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Factors Affecting Success in Endotracheal Intubation in a Teaching Hospital in Kwazulu-Natal

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LITERATURE REVIEW

Substandard care as a result of lack of basic skills training in anaesthesia and resuscitation contributed significantly to the increasing number of anaesthetic-related maternal deaths in South Africa [1]. The Saving Mothers Report [1] further indicated that 50% of the general anaesthetic related maternal deaths were due to difficult and failed intubation. Endotracheal intubation is a definitive means of achieving complete control of the airway. Successful intubation on the first attempt is of great importance both in the emergency and elective theatre setting.

In a recent special article in the British Journal of Anaesthesia on the 2015 Difficult Airway Society Guidelines, the authors mention that a suboptimal attempt at intubation is a wasted attempt, and that success declines with subsequent attempts [2]. The 4th National Audit Project (NAP 4) report shows that airway interventions outside theatre are more likely to result in adverse events with a serious outcome [3]. As with any other acquired skill, endotracheal intubation requires practice and good technique. A study by Garza et al supported the recommendation that proficient endotracheal intubation requires rigorous training and extensive experience [4]. Internship training provides new medical graduates with supervised practice during which they acquire a set of core clinical skills in order to develop confidence and allow for continuous practice in performing these skills adequately.

The challenge that we face therefore, is the requirement for practical skills acquisition in increasing numbers of interns without an equal increase in the number of teachers or teaching time; thus the need to streamline the process of skills acquisition to increase the number of competent doctors at the conclusion of their internship training. Self-reported confidence of interns and supervisors' assessments of competence have shown not to be related: [5] first year interns were formally assessed after a year of training in various clinical skills, and the outcomes were compared to self-assessments. Important findings were that there was a range of competence levels, including inadequate performances, and that there was no correlation between self-confidence and formal assessment of skill.

It has been acknowledged in a South African article by King [6] that an increase in intern numbers, less theatre time and a shortage of suitably experienced trainers, as well as variations in the quality of undergraduate training, are key problem areas in current anaesthetic intern training. This period is designed to equip junior doctors, who are often working alone, with basic anaesthetic skills that can be used in theatre and in the emergency setting during their community service year. However, community service medical officers reported that they were not confident in administering general anaesthesia, amongst other essential medical skills, after completing internship [7]. Sepelt raised similar concerns relating to junior doctors with minimal experience being left to work alone in trauma settings [8].

With regards to patterns of acquisition of confidence in skills, it has been shown that confidence levels in basic skills generally improved over a two-year post-graduate period equivalent to the duration of local internship programmes [9]. In this Sydney-based study by Marel, the author identified three patterns of clinical skill acquisition among early postgraduate medical trainees, and found that the first postgraduate year is particularly significant for skill acquisition [9]. The literature reviewed showed tracheal intubation success rates increase with cumulative experience [4,9,10], highlighting the roles of teaching, clinical exposure, and use of simulators.

However a study by Stewart [10] showed that there was minimal difference between didactic and manikin teaching versus no exposure, although it did highlight the role of theatre experience in improving skill and success rates over time. Furthermore, Burch discussed the theoretical benefits of simulation training [11] including concerns over patient safety, medico-legal issues, and the burden of communicable disease, as well as the overloaded clinical platform for students and patients. She thereafter described the lack of robust evidence to demonstrate better health outcomes for patients treated by trainees who have undergone simulation training compared to those who have not, and recommended that further data on training and patient safety was required.

Novice anaesthesia residents (with no intern training) required 80 or more intubations to achieve relatively consistent skills [12]. Teaching tools suggested were a formal one-day airway course, video laryngoscopy and simulator use, as well as regular retraining and audit. Using the cusum method to measure performance objectively during the learning phase of basic procedures [13], four of seven anaesthesia residents obtained acceptable failure rates for intubation after 43 attempts. The wide variability in time to success between residents suggests that performance should be monitored on an individual basis [13]. Paramedic training includes at least 30 intubations on patients. De Oliveira [14] observed paramedics in operating theatres, and found that 30 intubations was sufficient for a 90% success rate, despite the complication rate remaining high. His study found little benefit with less than 13 attempts.

In an Australian psychology article, Langan-Fox et al recommended 20 hours of practice to acquire highly complex skills [15]. In this article, a process was defined as a series of actions, changes or functions bringing about a result. The author suggested that it is important to conceptualise the part of process in skill acquisition. Internal and external processes contributing to skill are described. These include the importance of practice in committing a task to long-term memory and the negative effects of interruptions on early skill acquisition, as well as the role of emotion, motivation and memory in performing a skill.

