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## ORIGINAL ARTICLE

## A comparison of direct laryngoscopy to video laryngoscopy by paramedic students in manikin-simulated airway management scenarios



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## ABSTRACT

**Introduction:** We compare the effectiveness of direct laryngoscopy (DL) to video laryngoscopy (VL) in simulated, difficult airway scenarios in a cohort of novice, prehospital, emergency care providers.

**Methods:** Forty-five (45) students were randomised to DL or VL groups and then tasked to perform intubation on a manikin in three simulated airway scenarios. The scenarios included an uncomplicated intubation, intubation with manual in-line neck stabilisation (MILNS), and a simulated motor vehicle entrapment, with C-Spine held from behind, using a face-to-face intubation technique. The primary outcome was time taken to intubate, with secondary outcomes including first pass success rate, number of intubation attempts, Cormack-Lehane (CL) view grade obtained, adverse event rate, and self-reported laryngoscopist comfort.

**Results:** Twenty-seven participants (VL n = 15, DL n = 12) completed the study. Mean time to intubate was not statistically different between VL and DL groups in any scenario. VL was associated with an increased frequency of intubation attempts ( $p = 0.043$ ) and failed intubations (RR 6.4, 95% CI 0.92–44.33,  $p = 0.0175$ ) in the face-to-face intubation scenario, VL was associated with a reduced incidence of poor CL view (RR 0.06, 95% CI 0.004–0.997,  $p = 0.0497$ ) in the face-to-face intubation scenario, and a reduction in the frequency of dental damage (RR 0.13, 95% CI 0.02–0.96,  $p = 0.0165$ ) in the supine MILNS scenario.

**Discussion:** In our small sample, we found DL to be superior to VL in relation to a reduced risk of failed intubation and frequency of intubation attempts despite VL being superior in obtaining a good view of the vocal cords in a face-to-face intubation scenario. We found no statistically significant difference in the time taken to intubate in any scenarios. A larger study is required to inform practice and education around prehospital use of VL.

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## African relevance

- Intubation is an important prehospital skill in low resource settings where access to definitive care is challenging.
- Video laryngoscopy is perceived to improve intubation success rates.
- In our small study video laryngoscopy appeared to increase the risk of failed intubation despite providing better visualisation.

## Introduction

Video laryngoscopy (VL) has gained support for use as an alternative to direct laryngoscopy (DL) in routine airway management [1], emergency airway management, and management of expected difficult airways [2]. The utility, effectiveness, and place of VL for use in emergency intubation has been questioned [3] and in prehospital airway management has not been as extensively researched. Anecdotally, there is a belief amongst prehospital providers that the use of VL would translate well from the operating room to the prehospital setting. However, VL utilises a different psychomotor skill-set compared to DL, requires specific training [4] and familiarisation with the specific VL system itself. This can be argued as shown by the variability of performance between

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devices [5–7]. This is a concern in paramedic educational programs, as dilution of DL practice through the overuse of VL may result in DL skills attrition, which remains the standard rescue airway management option of choice when VL is not successful [8].

The incidence of the unexpected difficult airway in the prehospital setting, where alternative management strategies after failed intubation is required, has been demonstrated to be between 3 and 6% [9,10]. The use of VL as a primary method for endotracheal intubation to avoid failed intubation is attractive, as VL often produces better Cormack-Lehane (CL) views and is associated to high intubation success rates in the emergency setting [11,12]. In this study our interest was related to novice prehospital providers, with limited intubation experience using both VL and DL methods. Our objective was to investigate the use of VL in difficult airways as compared to the established DL techniques by less experienced providers. The use of novice providers in this study related to the notion that, as VL is associated to improved CL views [12], it may improve intubation success rates amongst novice providers in difficult prehospital airway situations. Our primary outcome was to assess whether the use of VL would provide equivalent or shorter times to successful intubation, with secondary outcomes including the occurrence failed intubation, oesophageal intubation, or adverse events.

