

## Hyperangulated videolaryngoscopy

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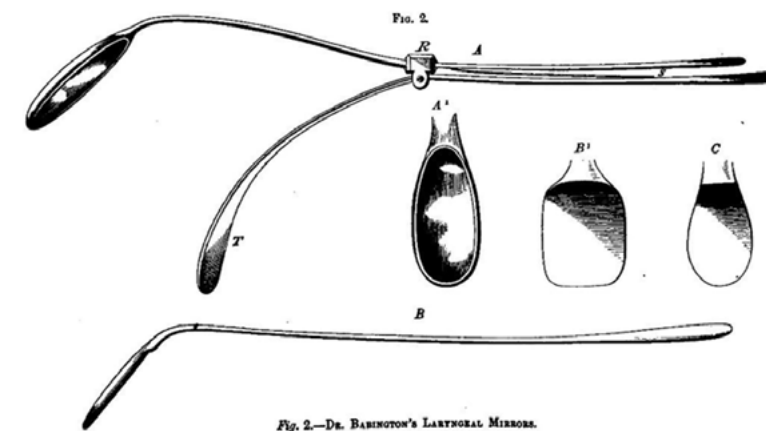
### INTRODUCTION

In the recent history of airway management, one of the most notable airway advances has been the development, widespread uptake and use of videolaryngoscopy. Most anaesthetic clinicians will be familiar and comfortable using standard geometry or Macintosh videolaryngoscopy blades, which utilise a similar technique to traditional direct laryngoscopy. Hyperangulated videolaryngoscopy, although less familiar, has emerging evidence regarding its potential benefits, particularly in managing difficult airways. This article aims to explore the perceived challenges associated with using hyperangulated blades by understanding the equipment and its interaction with the airway anatomy.

We aim to reassure and empower readers that by understanding the technical nuances of these devices and how to best employ reliable adjuncts, this is a skill everyone can easily hone with practice and add to their airway management armamentarium.

Laryngoscopy and tracheal intubation are core airway skills for all anaesthetists. The original instruments developed for visualisation of the glottis in the 19th century relied on indirect methods using systems of mirrors and sunlight (see Figure 1).<sup>1</sup>

Figure 1. Babington's laryngeal mirror



Direct laryngoscopy took off in the early twentieth century with the development of the Miller and MacIntosh blades in the 1940s.<sup>1</sup> A recent return to indirect laryngoscopy has occurred with the development of videolaryngoscopes in the 2000s and their increasing clinical use over the past twenty years.

While most anaesthetists are comfortable with using standard geometry (Macintosh) videolaryngoscopy (VL) blades, the use of their hyperangulated counterparts raises some questions, which we aim to address throughout this summary.

## WHAT TYPES OF VIDEOLARYNGOSCOPES ARE AVAILABLE?

Videolaryngoscopes can be classified broadly into channelled and non-channelled blades (see Figure 2). Channelled blades incorporate a groove within the blade, which aims to direct the endotracheal tube into the trachea. Non-channelled blades can be further subdivided into standard geometry (Macintosh style) blades and hyperangulated blades, which have a more acute curve (see Figure 3).