As mentioned, studies have demonstrated that intubation success rates improve with time and experience [4,9,10], specifically with formal anaesthetic training [16]. For example, in an Iranian study [16] of emergency medicine (EM) residents, the addition of an 'Anaesthesiology rotation' allowed residents to train in intubation on patients in operating theatres as an extension of their standard skills lab/manikin training. This in-theatre training resulted in statistically significant increases in intubation success rates, and the authors suggested the addition of this rotation to improve airway management training.

Those with no formal training have been shown to have higher complication rates. First attempt success rates at tracheal intubation in emergency departments correlated with predicted airway difficulty (greater success in non-difficult airways), level of training, and the use of rapid sequence induction (RSI) [17]. For EM physicians, the use of RSI improved first attempt success, but not for non-EM physicians. This highlights the positive effect of muscle relaxation in intubation success by emergency- and intubation-trained personnel. The authors also suggest training in RSI as part of routine airway management for non-EM physicians to improve success rates.

A critical care study by Lim [18] divided factors resulting in failed intubation into 1) operator-related factors e.g. unsupervised trainee; 2) disease-related e.g. emergency airway; 3) patient-related e.g. obesity, reduced C-spine/mandible mobility. This study also recommended multiple steps to aid laryngoscopy, such as cricoid manipulation. An American Airway Management Initiative [19] identified lack of knowledge of airway anatomy

and alternative airway manoeuvres as factors contributing to failed intubation. It highlighted that advances in anaesthetic airway management have resulted in less frequent use of tracheal intubation, and recommended structured training including manikin use. Minimum standards of training for those assisting in airway management outside the operating theatre have been recommended by The Association of Anaesthetists of Great Britain and Ireland (AAGBI) [20] and reiterated in NAP4 [3]. Advanced airway training modules for anaesthetists, including manikin use, have been shown to improve rates of success and exposure of weaknesses in skill even in the case of the trained anaesthetist [21].

The introduction of a safety intervention [22] have been shown by Bowles et al to reduce adverse events associated with intubation. A pre-intubation 'challenge-response' checklist has been suggested for use in emergencies. The Difficult Airway Society published new guidelines in 2015 [2]. These include the importance of appropriate head positioning including the 'ramped' position, use of neuromuscular blockade to facilitate optimal mask ventilation and intubation, as well as the use of video laryngoscopy to aid in difficulty during laryngoscopy with a traditional laryngoscope. The guidelines emphasise the need for cognitive aids in the form of algorithms and guidelines during crisis situations, which can also be used as a learning and teaching tool. Another important comment in these guidelines that is relevant to the intubation process is the need for structured communication between the anaesthetist and anaesthetic assistant, in terms of ensuring that all equipment is available and pre-empting difficulty.

Looking at the acquisition of a skill from the viewpoint of the trainer, the Conscious Competence learning model [23] illustrates the evolution of skills transfer through four stages. These range from an 'unconsciously incompetent' unskilled trainee, unaware of his/her lack of ability to carry out a task, through 'conscious incompetence' – the awareness of a need to learn – to 'conscious competence' – awareness of having learnt – to the 'unconsciously competent' expert who completes the task without having to recall each element. Transfer of the skill of intubation should aim to bring the trainee to the third 'conscious competence' stage, where the trainee is proficient at the skill, still requiring concentration and appreciation of the effort required to attain success with sufficient skill and knowledge. The question arises: How does the expert, from the level of 'unconscious competence,' teach a new trainee? Should the aim be to backtrack to 'conscious competence,' or to advance to a metacognitive state [24] that enables the expert to discern not merely how s/he was able to perform the skill but how most helpfully to guide the trainee?

In summary, the literature suggests that achieving consistent skill in intubation occurs somewhere between 43 and 80 successful attempts in anaesthesia residents, and with a 90% success rate within 30 successful attempts in paramedics. There was a 90% success rate after a mean of 57 attempts by anaesthesia residents, however 18% still required assistance after 80 attempts, providing the rationale for Graham [12] to suggest 80 attempts for novice anaesthesia residents.

In the article by de Oliveira, acceptable failure rates were calculated, and these were attained within a range of 9-88 attempts, with 20% obtaining these rates at 43 attempts [13]. The first issue arising from these figures is the uncertainty surrounding the number of successful attempts for adequate skill acquisition. As was mentioned by de Oliveira [13], there is wide variability among individuals performing intubation, and thus performance should be assessed on an individual's success rather than on a specific number of attempts. The paramedics described intubated in theatre under training conditions [14]. These included American Society of Anaesthesiologists (ASA) physical status classification grade 1 and 2 patients with no signs suggestive of a difficult airway. In the studies by Toda[14] and

Graham[12], intubations were supervised but there was no detail on the difficulty of the airways. The second issue to be raised with regard to these figures is the 90% success rate that paramedical requirements are based on, and whether 90% success is an acceptable figure for individuals required to perform this skill alone after their training. Toda et al. described that despite obtaining a 90% success rate, there was still a high complication rate amongst paramedics [14]. The lack of detail impedes our understanding of the discrepancies between the numbers required to achieve success in different studies, or to speculate on the implications of a 10% (or even a 1%) failure rate, 18% of trainees requiring assistance, or a 'high complication rate'.

