



Original article

Age-related laryngoscopic visual acuity

Abdul-Maajid Mathews^a, Christopher Stein^{b,*}, Marietjie Richter^c^a Department of Emergency Medical Care, Faculty of Health Sciences, University of Johannesburg, South Africa^b Department of Emergency Medical Care, Faculty of Health Sciences, University of Johannesburg, South Africa^c Department of Optometry, Faculty of Health Sciences, University of Johannesburg, South Africa

ARTICLE INFO

Keywords:

Endotracheal intubation
Laryngoscopy
Visual acuity

ABSTRACT

Background: Endotracheal intubation by direct laryngoscopy is a mainstay of advanced airway management performed both in the prehospital environment and in the Emergency Department. Many factors may affect the quality of view during direct laryngoscopy, one of them being the visual acuity (VA) of the intubator under these demanding conditions. While some individual variation in VA is to be expected in younger populations, VA naturally deteriorates in older populations particularly beyond the age of 40 years. This study aimed to describe VA in a younger ($n=19$) and an older (≥ 40 years of age, $n=20$) cohort of intubators at baseline and during simulated adult laryngoscopy, and to compare VA between these two age cohorts.

Methods: A baseline near VA test was done using a Sloan Early Treatment Diabetic Retinopathy Study (EDTRS) near vision chart at 40 cm under ambient indoor light. Participants in both age cohorts were then requested to perform laryngoscopy using an airway simulator at 40 cm viewing distance and again at a viewing distance of their choice. Both binocular and monocular VA were tested using a near VA chart placed anterior to the vocal cords of the airway trainer. VA was quantified using the logarithm of the minimum angle of resolution (logMAR). Differences in VA between age cohorts were assessed using independent samples *t*-tests and differences within age cohorts were assessed using paired samples *t*-tests.

Results: Binocular and monocular near VA was significantly reduced in the older cohort compared to the younger cohort at baseline (both eyes -0.129 logMAR; $p = 0.04$, right eye -0.147 logMAR; $p = 0.005$, left eye -0.197 logMAR; $p = 0.002$). Within each age cohort VA was significantly reduced during laryngoscopy at a fixed viewing distance (younger; both eyes -0.111 logMAR; $p < 0.001$, right eye -0.095 logMAR; $p < 0.001$, left eye -0.105 logMAR; $p < 0.001$; older; both eyes -0.08 logMAR; $p < 0.001$, right eye -0.110 logMAR; $p < 0.001$, left eye -0.065 logMAR; $p = 0.01$) but this was improved by reducing viewing distance.

Conclusion: Increased age was associated with a significant reduction in VA at baseline and during laryngoscopy, which can be partially compensated for by adjusting viewing distance. Although it is currently unknown to what extent this age-related reduction of VA might negatively affect time to place an endotracheal tube or success of placement under direct vision, older intubators should be aware of this effect and consider specialized corrective eyewear in order to maintain an adequate level of VA.

African relevance

- Endotracheal intubation is frequently performed during the emergency care of patients, worldwide and in African emergency care.
- In low-resource settings, endotracheal intubation is carried out using direct laryngoscopy - a procedure requiring good visual acuity.
- With advancing age visual acuity deteriorates - this may affect the ability of older clinicians to easily view the larynx.

- This study suggests that such decreases in visual acuity can be compensated for by the use of glasses or contact lenses.

Introduction

Endotracheal intubation by direct laryngoscopy is a mainstay of advanced airway management in emergency care, both outside and inside the Emergency Department [1–3]. In order to successfully place an endotracheal tube in the shortest possible time on the first attempt, an

* Corresponding author.

E-mail address: cstein@uj.ac.za (C. Stein).<https://doi.org/10.1016/j.afjem.2020.12.002>

Received 25 May 2020; Received in revised form 8 December 2020; Accepted 21 December 2020

2211-419X/© 2018 Published by Elsevier Ltd. CC BY-NC-ND 4.0 This is an open access article under the CC BY-NC-ND license

<http://creativecommons.org/licenses/by-nc-nd/4.0/>.

optimal view of the vocal cords is essential. Many factors, including skill of the intubator, the presence of secretions or blood in the airway and anatomical factors, are known to affect the quality of view during laryngoscopy [4,5]. In addition to these, one obvious and very important factor that has infrequently been subjected to study is visual acuity (VA) of the intubator under these conditions.