Figure 2. Videolaryngoscope classification

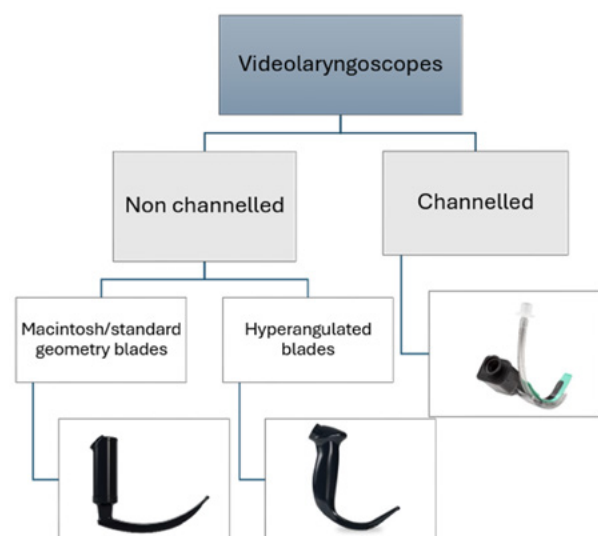
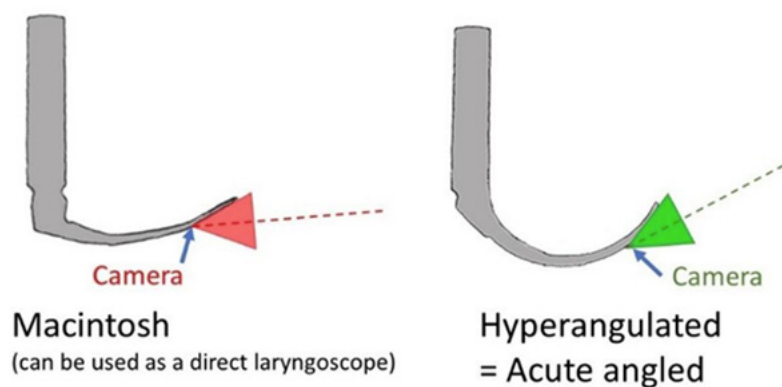


Figure 3. Non-channelled videolaryngoscope blades



All videolaryngoscopes incorporate a light source and a camera close to the blade tip.<sup>3</sup> This provides a wider angle of view and allows visualisation of airway structures. The light source is commonly a light-emitting diode powered either by an internal battery or by the monitor.<sup>3</sup> The camera uses a complementary metal oxide semiconductor (CMOS) sensor, which converts light energy to electrical energy. It is the technology

used in many digital cameras.<sup>3</sup> The Airtraq is slightly different as it uses optical mirrors to transmit the image to the eyepiece. It can, however, be connected to a Wi-Fi camera to digitally view the image, which uses a CMOS chip.

The image from the camera on the blade can either be displayed by an LCD display mounted on the device or on a standalone unit via a cable connection.<sup>3</sup> One advantage of a separate display unit is that the larger picture can be simultaneously viewed by multiple members of the team. This helps the team have a shared mental model of the airway management and facilitates teaching. Devices with mounted displays are portable, facilitating improved access to videolaryngoscopy in remote areas of the hospital or as part of a mobile emergency airway response team. Possible disadvantages of these devices are added weight to the blade, which may compromise manoeuvrability. The smaller screen limits the ability of others to visualise the airway, which may subsequently limit their ability to help the operator via external laryngeal manipulation or to predict the need for additional or alternative equipment.

## WHAT ARE THE DIFFERENCES BETWEEN MACINTOSH AND HAVL?

The hyperangulated videolaryngoscopy (HAVL) technique is distinct from that used with Macintosh-style blades. An appreciation of their differences allows the airway operator to optimise their technique and plan for, and overcome, the challenges when using these devices. Often, good visualisation of airway structures with hyperangulated blades doesn't equate with ease of placing the endotracheal tube (ETT), but by understanding the equipment the clinician will be able to devise a reliable strategy for successful ETT insertion.

Airway anatomy has been described using the two-curve theory as shown in Figure 4:

1. Primary curve – oropharyngeal curve.
2. Secondary curve – pharyngo-glottis-tracheal curve.

Figure 4. Two-curve airway theory

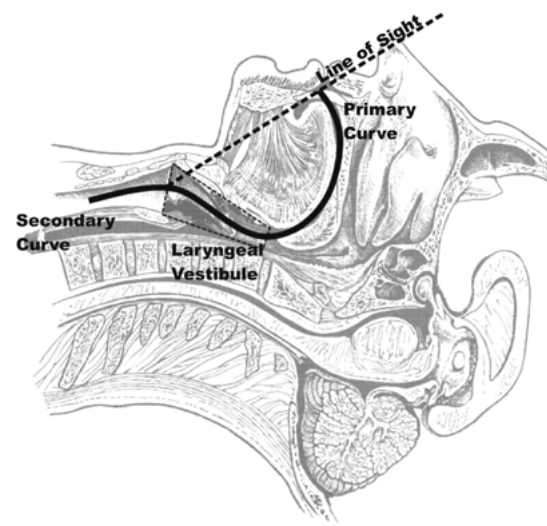
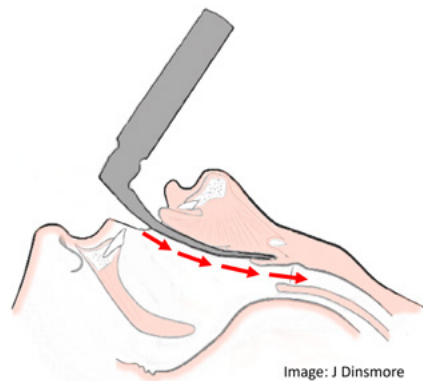


Figure sourced from Greenland et al. (2010)<sup>4</sup>

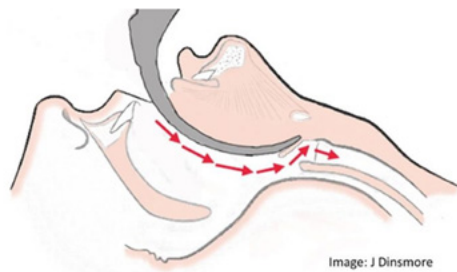
During Macintosh videolaryngoscopy (MacVL), the aim is to flatten the primary airway curve, creating a straight path to the glottis, which allows either direct (line of sight) or indirect (via the video screen) visualisation of the glottis. The straight path created has the advantage of making the delivery of the endotracheal tube to the glottis and passage into the trachea straightforward. Macintosh laryngoscopy is achieved by inserting the blade on the right side of the mouth and tongue, sweeping the tongue to the left and out of the way (Figure 5). The tip of the blade is placed in the vallecula, and a lifting motion allows exposure and visualisation of the glottis. This technique remains largely unchanged whether one is using a Macintosh-style blade for direct or videolaryngoscopy.

Figure 5. Macintosh laryngoscopy



In contrast, hyperangulated videolaryngoscopes have a similar shape to the primary airway curve and aim to look around the corner to achieve a view of the glottis. This means that a direct (line of sight) view cannot be achieved, and it is purely used as an indirect intubation technique. The blade is inserted in the midline of the tongue with the tip still inserted in the vallecula (see Figure 6). Despite achieving a good view of the glottis, the more acute angles involved can make the delivery of the endotracheal tube to the glottis and subsequent passage into the trachea the more challenging aspect of the technique. These challenges can be reliably overcome with the appropriate technique.

Figure 6. Hyperangulated videolaryngoscopy



### What are the benefits of HAVL over MacVL?

The 2022 Cochrane review evaluated the performance of videolaryngoscopy in comparison to direct laryngoscopy.<sup>5</sup> This meta-analysis included 222 studies with over 26,000 adult intubations looking at four critical outcomes:<sup>5</sup>

1. Failed intubation.
2. Hypoxaemia (desaturation below 94%).
3. Successful first attempt at tracheal intubation.
4. Oesophageal intubation.

The results demonstrated that Macintosh videolaryngoscopy reduced the rate of failed intubation with a risk ratio (RR) of 0.41 (0.26 – 0.65) and the risk of hypoxaemia, RR 0.72 (0.52 – 0.99).<sup>5</sup> There was also an increased chance of successful first-attempt intubation, RR 1.05 (1.02 – 1.09).<sup>5</sup>

Hyperangulated videolaryngoscopy was separately evaluated and showed reduced rates of failed intubation, RR 0.51 (0.34 – 0.76), which was particularly pronounced if there were predictors of a difficult airway, RR 0.29 (0.17 – 0.48).<sup>5</sup> Hyperangulated blades decreased the risk of oesophageal intubation, RR 0.39 (0.18 – 0.81), which was not seen with the use of MacVL.<sup>5</sup>

Following the Cochrane review, there has been increasing acceptance of the clinical safety benefits of videolaryngoscopy over direct laryngoscopy as the primary airway technique when endotracheal intubation is planned. The argument for universal or default videolaryngoscopy is emerging, and this is reflected in recent recommendations in international airway guidelines.