## Methods

The study employed a prospective, randomised control trial design. Forty-five (45) paramedic students, currently enrolled in a degree programme in emergency medical care, who volunteered to participate were enrolled into the study and randomly assigned using a computer generated number sequence to either the direct laryngoscopy (control group) or video laryngoscopy groups (experimental group). All participants had received training in laryngoscopy and endotracheal intubation as part of their degree program. As this was a pilot study the sampling strategy used was convenience sampling and as such an *a priori* sample size calculation was not used. Each participant performed intubation of an adult MegaCode Kelly™ manikin; a manikin that has been used in similar studies [3]. The study was conducted at the simulation and clinical skills' laboratory at the Department of Emergency Medical Sciences, Cape Peninsula University of Technology during August to November of 2015.

Participants in both groups were required to complete three scenarios. Scenario 1 required participants to perform intubation in an uncomplicated intubation scenario with full access to the airway. Scenario 2 required participants to perform intubation in a supine patient with suspected C-spine injury, with a research assistant holding manual in-line neck stabilization (MILNS). In this scenario the participants were also seated, simulating the ergonomics of performing intubation while seated in the back of an ambulance. This would represent a common prehospital airway management scenario of intermediate difficulty. Scenario 3 required participants to perform intubation on the manikin in a simulated light motor vehicle collision entrapment, using a face-to-face (or 'ice-pick') intubation technique. This represented an airway management scenario that is relatively rare in practice, but considered very difficult, with limited access to the airway and C-spine maintained from behind as salient features.

Intubation technique and equipment was standardised for all participants. A size 7.0 mm ID ET tube was used with a bougie pre-inserted by the researchers. All three of these scenarios were undergone sequentially, with each participant taking roughly 10 to 15 min to move through all three scenario stations. Results were recorded by the primary researcher and confirmed by a research assistant during and after intubation. The Kruskal-Wallis equality of populations rank test was used to compare the difference

between time to intubation between groups by scenario. The Spearman's rho statistic was used to compare best CL view obtained and laryngoscopist comfort. For the analysis of the secondary outcomes related to adverse events with smaller frequencies the Fisher's exact test was used for comparison and relative risks (RR) calculated where appropriate.

The DL group used a size 3 Macintosh laryngoscope blade (European design) and standard handle, while the VL group used an Intubrite® VLS 6600 Macintosh video laryngoscope (with VLS size 3 blade). For the VL group, the laryngoscope's screen was removed from the handle and held by an assistant in the face-to-face intubation scenario, allowing the laryngoscopist to see the screen, but not have it interfere with insertion of the blade by having the screen impact the manikin's chest. All participants of the VL group were given a short training session with the device prior to commencement of the study to ensure standardization. The primary outcome, time taken to intubate, was defined as the time from insertion of the laryngoscope blade into the manikin's mouth to the first effective ventilation of both of the manikin's lungs, measured in seconds. Secondary outcomes included first pass success, total intubation attempts, Cormack-Lehane view grade obtained, laryngoscopist comfort (graded on a Likert scale), and adverse event rates. Adverse events included failed intubation (defined as the inability to intubate within four attempts), any single intubation attempt of more than 30 s duration, poor view of the vocal cords (Cormack-Lehane view grade 3 or 4), oesophageal intubation, right-mainstem intubation, dental damage (defined as distortion of the manikin's teeth by the laryngoscope blade), or the use of excessive force (defined as force sufficient to disrupt MILNS, or force that causes excessive movement of the manikin's head).

## Results

A total of 15 and 12 students from the VL and DL groups completed participation, respectively ( $n = 27$ ). Demographics are represented in Table 1.

The primary outcome, time taken to intubate is shown in Table 2. Median and interquartile range data is represented in Fig. 1. There was no statistically or clinically significant difference between DL and VL with respect to time taken to intubate in any of the three intubation scenarios (Table 2).

A notable difference in the number of intubation attempts required was found in the face-to-face scenario, with VL requiring more attempts as compared to DL ( $p = 0.043$ ). The best CL view grade obtained was not statistically different between DL and VL groups in scenario 1 ( $p = 0.307$ ) or 2 ( $p = 0.208$ ), but VL was associated with statistically significant improved view grade obtained in scenario 3 ( $p = 0.01$ ), with a median grade 2 view in the DL group, and a median grade 1 view in the VL group. No statistically significant correlation between intubation modality and self-reported comfort was found in scenario 1 ( $p = 0.6977$ ), scenario 2 ( $p = 0.7716$ ), or scenario 3 ( $p = 0.8853$ ).