While visual acuity may vary from individual to individual in younger populations, it invariably declines with age due to presbyopia which begins around age 40 [6]. As a result, the near vision accommodation point of the eye (even in people with a history of near-perfect VA) goes through change and moves 2-3 cm outward making it more difficult to focus on objects which are up close. Thus, older intubators who may have acquired significant experience and skill at laryngoscopy may have some of these benefits offset by declining VA, which may not be easily noticed over a prolonged period of time. These changes may negatively affect the time taken or number of attempts to pass an endotracheal tube, both of which may potentially have negative effects on sick or injured patients [7,8]. The aim of this study was to describe VA in a younger and an older (by presbyopic definition ≥ 40 years) cohort of intubators at baseline and during simulated adult laryngoscopy, and to compare VA between these two age cohorts.

Methods

This research used a prospective observational design, comparing the VA of two participant age cohorts at baseline and during simulated laryngoscopy.

Population, sample and sample size

Participants were sampled from two different populations. A younger cohort was sampled from the third and fourth academic year student groups in the Department of Emergency Medical Care at the University of Johannesburg. All students in these two years had been trained in the technique of direct laryngoscopy and had practiced the skill in both a laboratory and clinical setting. An older cohort was sampled from a list of qualified Emergency Care Practitioners and medical practitioners known to the researchers, who worked in the Johannesburg area. The lower age limit in this cohort was 40 years of age. In both cases, sampling was based on convenience.

A total sample size of 42 participants was estimated to be sufficient based on a moderate effect size (0.8), statistical power of 0.8 and alpha of 0.05. A moderate effect size was estimated to be of practical significance in relation to VA during laryngoscopy.

Visual acuity measure

Visual acuity was quantified using the logarithm of the minimum angle of resolution (logMAR), using a logMAR conversion chart. Participants were asked to read out letters on each line of a standard near vision chart, starting with a line that they could easily read. The logMAR value was obtained by cross-referencing the letter size of the smallest correctly read letters at 40 cm on a conversion table. A logMAR of zero is equivalent to 20/20 VA with larger values indicating progressively diminishing VA and smaller values indicating progressively better VA.

Data collection setup

Data for this research was obtained using an adult airway simulation trainer (Airway Management Trainer, Laerdal Corporation, Stavanger, Norway). A Sloan Early Treatment Diabetic Retinopathy Study (EDTRS) near vision chart measuring approximately 30 mm by 40 mm was inserted into the larynx of the airway trainer in an approximately vertical plane immediately in front of the vocal cords following a similar approach to that used by Baker et al. [9] The distance, inside the airway, from the VA chart situated in front of the vocal cords to the airway

trainer's top row of teeth was measured. A piece of string was then measured as the difference between 40 cm and the distance between the VA chart and the airway trainer's top row of teeth. This piece of string was attached to the airway trainer's top row of teeth. The airway trainer was placed on a non-adjustable table at a height of approximately 75 cm to 80 cm from the ground. The same standard bulb stainless steel laryngoscope (Welch Allyn MacIntosh 2.5 V Standard Laryngoscope Set, Welch Allyn Hillrom, Chicago, USA) was available to all participants for laryngoscopy. Participants were allowed to choose the blade size for laryngoscopy, but were not allowed to use any adjunctive airway maneuvers.

Baseline near vision acuity test

Prior to laryngoscopy, all participants completed a standard near vision VA test under adequate indoor lighting conditions. A near Sloan EDTRS chart was held at a distance of 40 cm from the participant's eyes (determined using a 40 cm-long piece of string held taut between the near vision chart and the participant's eye line). Participants were then requested to read, initially with both eyes, the row of letters on the chart that was most easily identifiable for them and to continue with each row below this if they could correctly identify between three to five letters.