1. The Project for Universal Management of Airways (PUMA) guidelines for the prevention of unrecognised oesophageal intubation state to, “routinely use a videolaryngoscope whenever feasible”.<sup>6</sup>
2. The Canadian Airway Focus Group recommends, “routine primary use of VL with an appropriate blade type for all tracheal intubations. If difficulty is predicted with glottic exposure using DL or MacVL, first-attempt use of HAVL to facilitate tracheal intubation should be strongly considered”.<sup>7</sup>

The question of which type of VL device is optimal remains open.

A recent study by Kohl et al. sought to examine the performance of hyperangulated videolaryngoscopy in comparison to Macintosh videolaryngoscopy. This randomised controlled trial of 182 adult patients undergoing elective head and neck surgery with a predicted difficult airway compared CMAC D blade with CMAC MacVL performance.<sup>8</sup> The primary outcome of percentage of glottic opening (POGO) showed an improved view with the hyperangulated D blade (89% vs 54%,  $p < 0.001$ ).<sup>8</sup> This result is perhaps unsurprising; however, achieving a view with a videolaryngoscope is only part of the procedure, with the goal being quick and successful first-pass intubation of the trachea. This was evaluated in the study's secondary outcomes, which demonstrated successful first-line technique intubation of 99% with HAVL vs 87% with MacVL ( $p = 0.002$ ).<sup>8</sup> The paper describes one episode of failed intubation with a hyperangulated blade, which ultimately resulted in a tracheostomy to secure the airway, compared to twelve failed MacVL intubations, which were all successfully rescued with HAVL.<sup>8</sup> There was also an improved first attempt success with HAVL 97% vs 67% ( $p < 0.001$ ) and first attempt success without complications 92% vs 64% ( $p < 0.001$ ).<sup>8</sup> Intubation time was evaluated, with this being shorter overall in the hyperangulated group (19 vs 27 seconds); however, this represents the Macintosh VL group requiring multiple attempts as when time was compared for first attempt time, there was no difference (19 vs 20 seconds).<sup>8</sup>

### HOW DO I USE ADJUNCTS TO RELIABLY DELIVER THE TUBE TO THE LARYNX?

The use of an introducer is required when using HAVL, as without one, the endotracheal tube will naturally advance posteriorly into the oesophagus, as shown in Figure 7.

Figure 7. Path of ETT compared to HAVL blade curve without and with a stylet



Different adjuncts have potential benefits and limitations, so it is essential that the airway operator is familiar with these to make informed choices.

### Can I use a bougie with HAVL?

While bougies work well with Macintosh blades, the lack of stability when shaped makes malleable designs less suitable for HAVL use. Despite pre-shaping prior to intubation, the curve of malleable bougies often unfurls in the airway, making them less reliable than more rigid or fixed adjuncts. The Steerable Tracheal Intubation Guide (STIG) bougie, available in Australia, has a stable curve, although this is relatively shallow compared to stylets optimised for HAVL (see Figure 8). As the name suggests, this specialised bougie has a flexible tip which is controlled by a thumb slider tab allowing it to be flexed and retroflexed into the trachea. It performed well when used with a CMAC D-blade in a recent critical care study by Taboada et al.<sup>9</sup> It is

unclear how it performs in patients who are conventionally considered difficult to intubate. The STIG can only be used for ETTs 7.0 and larger, making it unsuitable for paediatric use or with smaller adult tubes.

Figure 8. Steerable Tracheal Intubation Guide (STIG) bougie



If a bougie can be placed in the upper trachea, then tube advancement into the trachea is usually not challenging if it is rotated 90° anti-clockwise before reaching the vocal cords. This rotation creates a more optimal alignment of the bevel at the tip of the endotracheal tube and the glottic opening, facilitating the advancement of the tube into the trachea.