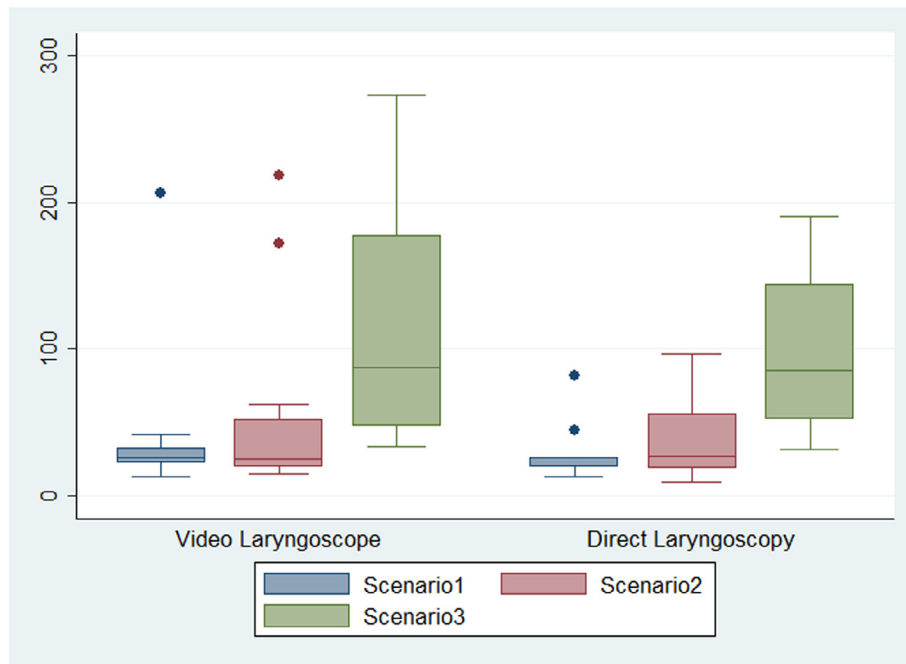
There was no statistically significant difference in the total number of adverse events between the DL and VL groups in scenario 1 ( $p = 0.926$ ), scenario 2 ( $p = 0.191$ ), or scenario 3

**Table 1**  
Participant demographics.

	Direct Laryngoscopy Group (Control) ( $n = 12$ )	Video Laryngoscopy Group (Experimental) ( $n = 15$ )
Second Year Students	2	6
Third Year Students	10	9
Total (number loss to follow-up)	12 (10)	15 (8)

**Table 2**  
Mean time taken to intubate in seconds.

Time to intubate	Direct Laryngoscopy Group (Control) (n = 12) Mean (CI 0.95%)	Video Laryngoscopy Group (Experimental) (n = 15) Mean (CI 0.95%)	Difference (seconds)	p value
Uncomplicated ETI (Scenario 1)	27.82 (14.61–41.02)	38.50 (10.34–66.66)	10.68 s	p = 0.1977
ETI with MILNS (Scenario 2)	39.33 (21.21–57.46)	50.93 (17.37–84.50)	11.60 s	p = 0.788
Face to Face ETI (Scenario 3)	90.36 (55.20–125.53)	116 (42.62–189.38)	25.64 s	p = 0.7725

**Fig. 1.** Median time taken to intubate (seconds) by VL and DL for each scenario. (Scenario 1: Uncomplicated intubation, Scenario 2: Intubation with MILNS, Scenario 3: Face-to-face intubation).**Table 3**  
Secondary outcome comparisons. N/A = No events in either DL or VL groups.

VL compared to DL for Adverse Events	Uncomplicated ETI (Scenario 1) RR (CI 0.95) p value	ETI with MILNS (Scenario 2) RR (CI 0.95) p value	Face-to-face ETI (Scenario 3) RR (CI 0.95) p value
Failed Intubation	1.6 (0.16–15.6) 0.586	N/A –	6.4 (0.92–44.33) 0.018
Dental Damage	1.6 (0.16–15.6) 0.586	0.13 (0.02–0.96) 0.017	0.73 (0.44–1.21) 0.017
Single intubation attempt > 30 s	2 (0.47–8.56) 0.298	1.2 (0.24–6.06) 0.612	1.2 (0.93–1.55) 0.188
Poor CL View (Grade 3 or 4)	N/A –	0.8 (0.06–11.5) 0.7	0.06 (0.004–0.997) 0.0497
Oesophageal intubation	N/A –	N/A –	N/A –
Right Mainstem Bronchus Intubation	N/A –	N/A –	N/A –
Use of excessive force during Laryngoscopy	N/A –	0.4 (0.04–3.9) 0.414	0.64 (0.22–1.87) 0.34

(p = 0.901). The differences however became apparent when individual adverse events were considered (Table 3).