Each participants' VA score was determined from the row with the smallest letters in which they were able to correctly identify between three and five letters. If between three and five letters were correctly identified, the decimal value was read from the near vision chart and converted to a logMAR value using a conversion chart. Participants were allowed to wear glasses or contact lenses if they normally wore these for vision at this distance. Following this initial test with both eyes, participants underwent two identical tests – one with the right eye occluded and one with the left eye occluded. The VA score was recorded in the same way for each eye independently.

Laryngoscopy near vision acuity test – fixed distance

Each participant was requested to perform direct laryngoscopy on the airway trainer with the laryngoscope provided and to obtain the best possible view with no time restriction. Participants were requested to position their head in such a way that they maintained an optimal view of the larynx, but also so that one end of the piece of string referred to above, measuring a total distance of 40 cm from the visual acuity chart in the larynx, was at their eye line when pulled taut by one of the researchers. Participants were then asked to read off letters from the VA chart in the same way that was done in the baseline test, first with both eyes and then with each individual eye (they were assisted in covering the other eye by the researcher).

Laryngoscopy near vision acuity test – participant-determined distance

The procedure described above was repeated, with the only difference being that (i) participants were allowed to choose their own viewing distance and (ii) participants chose either binocular or monocular vision. Once each participant had indicated verbally that they had obtained their optimal view of the larynx, and before reading off letters from the VA chart in the larynx, the distance from the airway trainer's top row of teeth to the participant's eye line was measured. This measurement was added to the known distance from the visual acuity chart to the upper teeth in order to obtain the total distance from the visual acuity chart to the participant's eye line.

Data analysis

Descriptive data are presented as means \pm standard deviation. Differences in logMAR between age cohorts were assessed using independent samples *t*-tests and differences within age cohorts were assessed using paired samples *t*-tests. A $p < 0.05$ was considered significant and

IBM SPSS (version 26, IBM Corporation, USA) was used for data analysis.

Ethical approval

This study was approved by the Faculty of Health Sciences Research Ethics Committee at the University of Johannesburg.

Results

A total of 39 participants consented; 19 in the younger cohort and 20 in the older cohort. Age range in the younger cohort was 19–29 years and in the older cohort was 40–53 years. The distribution of logMAR VA results across test groups is shown in Table 1.

Allowing participants to adjust their viewing distances and choice of binocular or monocular viewing during laryngoscopy increased VA slightly in both age cohorts (Table 2). The mean distance at which this effect occurred was 1.95 cm less than the standardised 40 cm in the older cohort but approximately 12.94 cm less in the younger cohort. The older cohort displayed much greater variance in chosen viewing distance than the younger cohort. All participants in the older cohort chose binocular vision to obtain their best view of the larynx. Of the younger cohort, 15 (79%) chose binocular vision and the remaining four (21%) chose monocular vision (three with the left eye and one with the right eye).

Baseline differences in VA between the two age cohorts were significant for both binocular and monocular tests, while age cohort differences in VA during laryngoscopy were only significant for monocular tests and during laryngoscopy at chosen viewing distances (Table 3). All within groups differences were significant. Effect sizes for all group comparisons were large, with the exception of baseline vs laryngoscopy at 40 cm (left eye) and younger vs older cohort laryngoscopy at 40 cm (both eyes) where effect sizes were moderate.

Results of the baseline VA test show that, in the older cohort, VA was not perfectly corrected by the use of glasses or contact lenses (Table 1). Possible reasons for this are discussed below. However, in order to simulate the effect of perfect VA correction in the older cohort, the difference between a logMAR of 0 and each observed binocular and monocular logMAR was calculated for each participant. The means of these difference were -0.055 (-0.133; 0.023) for both eyes, -0.115 (-0.205; -0.025) for the right eye and -0.150 (-0.263; -0.037) for the left eye. The difference calculated for each participant was then added as a correction coefficient to each binocular and monocular laryngoscopy observation in the older cohort (Table 4). These corrected observations for the older cohort were then used in a repeat comparison of mean logMAR between older and younger cohorts during laryngoscopy (Table 5).