Factors commonly cited as negatively affecting intubation success in inexperienced individuals, including rapid sequence induction, difficult airways, emergency intubations and level of expertise. Concerns regarding proficiency of junior personnel in essential medical skills, including intubation, is expressed both locally and internationally. Many authors have suggested simulation as an aid as part of airway training; however, as mentioned by Burch [11] and Stewart [10], there is still no strong evidence for simulation use to improve trainee or patient outcome. The impact of in-theatre training should be emphasised following the statistically significant improvement in intubation success in the study by Soleimanpour [16], as compared to success rates with simulation training alone.

Methods to improve communication and standardise procedures to provide optimal intubating conditions have been suggested. The routine use of muscle relaxant, adequate head position and video laryngoscopy have been advocated. Effective training of assistants and communication between intubator and assistant have been emphasised in recent guidelines. The need for check lists and 'cognitive aids' such as algorithms may aid in the learning and emergency recall of procedures such as tracheal intubation. In terms of supervision and skills transfer, the 'unconsciously competent' expert should be given the task of instructing a trainee, who as the literature suggests, may not be aware of his/her level of skill.

In-theatre training on selected patients has been shown to have added benefit over 'lab'-training alone. Studies have observed medical and paramedical trainee-intubations in emergency rooms and during field work. Some studies have examined supervised attempts in theatre settings with the aim of analysing the learning curve and eliciting the number of attempts required for skill consistency. It is hoped that understanding the process of skill transfer in this specific skill of intubation, can be applied to the teaching and training of other essential medical skills, which according to the literature, undergraduates feel is lacking.

Although the literature addresses success rates after training, the lack of consistency suggests that factors other than the number of repetitions of a task influence trainees' success rates. To discover those factors is perhaps more important in the South African context, in the light of junior healthcare workers having to perform this crucial skill without direct supervision. Most studies analysed factors contributing to successful intubation, however none has focused on actual skill transfer and the *process* required to attain a successful intubation

PROBLEM STATEMENT

The purpose of this observational descriptive study was to analyse factors influencing success in acquiring and performing the skill of tracheal intubation in supervised medical and allied healthcare trainees at King Edward VIII Hospital. This was done by means of a questionnaire on intubation experience hitherto, and observed plus video-recorded attempts to intubate selected patients undergoing general anaesthesia, with attention to both the trainees' and the supervisors' actions. Tracheal intubation forms part of securing the airway during the induction of general anaesthesia, as well as during cardiopulmonary resuscitation to allow for appropriate ventilation, oxygenation and prevention of aspiration of gastric contents. After a period of training, most medical and paramedical health care workers are required to work alone in peripheral settings where they are required to be proficient in resuscitation and the administration of general anaesthesia, making successful tracheal intubation an essential skill. This study was prompted by mishaps in theatre associated with junior doctors' poor intubation skills.

Despite numerous authors trying to determine the number of attempts required for various end-points in successful tracheal intubation (achieving success, eliciting 'acceptable failure rates' or attaining skill consistency – which remains poorly defined), it is clear that competence cannot be predicted after a set number of repeated attempts, and that the number of attempts before achieving consistent success varies greatly between individuals, although in most studies trainees were observed in practical situations, some including relatively controlled environments such as the operating theatre.

The study described here examined supervised intubation attempts on patients with non-difficult airways in the controlled theatre environment, to provide optimal intubating conditions so as to assess trainee or 'operator-dependent' errors as well as the process of skill. Video recording was included as a new method of data collection and helped to improve analysis. This study looked at tracheal intubation focusing on what makes for effective skill transfer rather than mere success in correctly placing the tracheal tube. Analysing this procedural gap seeks to optimise training in a limited timeframe, as well as to address what may be the cause of inadequate skill resulting in airway-related morbidity and mortality.

This intubation skill deficit was highlighted in the Saving Mothers Report that mentioned lack of basic resuscitation and anaesthesia-related skills, including failed intubation that contributed to the causes of maternal mortality. That this deficit must be addressed is evident; to a large extent, adequate transfer of the skill is the solution. However, it is moot whether the facilities, the opportunity and the personnel to effect this skill transfer are available.