Notably VL was associated to an increased risk of failed intubation in the face-to-face ETI scenario (RR 6.4, CI 0.95; 0.92–44.33, p = 0.018, absolute risk Increase = 45%) (Fig. 2). VL, however, was associated to a decreased risk of self-reported poor CL (Grades 3 or 4) views in the same scenario (RR 0.06, 95% CI 0.004–0.997,

p = 0.0497) (Fig. 3). Risk of potential dental damage was notably less using VL in scenario 2 (supine ETI with MINLS) (Fig. 4) when compared to DL (RR 0.13, CI 0.95; 0.02–0.96, p = 0.017). There did not appear to be any difference between the VL and DL groups with respect to risk of oesophageal intubation, right mainstream bronchus intubation, or application of excessive force by the laryngoscopist.

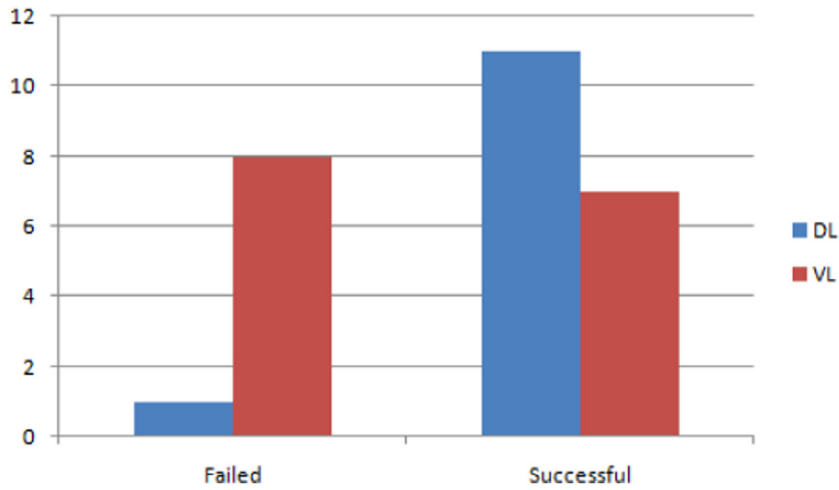


Fig. 2. Failed compared to successful intubation frequency between DL and VL groups in scenario 3 (Face-to-face ETI).

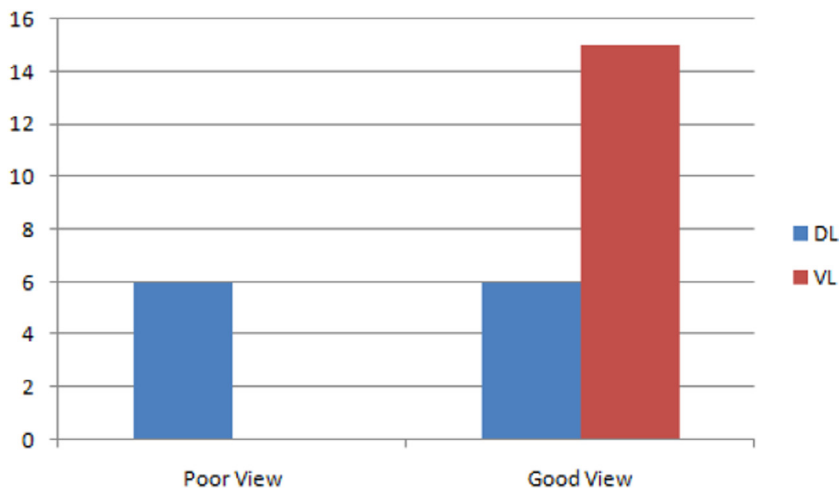


Fig. 3. Frequency of self-reported poor CL view grade (Grade 3 or 4) as compared to good CL view (Grade 1 or 2) between DL and VL groups.