The mean corrected logMAR for binocular and monocular observations suggests improved VA under laryngoscopy conditions at 40 cm

Table 1
Baseline and laryngoscopy VA: descriptive data.

Age cohort	Acuity test	Eye(s) tested	logMAR
			Mean (SD)
Younger	Baseline	Both	-0.074 (0.073)
		Right	-0.032 (0.1)
	Laryngoscopy at 40 cm	Left	-0.047 (0.07)
		Both	0.037 (0.096)
		Right	0.058 (0.069)
		Left	0.063 (0.076)
Older	Baseline	Both	0.055 (0.167)
		Right	0.115 (0.193)
		Left	0.150 (0.242)
	Laryngoscopy at 40 cm	Both	0.135 (0.208)
		Right	0.225 (0.205)
		Left	0.215 (0.232)

SD = standard deviation.

Table 2
Laryngoscopy VA at chosen distance: descriptive data.

Age cohort	Laryngoscopy distance (cm)	logMAR
	Mean (SD)	Mean (SD)
Younger	27.06 (4.693)	-0.061 (0.05)
Older	38.05 (8.432)	0.080 (0.217)

SD=standard deviation, all participants were allowed to choose between binocular or monocular vision, whichever gave them the best view.

Table 3
Within and between group comparisons.

Comparison	Eye(s) tested	Mean logMAR difference and 95% CI of the difference	Effect size	p
Between groups				
Younger vs older baseline	Both	-0.129 (-0.213;-0.044)	1.001	0.004
	Right	-0.147 (-0.247;-0.047)	0.957	0.005
	Left	-0.197 (-0.314;-0.081)	1.108	0.002
Younger vs older laryngoscopy at 40 cm	Both	-0.098 (-0.204;0.008)	0.605	0.07
	Right	-0.167 (-0.267;-0.067)	1.092	0.002
Younger vs older laryngoscopy at chosen distance	Left	-0.152 (-0.265;-0.039)	0.879	0.01
	Choice ^a	-0.141 (-0.245;-0.038)	0.897	0.010
Within groups				
Younger: baseline vs laryngoscopy at 40 cm	Both	-0.111 (-0.146;-0.075)	1.506	<0.001
	Right	-0.095 (-0.142;-0.048)	0.979	<0.001
	Left	-0.105 (-0.135;-0.075)	1.690	<0.001
Older: baseline vs laryngoscopy at 40 cm	Both	-0.080 (-0.119;-0.041)	0.960	<0.001
	Right	-0.110 (-0.158;-0.062)	1.078	<0.001
	Left	-0.065 (-0.114;-0.016)	0.624	0.01

CI=Confidence interval.

^a Participant's choice of which eye(s) to view with (left, right or both).

Table 4
Corrected logMAR older cohort: descriptive data.

Age cohort	Acuity test	Eye(s) tested	logMAR
			Mean (SD)
Older	Laryngoscopy at 40 cm	Both	0.080 (0.083)
		Right	0.110 (0.102)
		Left	0.065 (0.104)

SD = standard deviation.

Table 5
Younger vs. older cohort at 40 cm viewing distance: corrected older cohort logMAR.

Eye(s) tested	Mean logMAR difference and 95% CI of the difference	Effect size	p
Both	-0.043 (-0.101; 0.015)	0.480	0.141
Right	-0.052 (-0.109; 0.005)	0.596	0.072
Left	-0.002 (-0.061; 0.058)	0.022	0.950

CI = confidence interval.

with simulated perfect correction of VA. Using these corrected logMAR values, there were no significant differences between younger and older cohorts during laryngoscopy at 40 cm.

Discussion

In this study we found a significant reduction in binocular and monocular VA among an older cohort of participants at baseline, compared to a younger cohort. We also found a significant reduction in monocular and binocular VA of similar magnitude within each cohort during laryngoscopy at a fixed viewing distance of 40 cm, compared to baseline (at the same viewing distance). Participants were able to improve their VA during laryngoscopy by shortening their viewing distance and choosing which eye(s) to view the larynx with.