## STYLETS

Several manufacturers produce preformed rigid stylets, the distal section of which has a similar curve to their model of hyperangulated blades and which are thus optimised for use with them. The rigidity of the stylet ensures the curve is maintained during insertion into the mouth, in contrast to a malleable stylet, which may lose some of the preformed curve if careful insertion alongside the blade is not performed.

Verathon produces the Gliderite stylet in various sizes (see Figure 9) to complement their hyperangulated blades:

1. Small                      ETT 3.0 – 4.0
2. Medium                    ETT 4.5 – 5.5
3. Large                      ETT 6.0 and larger

It is important to note that a medium Gliderite stylet is not suitable for use with a 5.0 Microlaryngoscopy ETT, as it is too short and the curve is not matched to the smaller Lopro blades. Therefore, when performing an adult intubation with an ETT smaller than a 6.0, an alternative stylet system should be used.

Figure 9. Verathon Gliderite preformed stylets



Figure sourced from Verathon<sup>10</sup>

Storz CMAC also produces a rigid preformed stylet to conform to their D blade.

Malleable stylets are a cheap and widely available alternative. Shiley intubating stylets come in a variety of sizes, as shown in Table 1.

Table 1. Shiley intubating stylet sizes

Size (Fr)	ID tube recommendation (mm)	Length (cm)
6	2.5 – 4.5	280
10	4.0 – 6.0	350
14	> 5.0	350

Data sourced from Medtronic<sup>11</sup>

When using malleable stylets, it is paramount to curve the stylet to match the blade being used to achieve accurate delivery to the glottis.

## Which is the optimal adjunct when using HAVL?

If the appropriate technique is matched with an appropriately shaped stylet, then there is a high likelihood of a successful HAVL intubation. Recent studies (by Ruetzler et al. and Kohl et al.) used rigid stylets to achieve first-pass success rates of 98.3% (>4000 patients requiring intubation) and 97% (a convincingly difficult group of patients undergoing head and neck surgery).<sup>8,12</sup>

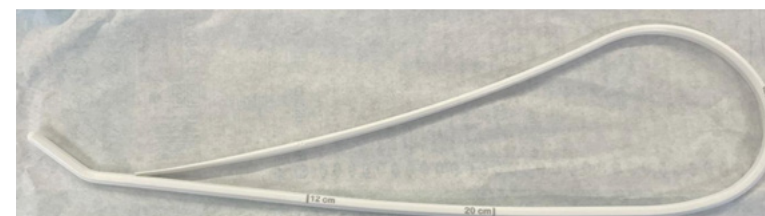
It is equally apparent from recent publications that if there are issues with technique or stylet shaping, then failure can occur frequently. Eum et al. reported an 88% first-pass success rate when using malleable stylets in 83 patients with soft features of intubation difficulty.<sup>13</sup> This contrasted with a 98% first pass success rate in a malleable bougie group. Most stylet failures occurred because the stylet shaping resulted in the tube missing the larynx posteriorly, suggesting a stylet shaping issue. Of note, the study protocol involved the complete removal of the stylet after the tube tip had been passed through the cords. We would not recommend this. This is the same technique used in the (malleable) stylet group of the Taboada et al. critical care study, which had only an 83% first pass success rate.<sup>9</sup>

Due to conflicting studies, there is currently no consensus on the optimal adjunct when using HAVL. If a bougie is to be used, it is recommended that one with a stable curve be used in preference.<sup>14</sup>

## Alternative adjuncts and special situations

The recent development of the universal stylet bougie aims to combine the desirable features of both adjuncts, allowing it to be used as either. It has two malleable sections that allow it to be curved to shape (see Figure 10).