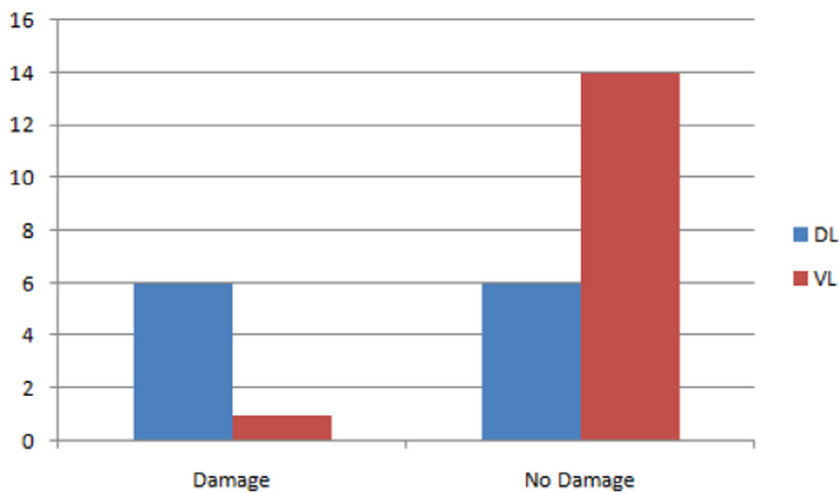


Fig. 4. Frequency of potential dental damage compared between VL and DL groups in Scenario 2 (Supine ETI with MILNS).

## Discussion

The results indicate that DL and VL were comparable with regards to time taken to intubate in all scenarios. In the difficult intubation scenarios, differences emerged between the groups, with DL proving superior to VL in reducing the number of intubation attempts and risk of failed intubation. There was also some difference in the adverse event incidence in certain scenarios, albeit less significant.

We did not find a statistically significant difference in TTI between VL and DL in any of the intubation scenarios (Table 2). A limitation in this study however was that failed intubation attempts did not have their stop time recorded and as such only times were recorded for successful intubations. Given that more VL participants in our study were unable to intubate the manikin in scenario 3, the true TTI for VL in scenario 3 may be much higher than reported. The intubation times recorded in our study were similar to that found in previous studies for inexperienced providers, uncomplicated ETI and ETI with MILNS. Bhalla et al. [5] prospectively compared the use of the McGarth and Truview VL systems in patients with MILNS applied throughout airway management in the operating room. The authors reported mean intubation times ranging between 30.02 and 38.72 s for the respective devices. Butchart et al. [6] compared the use of the Glidescope Ranger and Venner A.P. advanced video laryngoscope systems in simulated difficult airway scenarios when used by paramedics naive to video laryngoscopy. The authors reported a mean intubation time of 25 and 45 s between devices, with the Venner A. P. device being superior ( $p < 0.0001$ ).

In our study, there was no statistical difference in the incidence of failed intubation between DL and VL in the uncomplicated and MILNS scenarios ( $p > 0.05$ ). We were however surprised by the poor performance of VL in the face-to-face intubation scenario, as our initial hypothesis was that the device was likely to provide improved views of the glottis as opposed to DL (which was in fact the case, as shown in Fig. 3), translating to improve intubation success, and reduced intubation times. Contrary to this our results in fact indicated the opposite. These findings correlate with that of Choi et al. [13] who, at same period of our data collection, conducted a similarly study comparing different VL and DL devices in the restricted space face-to-face intubation scenario. Choi et al. [13] reported that intubation time was significantly improved with the use of the DL (Macintosh and Pentax Airway Scope), as compared to the C-MAC and Glidescope VL systems. Similar to our observations, Choi et al. [13] attributes this to the significant hand-eye discordance which appears to occur when the VL is used in this unconventional situation. The finding in our study that use of VL was also associated to an increased risk of failed intubations (RR: 6.4, CI 0.95; 0.92–44.33,  $p = 0.018$ ) and that of Choi et al. [13] suggests that DL remains the technique of choice in the restricted space face-to-face scenario, and VL should not be used in these situations. Our findings also suggest that in the hands of novice prehospital providers VL does not appear offer any additional advantage over DL in the simulated setting for intubation success, although other studies have indicated contradictory findings [11].