This study aims to identify critical junctures and relevant flaws encountered in the intubation process, that could be improved during skills acquisition and training. In a resource-constrained environment, there is less opportunity for 'hands-on' experience due to the greater number of trainees, the smaller number of trainers, and mounting concerns about patient safety. The increasing use of newer generation airway devices has tended to reduce the need for tracheal intubation in many cases, thus reducing the opportunity to witness and practice intubation. Simulation therefore now forms part of most airway training modules, however there are mixed reactions to the benefit on patient and trainee outcomes as is demonstrated in the literature.

STUDY QUESTION

What are the factors influencing endotracheal intubation success and skill transfer in inexperienced trainees in a controlled, clinical environment? The aim of the study was to observe intubation technique in relatively inexperienced medical and allied personnel, and identify factors which influence the success of their attempts. Other objectives were to observe supervisor and trainee response to failure and difficulty, as well as to document common shortcomings in the training process.

ABSTRACT

Background
Tracheal intubation is an essential skill for anaesthetists and other disciplines that require emergency establishment of a secure airway. Early attempts in patients often meet with failure. Existing publications focus mainly on trainees in emergency settings and highlight the role of experience in success; most recommend prior simulation training. Common factors identified as contributing to difficulty have been difficult airways, emergencies and rapid sequence induction. Early intubation skill development in a controlled environment with straightforward patients has received little attention.

Objectives
The purpose of this observational study was to identify common difficulties associated with a supervised intubation process by inexperienced personnel in the relatively stress-free conditions of elective surgical procedures in the operating theatre.

Methods
Following institutional and ethical approval, participants, supervisors, anaesthetic assistants, and patients consented to observation and video recording of supervised intubations in a Durban teaching hospital. Anonymity and confidentiality were assured. Contemporaneous observations were recorded in theatre, and video recordings were subsequently reviewed for content. Errors, and interactions between supervisor, assistant and participant, and their contribution to outcome, were identified.

Results
There were 20 participants (medical interns and medical, paramedical and nursing students) and 72 intubations (oral or nasal) observed. All participants had been previously trained using manikins or simulators. There were 61 successful intubations and 11 unsuccessful attempts. Factors associated with failure included unfamiliarity with airway, equipment or process. Process errors included inadequate head positioning, laryngoscope handling and tracheal tube manipulation. Anaesthetic assistants contributed to error in some cases. Supervisor support was either verbal, physical or both. Less experienced supervisors had a tended to intervene earlier. There was a significant trend for success associated with the reported number of prior successful intubations. A successful intubation within the study was, however, no guarantee of subsequent success.

Conclusion
Despite prior simulation training, many participants demonstrated lack of familiarity with the airway, intubation process and equipment. While improved simulation training might partly address these issues, supervision of early clinical intubation attempts needs to be redirected from the process of intubation itself to the process of intubation skills transfer. A first step would be to ensure that all supervisors and assistants are trained for the latter goal,

anticipating common errors and providing standardised conditions for success. The use of video-recording of the events is an invaluable aid to observation and interpretation, and is recommended as an adjunct to further studies of mechanical skills transfer.

TEXT

Background and Introduction

Despite the importance of tracheal intubation as a basic clinical skill for both doctors and allied health care workers, first attempts to intubate patients frequently meet with failure, this notwithstanding the use of some form of simulation training (either plastic airway manikins or simulators). After their training, junior health workers are required to work alone and be proficient in resuscitation and/or the administration of general anaesthesia, making intubation an essential skill.

Success in intubation improves with experience [1]. Factors known to impede success include patients with difficult airways and emergencies requiring rapid sequence induction (RSI) [2]. Most studies have observed early intubation attempts in emergency departments or at remote sites. Few have observed trainees in operating theatres, and none from the perspective of skills transfer. Acquisition of experience should be led by early success in a controlled, supervised environment, such as elective lists in the operating theatre, resulting in more efficient skill transfer. Accordingly; the purpose of this exploratory observational study was to describe and analyse factors affecting success in early attempts at tracheal intubation by junior doctors and allied health trainees in a controlled clinical environment at a teaching hospital in KwaZulu-Natal, South Africa.

Methods

Following institutional, ethics (BE 489/14) and gatekeeper approval, operating lists at King Edward VIII Hospital were identified that provided most opportunity for observation of intubation by personnel of little or no experience. Participants were recruited at convenience from all groups of students and medical and allied health personnel who required supervised intubation experience. All patients were seen preoperatively by the principal investigator (PI), who examined them to exclude patients with any indication of a difficult airway or features known to be associated with difficult intubation. Children, other vulnerable groups and patients requiring emergency intubation were also excluded.

Participants and their clinical supervisors gave written informed consent to observation and digital video recording of the attempted intubations. Confidentiality and anonymity were assured. Patients also gave informed consent for digital recording and observation of the events, with assurance that they would not be identifiable and their clinical details would not be documented. Trainees were asked to complete a short questionnaire containing closed and open questions about prior intubation experience and training.

