conducted as per relevant guidelines and regulations or declaration of Helsinki.

11. Authors' contributions

BA: Data Collection, Manuscript writing
AA: Concept and Design of Workshop
AAK: Critical Review of Writing
HS: Supervision of Workshop

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