An interesting observation in our study was that the VL group participants were able to quickly obtain a good view of the vocal cords (CL grade I or II), as compared to the DL group, who found obtaining a view more difficult, as also reported by Noppens et al. [14]. Once the view had been obtained however, participants in the DL group easily intubated the airway, whereas the VL group had more difficulty. This appeared to be related to the ET tube needing to navigate a curved path to the vocal cords (a path that the laryngoscopist could not directly visualise) [13]. Although we did not measure this time interval in our study our observation

was similar to that reported by Butchart et al. [6]. These authors reported that although the time to obtain views of the glottis was similar between DL and VL modalities, the placement of the ETT takes longer when using VL. In the event of face-to-face intubation, as reported by Choi et al. [13] our results suggest VL may very well increase the risks of failed intubation due to the more complicated psychomotor technique required to place the ETT after a view of the glottis has been obtained. Although it could be argued that face-to-face intubation is a rare scenario and that it would naturally be difficult for novice providers. Despite this we believe that due to the lack of experience of participants with this scenario both VL and DL groups would have had similar challenges with the unfamiliar psychomotor requirements of face-to-face intubation and our results are a useful demonstration that VL may not make intubation easier or translate to improved success rate in these circumstances, particularly when used by providers not experience in the use of VL.

Another interesting observation, likely related to the ease of obtaining a good view using VL was a statistically significant decrease in the risk of dental damage in comparison to DL in the ETI with MILNS scenario (Fig. 4). The occurrence of dental damage during laryngoscopy and ETI, particularly in difficult airways, has been linked to increased airway manipulation and its consequences has been well documented [16]. Although our study did not find statistically significant differences in glottic view (RR 0.8 CI 0.95; 0.06–11.5), or excessive force used by the participants (RR 0.4, CI 0.95; 0.04–3.9) in the ETI with MILNS scenario, the trend in both measures was towards VL reducing the risk. The increased incidence of dental damage observed in the DL group appeared to be a result of repeated attempts by participants to obtain a view of the glottis. VL has been shown to produce superior views to DL in patient whom require MILNS [17]. As MILNS is recommended for patients with suspected C-spine injuries requiring ETI [17,18], and has the effect of potentially reducing the laryngoscopic view of the glottis by up to 45% [19], the use of VL does appear to hold an advantage [20] in these patients.

Given that the primary benefit of VL over DL as found during our study appears to be the ease with which a good view of the vocal chords can be obtained, the limitations of VL in the emergency setting should be considered. Blood, vomitus, and secretions in the airway are commonly present in these settings, and although this is often easily managed by the use of suction, allowing direct visualisation, even trace amounts of these substances in the airway may obstruct the camera at the end of the VL blade [10]. With this known limitation of VL considered in light of our findings and those of others [15,6] VL appears the less favourable of the two intubating modalities.

As this was a pilot study, the study has a number of potential limitations. The study was not sufficiently powered, particularly in the subgroup analysis. It is possible that with a larger sample size, clearer results could be elicited. Of the 45 enrolled students, there was loss to follow-up of 18 participants. Loss to follow-up occurred due to university student unrest at the time of data collection and affected both VL and DL groups with more loss to follow up occurring in the DL (control) group. All participants of the study had received standardised training in intubation however, the amount of clinical experience was not recorded, and as such some participants may have been more capable than others. Additionally, a higher proportion of senior students were present in the DL group despite the random allocation. For some of the secondary outcomes observations for all VL participants were made by the primary researcher and a research assistant, whereas observations for DL participants were self-reported. There is thus potential for reporting bias and influences of inter-rater reliability in these measurements.

In conclusion, our small pilot study found VL and DL to be comparable when used by novice prehospital providers in uncomplicated ETI and ETI with MILNS simulations, but that DL proved to be significantly benefit in reducing the number of intubation attempts and incidence of failed intubation in very difficult scenarios. Further study is required to definitively guide the use of VL in the prehospital setting.

### Dissemination of results

Results were presented as a poster at the 2016 International Conference on Emergency Medicine. The poster has been placed in the Department of Emergency Medical Services at Cape Peninsula University of Technology where the study was performed.

### Author contribution

BdW and TM conceived the original idea. Both authors collaborated on the development of the design. TM collected the prospective data and drafted the original manuscript. BdW assisted in the statistical analysis and development of the manuscript. TM and BdW approved the final version of the manuscript submitted.

### Conflict of interest

The authors declare no conflict of interest.

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