Figure 10. Universal stylet bougie



Another method is using a Ducanto suction catheter to direct the bougie anteriorly to the glottis. This type of suction catheter has a larger diameter and is more curved than a standard Yankauer, making it suitable as a "bougie introducer". This technique has recently been presented in a case report.<sup>15</sup> In the authors' practice, this method has been successful when using a paediatric bougie in order to subsequently railroad a 4.5 laser endotracheal tube.

## Video-assisted fibreoptic intubation (VAFI)

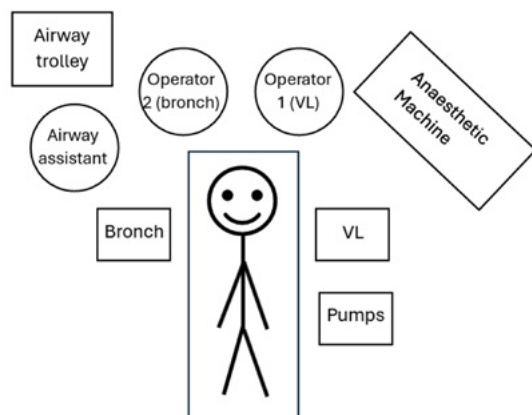
A flexible bronchoscope can be used as the endotracheal tube introducer in conjunction with a hyperangulated blade. In this technique, the flexible bronchoscope acts like the ultimate steerable bougie. This technique requires two operators: person one performs laryngoscopy and maintains a view of the glottis on screen. In contrast, person two operates the flexible scope with an ETT pre-loaded to manoeuvre the bronchoscope into the trachea and then pass the ETT. There is a wide range of scope sizes. The Ambu A5 scope range includes a slim scope with an outer diameter of 2.7 mm, which will fit a 3.5 ETT.

An additional advantage of this technique is that it facilitates the training and maintenance of flexible bronchoscopy skills in trainees and anaesthetists. Degradation of flexible bronchoscopy skills in an environment where awake fibreoptic intubation seems to be becoming less frequent is a topical issue. Any opportunity to maintain manual dexterity with the scope reduces the cognitive load during an awake fibreoptic intubation, where small gains can make the difference between success and failure.

Disadvantages include the cost of the bronchoscope compared with the cheaper stylet and bougie alternatives. In many institutions, disposable bronchoscopes are the mainstay, which also raises concerns about waste in an era where green and sustainable practices are increasingly important.

The ergonomics of using both a HAVL and a flexible bronchoscope can often require the use of two displays (see Figure 11). Some systems, such as Verathon's Glidescope, can attach both devices and display them on one screen as a split screen. This helps with the ergonomics and ease of performance, as the operators only have one screen to pay attention to. It can, however, easily be done with two screens positioned on either side of the patient.

Figure 11. VAFI ergonomics



## WHICH TECHNIQUES HELP RELIABLY DELIVER THE TUBE TO THE LARYNX?

### Compromising glottic view

Accepting a restricted glottic view helps reduce the angles required to manoeuvre the ETT into the trachea. In Figure 12, the top image shows a POGO of 100% with Kovacs sign (visualisation of the anterior cricoid ring and tracheal wall), which also corresponds with increased angles between the pharynx, glottis and trachea, making passage of the tube potentially more difficult. In the lower image of Figure 12, a more compromised glottic view is accepted by dropping the blade tip so it is parallel to the floor and withdrawing the tip slightly out of the vallecula. This achieves the recommended restricted glottic view of 50% POGO in the upper 50% of the screen, creating a straighter path for endotracheal tube delivery.