Theoretically, the older cohort should have had VA equivalent to the younger cohort at baseline as it would be an expectation that those with an age-related reduction in VA would have been wearing glasses or contact lenses to correct for this. Our results show that this was not the case, and that the older cohort had a significantly reduced VA at baseline. We attribute this difference to the possibility that some participants in the older cohort who used glasses or contact lenses may not have updated their prescriptions for some time, and were not aware that their vision had deteriorated. Results obtained by correcting the older cohort's logMAR values to simulate perfect correction of VA from glasses or contact lenses suggest that this would have reduced to non-significant the differences between the age cohorts (Table 5).

There are two possible explanations for the observed reduction in VA during laryngoscopy, compared to baseline, within each age cohort. One of these is that the light intensity during laryngoscopy is expected to be less than during a baseline near VA test under ambient light [9]. The other explanation is that the visual demands of laryngoscopy are greater than those of a baseline near VA test, which involves looking at a VA chart from a distance of 40 cm with no interruptions in the line of sight. For participants in either age cohort, visualization of the vocal cords during direct laryngoscopy, on the other hand, is challenging due to the distance (30–50 cm) and the fact that the view is constrained with the target to be focused on at the end of what is equivalent to a narrow tube [10]. Among older participants, who usually wear reading or distance glasses, neither would be expected to compensate fully during laryngoscopy as the visual target in this procedure tends to be too far for reading glasses and too close for distance glasses [11]. To a certain extent, as indicated by the data in Table 2, small to moderate adjustments in viewing distance brought about by participants moving their head closer to the target can improve VA close to baseline (i.e. non-laryngoscopy) values. For older intubators, further improvement in VA closer to a logMAR value of zero could likely only be brought about by the use of specialized eyewear. Alternatively, video laryngoscopy could be considered for older intubators if such resources are available.

Although the age related reduction in VA observed in this research was only roughly equivalent to one line on a VA conversion table, it may make laryngoscopy and endotracheal tube placement quite a lot more difficult for older intubators when added to the other constraints mentioned above. The practical effects of reduced VA during laryngoscopy on endotracheal intubation have only been studied in the case of acute vision impairment [12]. In cases of VA reduction due to acute vision impairment, a negative impact on time to intubation has been found along with an increase in the rate of esophageal intubation. Due to the difference in pathology and effects between acute and chronic, age-related vision impairment, it is not possible to generalize these results to our study.

In a study of anesthesiologists and emergency physicians, Levitan et al. established that the larynx is viewed during laryngoscopy with only one eye at a time, despite the opinion of most of their participants that they utilized binocular vision [10]. We recorded acuity according to what participants reported as binocular views of the larynx, as well as left and right monocular views. Levitan et al.'s data suggest that

intubators claiming to view the larynx with both eyes are actually, subconsciously, viewing it with only one eye at a time – usually their dominant eye. Thus, the VA data recorded as representing both eyes in this research may be a more complex mix of either left or right monocular acuity depending on the participants visual dominance and any other factors that lead to them subconsciously choosing one eye over the other. The observation of Levitan et al. that, contrary to what is commonly believed and taught, a closer head position improves the laryngeal view is supported by our data (Table 2).

Limitations

The sample size achieved in this study was not equal to the required minimum sample size however, the difference was small (three participants). We did not measure the light intensity created by the laryngoscope that was used by all participants during laryngoscopy, which thus remains an unknown factor that can affect VA. However, comparing baseline data in Table 1 with data in Table 2, the effects of decreased light intensity during laryngoscopy (relative to the baseline test conducted in ambient light) appear to have had a negligible effect on VA. We also did not attempt to establish or take note of participants' dominant eye during VA testing and thus are not able to reach conclusions about the influence of dominant eye use and VA during laryngoscopy.