Following patient entry to theatre and transfer to the operating table, a small digital camera was positioned on a tripod beyond the foot of the table. The height, angle and focal length were adjusted to include the intubation action space, comprising the anaesthetic assistant to the left, the anaesthetic machine, participant, and any intervention by the supervisor, precluding patient identification. The PI was positioned perpendicular to the patient's head and could observe and record events which were subsequently matched to the video record.

The PI used a structured data sheet to observe different elements of the intubation attempt, defined as time from removing the facemask following mask ventilation to removing the

laryngoscope blade following either successful insertion of the tracheal tube or to recommence mask ventilation (failed attempt). Observations included basic equipment checks, mask ventilation, laryngoscope handling, and insertion and securing of the endotracheal tube. Videos were subsequently reviewed by all authors, both individually and as a group, to permit timing of each attempt and confirm the data extracted.

Difficulties were identified, described and grouped according to themes such as “head positioning”, “laryngoscopy”, etc. No statistical analysis was planned beyond simple descriptive summary statistics. During video review, an effort was made to identify the seminal process (es) leading to failed attempts. Supervisor responses to participants’ difficulties or failure were noted, as were the actions of the anaesthetic assistant. Attempts by participants observed on more than one occasion were compared.

Results

There were 20 participants from various disciplines viz.

Medical interns	8
New medical officers	1
Paramedics	1
Paramedic students	4
Nursing students	1
Medical students	3
Overseas exchange medical students	2

All 20 participants claimed to have been trained on some sort of simulator, and the majority (14) felt able to intubate a patient. Those who had already attempted intubation had been supervised by anaesthetic consultants or registrars; half of the participants had noted difficulties: other than the common feature of being unable to visualize the vocal cords, they described a wide range of problems with all phases of the procedure. In 15 unsuccessful attempts, their supervisor had pointed out their mistake and allowed a second attempt; in 7, the supervisor had physically taken over the intubation. With two exceptions, participants conceded that they required more training.

Observations were made of 72 intubations:

Oral	49
Nasal	23
Successful	61
Unsuccessful	11
Rapid sequence	4

Of these, 68 were video recorded; three unrecorded due to equipment difficulties and one when the participant declined video recording.

Oral Intubation

Of the 48 oral intubations assessed, 38 were successful, 30 on the first attempt and eight following more than one attempt. Of the eight requiring more than one attempt, three required physical intervention by the supervisor, four verbal support, and two participants were successful following self-correction. There was more verbal assistance during first attempt success, and equal verbal and physical assistance in success after multiple attempts.

There were 11 failed attempts (nine participants; two failed twice). Four of these participants were making their first attempt on a patient (three were talked through the process beforehand, with the use of hand gestures and demonstration with the laryngoscope). All four were all allowed more than one attempt on each patient, but demonstrated difficulty in identification of landmarks and failure to grasp the correct sequence of actions within the process; one participant failed twice on attempts in two consecutive patients, however the second 'failure' was associated with early supervisor intervention due to concern over the haemodynamic response to intubation in a hypertensive patient.

The other five participants had made previous attempts on patients. There was one unanticipated difficult airway. Despite a satisfactory pre-operative assessment, the participant had difficulty displacing a large tongue, to reveal a grade three laryngoscopy where only the epiglottis was visualized, necessitating senior intervention. One had been successful previously (recorded) and then failed (early supervisor intervention), had a subsequent success (recorded) and then failed again. Both failures were associated with poor laryngoscope technique: the second failure was also associated with failure to insert a reinforced tube through moving cords.

The next participant had three successful intubations, followed by a failure to insert the reinforced tube through moving vocal cords, and then two subsequent successes (all attempts on record). The remaining two participants gave a history of previous successful attempts (unrecorded) and then failed. On the recorded attempt, one was a left handed participant who failed despite several manoeuvres and supervisor assistance; and the other (a trainee paramedic) failed to obtain a view of the cords at laryngoscopy, returned to mask ventilation subsequent to desaturation, then failed again and the supervisor completed the intubation without difficulty.

Type of tracheal tube
In five observations where a reinforced tube with an introducer was used instead of a regular tube, two were successful with difficulty, and three failed.

Rapid Sequence Induction (RSI)
There were four RSI's. This was not an observed factor contributing to intubation failure.

Experience
Four out of five participants with no previous experience were unsuccessful. As shown in Table 1, there was one failed attempt amongst those who successfully intubated 10-20 times, but this was due to the omission of muscle relaxant and inability to pass the tube through moving vocal cords despite adequate laryngoscopy.