Conclusion

In this study of laryngoscopic VA in two age cohorts, we found that increased age was associated with a significant reduction in VA at baseline and during laryngoscopy. We also observed a reduction in VA during laryngoscopy at a fixed viewing distance of 40 cm regardless of age, which was improved to approximately baseline VA by allowing participants to reduce their viewing distance during laryngoscopy. Although it is currently unknown to what extent this age-related reduction of VA might negatively affect time to place an endotracheal tube or success of placement under direct vision, older intubators should be aware of this effect and ensure that their VA is frequently tested or consider specialized corrective eyewear in order to maintain an adequate level of VA.

Dissemination of results

These results have not been previously disseminated.

CRediT authorship contribution statement

Authors contributed as follows to the conception or design of the work; the acquisition, analysis, or interpretation of data for the work; and drafting of the work or revising it critically for important intellectual content:

A-MM contributed 40%; CS 40%; and MR 20%.

Authors' contributions

Authors contributed as follows to the conception or design of the work; the acquisition, analysis, or interpretation of data for the work; and drafting of the work or revising it critically for important intellectual content: A-MM contributed 40%; CS 40%; and MR 20%. All authors approved the version to be published and agree to be accountable for all aspects of the work.

Declaration of competing interest

One of the authors (CS) is Chairperson of the Research Ethics Committee that gave ethical approval for this research. This conflict was declared at the time of protocol review and he was not involved in the

decision to approve this study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.afjem.2020.12.002>.

References

- [1] Walls RM, Brown CA, Bair AE, Pallin DJ, NEAR II Investigators. Emergency airway management: a multi-center report of 8937 emergency department intubations. *J Emerg Med* 2011;41(4):347–54.
- [2] Sagarin MJ, Barton ED, Chng YM, Walls RM; National Emergency Airway Registry Investigators. Airway management by US and Canadian emergency medicine residents: a multicenter analysis of more than 6,000 endotracheal intubation attempts. *Ann Emerg Med* 2005;46(4):328–36. Oct.
- [3] Hubble MW, Brown L, Wilfong DA, Hertelendy A, Benner RW, Richards ME. A meta-analysis of prehospital airway control techniques part I: orotracheal and nasotracheal intubation success rates. *Prehosp Emerg Care* 2010;14(3):377–401.
- [4] Wang HE, Kupas DF, Paris PM, Bates RR, Costantino JP, Yealy DM. Multivariate predictors of failed prehospital endotracheal intubation. *Acad Emerg Med* 2003;10(7):717–24. Jul.
- [5] Doran JV, Tortella BJ, Drivet WJ, Lavery RF. Factors influencing successful intubation in the prehospital setting. *Prehosp Disaster Med* 1995;10(4):259–64. Oct-Dec.
- [6] Klein R, Klein B, Lee K, Cruickshanks K, Gangnon R. Changes in visual acuity in a population over a 15-year period: the Beaver Dam eye study. *Am J Ophthalmol* 2006;142:539–49.
- [7] Hasegawa K, Shigemitsu K, Hagiwara Y, et al. Association between repeated intubation attempts and adverse events in emergency departments: an analysis of a multicenter prospective observational study. *Ann Emerg Med* 2012;60(6):749–754. e2.
- [8] Natt BS, Malo J, Hypes CD, Sakles JC, Mosier JM. Strategies to improve first attempt success at intubation in critically ill patients. *Br J Anaesth* 2016;117(Suppl. 1):i60–8. Sep.
- [9] Baker PA, Raos AS, Thompson JM, Jacobs RJ. Visual acuity during direct laryngoscopy at different illuminance levels. *Anesth Analg* 2013;116:343–50.
- [10] Levitan RM, Higgins MS, Ochroch EA. Contrary to popular belief and traditional instruction, the larynx is sighted one eye at a time during direct laryngoscopy. *Acad Emerg Med* 1998;5(8):844–6.
- [11] Levitan RM. Avoiding common laryngoscopy errors. *Emergency physicians monthly*. Available from: <https://epmonthly.com/article/avoiding-common-laryngoscopy-errors/>. [Accessed 18 September 2020].
- [12] Tessler MJ, Trihas ST, Overbury O, Ducruet T. Acute vision impairment: does it affect an anesthesiologist's ability to intubate the trachea? *Anesth Analg* 2002;94(6):1566–9. Jun.