Table 1: Relationship of prior intubation experience to successful observed attempts

	Previous intubation attempts prior to study			
	0	<10	10-20	>20
Successful/total	5/10	12/16	31/32	11/11

In terms of experience needed for success (number of attempts prior to successful intubation), there was no single number needed before a participant was successful. There was no pattern of success between initial and subsequently observed successful attempts, as in three cases, failed attempts were preceded by a previous successful attempt. Some participants showed decreasing time to success with multiple attempts, while others showed variable times to success.

Times to success with oral intubation (seconds):

Mean	95
Median	94
Interquartile range	60-125

Muscle relaxant

Of two observations where no muscle relaxant was used, both intubations failed (omitted due to the need for peripheral nerve stimulation for nerve block following intubation.)

Patient positioning

In 14 observations of oral attempts, change in head position was used to improve laryngoscopy view. In two observations, the supervisor lowered the head of the bed in an attempt to improve the view at laryngoscopy, and in two observations a pillow or head-ring was added. The head-ring was removed in one observation. Four observations included patients with large hairpieces which made positioning more difficult. There were five observations in which the table height was too low, making laryngoscopy difficult.

Laryngoscopy

Of the 38 successful oral intubations, 10 attempts showed difficulty with laryngoscopy. Of the 10 failed attempts, 8 demonstrated incorrect laryngoscope handling. Most difficulties with laryngoscopy involved incorrect head positioning to insert the laryngoscope (12/72), incorrect wrist movement (13/72) to obtain and maintain an adequate view of the cords, or inadequate displacement of the tongue (9/72). In eight observations, the laryngoscope was inserted on the wrong side: two intubations were successful and six were unsuccessful. Three participants received the laryngoscope in the wrong hand and attempted laryngoscopy. These participants, however, self-corrected this mistake in order to proceed with their attempt. In two of the first attempts at intubation, participants were unfamiliar with anatomical landmarks relevant to visualising the cords. In six observations, the laryngoscope blade was inserted too deep.

Manoeuvres to improve laryngoscopy and intubation success

In four observations, manoeuvres to optimize view at laryngoscopy, following a failed initial attempt, resulted in successful intubation. These manoeuvres included repositioning the head, the application of backward-upward-rightward-pressure (BURP), changing laryngoscope blade size, and the use of suction. In four observations, the supervisor obtained an adequate view of the cords and allowed the participant to pass the tube. Cluster plots for oral intubations (Tables 2 and 3) indicate that the position of the patient's head appeared to be the primary factor to which other phases of a successful intubation process were related, and that manipulation of the laryngoscope seemed to be the leading problem when intubation failed.

Table 2: Clusters for successful oral intubations

Primary Cause (n)	**Secondary Cause**			
	HP	**LH**	**TI**	**AE**
Head Position (HP) **(n=10)**		**5**	**3**	**1**
Laryngoscope handling (LH) (n=10)	1		0	1
Tube Insertion (TI) (n=2)	0	0		0
Assistant Error (AE) (n=1)	0	0	0	

Table 3: Clusters for failed oral intubations

Primary Cause (n)	Secondary Cause					
	HP	**LH**	**TI**	**AE**	**SE**	**U**
HP (n=1)		1	1	1	1	0
LH (n=7)	**3**		**3**	**2**	**0**	**2**
TI (n=1)	0	0		0	0	0
AE (n=0)	0	0	0		0	0
Supervisor Error (SE) (n=0)	0	0	0	0		0
Unfamiliarity with airway, process, equipment (U) (n=0)	0	0	0	0	0	

Nasal Intubation

All participants attempting nasal intubations had accomplished previous successful oral intubations. All 23 nasal attempts were successful, four using a blind technique. Nasal intubations took longer. Increased time was spent inserting the tube through the nostril, and in four attempts (four participants) difficulty was experienced manipulating the tube with the Magill forceps. Once the tube was through the nostril, and grasped by the forceps, only one participant experienced difficulty passing the tube through the vocal cords. All nasal intubations were confirmed with laryngoscopy.

Times to success in nasal intubation (seconds):

Mean	115
Median	103
Interquartile range	92-190

As in the case of oral intubations, there was no clear trend in time to success amongst participants who were observed more than once.

The supervisors

Experience of 16 supervisors:

Specialist anaesthetist (Consultant)	5
Medical officer completed registrar training	6
Registrar in training	1
Medical officer > one year's experience	2
Medical officer < one year's experience	2

One intubation was taken over by a less experienced supervisor, after one failed attempt at laryngoscopy with no change in oxygen saturation. The same supervisor allowed another participant multiple attempts to optimize their view at laryngoscopy with no deterioration in saturation, and proceeded to take over the intubation. One intubation following a successful laryngoscopy was taken over by a non-consultant with concern about an intubation response.

Two intubations were taken over after the participants struggled to pass the tube through moving vocal cords following omission of muscle relaxant. Both attempts were supervised by the same consultant. In one attempt, the participant succeeded at laryngoscopy, and in the other the participant required senior assistance with laryngoscopy and still failed. One intubation was taken over by a non-consultant supervisor following desaturation and a further attempt at laryngoscopy once the saturation was optimized. This attempt also failed despite supervisor assistance.

Two of the four first attempts at intubation were supervised by consultants, and two by non-consultant anaesthetists. In all four, the supervisor allowed multiple attempts. Both medical officers and one consultant talked the participant through the procedure before the attempt, and one consultant demonstrated the procedure after the first failed attempt. Participants were physically and verbally supported by their supervisors, with a tendency to start with verbal supervision first and progress to physical assistance. There was more verbal assistance during first attempt success, and equal verbal and physical assistance in multiple attempt success.

In six observations, the process was demonstrated and discussed by the supervisor before the attempt. This was in the scenario of a less experienced participant with an experienced (>1year) supervisor. In six observations, the process was discussed during the attempt, usually where the participant was less experienced and struggling.

The Anaesthetic Assistant

The anaesthetic assistant in every case was a nurse. In three observations, the assistant was unsure of the intubation process and could not optimally assist. In three observations, the tube was passed with the cuff inflated, and in one observation the assistant was unfamiliar with laryngeal BURP. Airway equipment (laryngoscope and airway) was checked by the anaesthetic assistant in 62/72 observations. In the remaining 10, the supervisor checked in five and the participant in five. Of the oral intubations, participants received the tube from the assistant by grasping the top end in 21 observations, and in the middle in 24. By holding the tube in the middle, participants tended to insert the ETT in small shuffling movements instead of in one smooth action.

Discussion

Our results support existing evidence that previous intubation experience is associated with subsequent success [1,3] The data suggest that 20 prior attempts would be a basic minimum for reasonable expectation of subsequent success in uncomplicated airways in a controlled, supervised environment. This may not be the case in other circumstances. The focus of the study was on the journey from unconscious incompetence to conscious competence [4] and any obstacles along the way. For skills transfer, much depends upon firm groundwork and the ability of the supervisor to recognise the next required step and apply it. Neither was evident in our study.

All participants had received simulator training. It is a reasonable assumption that the next step to intubating a patient would be straightforward. However, our findings, in keeping with local and international literature, included poor trainee understanding of airway anatomy. [1,3,5] Simulation forms part of most international recommendations for airway training [6]; however, there may be little difference between didactic and manikin teaching versus no exposure [3]. Despite simulator training, the four participants making their first intubation attempts failed because of unfamiliarity with the airway, equipment and the process. This supports the view that evidence is lacking in terms of better health outcomes where trainees have undertaken simulation-based training [7].

This begs the question, is it the type of simulator or the quality of training that seems to confer no benefit to tracheal intubation in patients? ‘A map is not the territory’ [8]; to be of value the map has to be of similar structure to the territory. Two participants emphasised that intubating a rubber manikin is very different to human tissue. Another two participants were unable to identify anatomical landmarks such as the epiglottis and the vocal cords. A possible way around this disparity between simulator and patient would be to incorporate video-laryngoscopy demonstrations as part of training.

It is possible that there are similarities in the quality of training on the simulator and in theatre. We observed an obsession with “getting the tube in the hole”. This is understandable on the part of the participant, but unnecessary on the part of the supervisor, who is available to accomplish this task. While intubation itself is an appropriate end, the skills transfer process demands that the means to the end are also appropriate. Seldom did supervisors intervene when equipment handling or patient positioning was incorrect, only when failure had occurred.

Many of the “successful” participants somehow managed to achieve the end of intubation while working around perseveration of error. This is highlighted by the participant who failed on two observed occasions due to poor technique, later managed to intubate successfully despite making the same errors, and then supervised other participants while still making the same errors. So perseveration of error became normalisation of deviance. If a similar process were occurring with simulation training, this would explain the unhelpfulness of prior simulator training. The end for the supervisor has to be the transfer of correct skills for the participant to achieve the end of intubation using the correct means.

The three broad themes of error were head-positioning, laryngoscopy, and tube-handling; the first two being evident from the cluster plots for success and failure, the last, while not contributing to one or other, was noted to contribute to the ease and speed of intubation. The commonest (almost universal) mistake in head positioning was the absence of a pillow. In only one case was a pillow inserted to assist intubation in a moderately obese patient. In two cases, supervisors actually dropped the head of the table in an attempt to help. Many participants struggled to position the patient’s head and neck, resulting in difficult or failed laryngoscopy. The scarcity of pillows in King Edward VIII and many other resource-constrained state hospitals should not be regarded as an inconvenient laundry issue but a serious lack of vital equipment.

Assistants should be trained in the process of checking equipment, providing tracheal pressure and handing over equipment to maximize the chance of success. Transferring the laryngoscope into a trainee’s right instead of left hand sets the trainee up for difficulty, especially if the latter is unsure of how to manipulate the instrument: where to insert it, how to keep the tongue out of the field of view, and how to lift rather than lever. Each of these actions was seen to be problematic in our study.

Passing a tube with the cuff uninflated and holding the tube in the middle so that the trainee naturally grasps it near the top seems to improve time to intubation and minimize the number of movements as the tube is advanced. The supervisor should ensure that the assistant facilitates in these ways, and might ideally take the assistant’s place for the tyro’s first few intubations; this allows the supervisor to guide the novice in introducing the tube from the right rather than in the midline, without obstructing the view. The supervisor is also optimally placed to look over the trainee’s shoulder if required.

Although the literature quotes RSI [2] to be a factor influencing success, all four in this study were successful, and there was no increased time to success. This may be due to the controlled nature of induction of anaesthesia in theatre, compared to intubation in the emergency situation. Optimal intubating conditions should be provided for novice trainees to allow the best chance of success. The Difficult Airway Society Guidelines [14] recommend the use of muscle relaxant for optimal conditions. The omission of muscle relaxant for trainee intubation in our observed attempts therefore provides suboptimal conditions, resulting in failure of all such observed attempts in this study. It is an error in supervisor judgement to allow a less experienced trainee to attempt intubation under these conditions.

The same difficulty arose with the use of reinforced tubes with introducers. It should be suggested that supervisors introduce alternative intubation techniques and equipment once the trainee is consciously competent at intubation using optimal conditions and standard equipment. Supervisors and assistants should be trained to increase the chance of success, while ensuring patient safety. It was noted that more junior supervisors intervened earlier, before deterioration of patient condition, whilst more experienced supervisors appropriately intervened after a number of unsuccessful attempts. Another consideration is patient selection with regard to co-morbidities that render them unsuitable for training.

This study is exploratory, based on its unique methodology using video-recording. It is also novel because it examines a trainee group specific to the South African teaching and training context, to highlight local issues. The use of digital video-recording allowed for more detailed analysis by the PI and supervisors. This was a novel method of data collection, combined with direct observation. This method has not been described previously in studies of this nature. Elements resulting in failed intubation have been divided into operator-, disease- and patient-related factors [9]. This study, using strict exclusion criteria, removed confounding factors and examined participants intubating non-difficult airways. Isolating operator-related factors allowed a closer examination of the phases of intubation.

A noteworthy finding in this study was that intubation success significantly increased after 10 previous attempts. Dawkins' concept of the extended phenotype [10] can be applied to becoming proficient at a skill. It was noticed that as participants became more experienced, they learned to accommodate their environment, the anaesthetic machine and task-directed equipment in the process of intubation, requiring less assistance to achieve success. Novice UK anaesthesia trainees [11] required 80 intubations before skill consistency was achieved, and in Australia, [12] 20 hours of practice was recommended to acquire highly complex skills. In a time- and resource-constrained setting, either of the above may be impossible. Findings of this study support local practice [13] which requires interns to perform 20 general anaesthetic cases as part of their anaesthesia training.

Limitations of the study include its exploratory nature, although a sample size of 60-100 observations was acceptable and provided richness and saturation of data within the 72 recordings. The method of video recording required familiarization of the PI with the recording equipment; future modifications include a higher camera angle to incorporate the patient's chin and lips to directly observe laryngoscope insertion whilst maintaining patient anonymity. We observed that, even when intubation became difficult, a sense of calm pertained due to the presence of a senior anaesthetist who was able to adjust the anaesthetic settings, help with ventilation, and intubate if necessary. This immediate back-up is unlikely under conditions of community service and, despite seeing participants becoming more familiar with the equipment and technique, retention of the skill under study plus all its ancillaries may be questionable.

Further investigation into the quality and benefit of simulation training, as well as the role of video laryngoscopy as an aid to early teaching of airway skills, is recommended. More broadly, the use of video recording is recommended to enhance the quality of observational studies. Training of supervisors and assistants should be standardized, with early training under optimal conditions. The creation of a basic algorithm may also assist during early training, and as a guide in emergencies.

This study provides a framework by which other institutions can assess trainee performance and improve teaching so that transfer of essential skills can occur optimally in a limited training period. An editorial [15] reflected the need of young community service doctors for greater training in general anaesthesia. There are several skills related to this and other disciplines, for the training of which supervisors need to progress from unconscious competence to meta-conscious competence in order to optimally transfer their skills in the most efficient way. The implication of a more efficient training process is that young health care professionals are capable of performing essential skills when required to work alone in peripheral settings.

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