Figure 12. Restricted glottic view

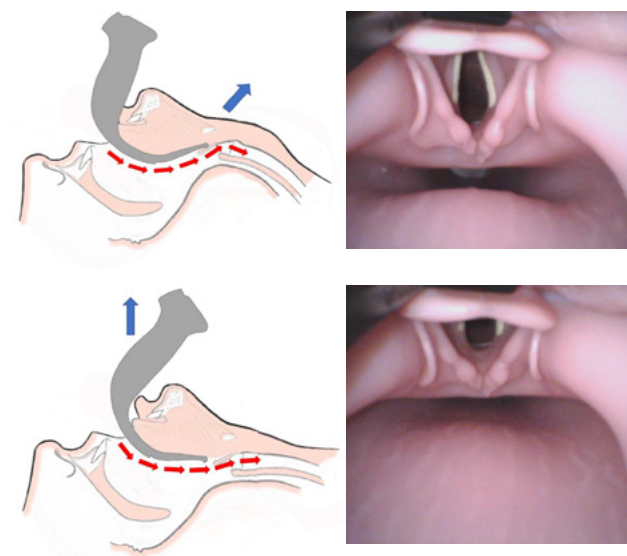


Image: J Dinsmore

A 2016 randomised parallel group superiority clinical trial by Gu et al. evaluated a full glottic vs restricted (<50% POGO) view for intubation using a Glidescope GVL plus Gliderite rigid stylet. The results demonstrated a faster intubation time in the restricted view group (27 vs 36 seconds,  $p < 0.001$ ) and an operator rated easier intubation on a visual analogue score (14 vs 50,  $p < 0.001$ ).<sup>16</sup> Interestingly, in three cases in the "full view" group, the tube was able to be advanced past the cords but not into the trachea. When they converted these cases to a restricted view, tracheal intubation was easily completed, which highlights how the reduced angles achieved with more restricted views help avoid anterior tracheal wall impingement of the ETT.<sup>16</sup>

Apart from the changes in airway angles, another potential benefit of this restricted view is achieving a wider field of view, allowing for earlier visualisation of the ETT and thus enabling earlier redirections to improve passage into the airway.

### Endotracheal tube rotation

Anterior tracheal wall impingement of the endotracheal tube is a potential issue when using HAVL, particularly when advancing a standard pre-curved (Magill) tube off a preformed stylet.

After placing the tube tip gently through the vocal cords, 90° clockwise tube rotation is recommended before tube advancement (see Figures 13 and 14). This aligns the curve of the tube with the trachea, allowing easy and atraumatic advancement. Clockwise rotation is preferred to anti-clockwise rotation as the bevel orientation means the tube tip is less likely to dig into the anterior tracheal wall.

This 90° clockwise rotation of the endotracheal tube can be achieved by rotating the whole stylet-tube assembly, rotating the tube on the stylet, or a combination of both. While rotating the stylet-tube assembly can result in very slick, one-operator intubations, it may not be possible to rotate adequately due to the anatomy of some patients. Rotating the endotracheal tube on the stylet requires an assistant to stabilise the stylet, but may be more reliable in achieving success.

Figure 13. ETT rotation

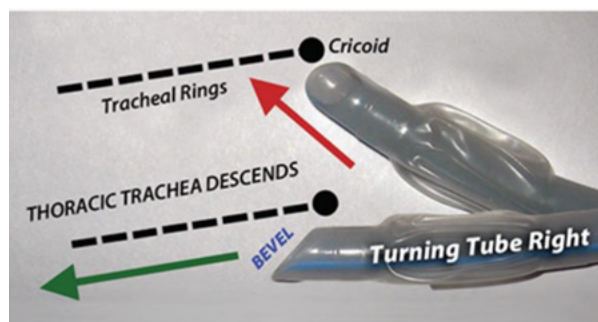
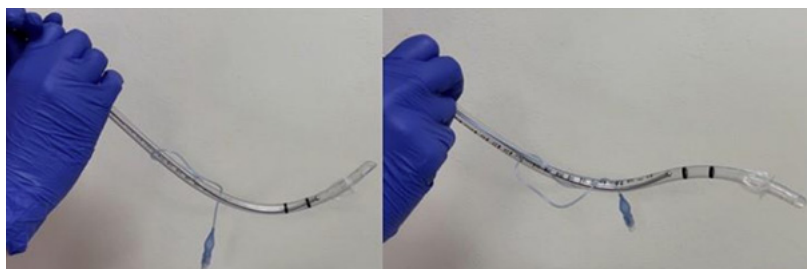


Image sourced from Levitan (2015)<sup>17</sup>

Figure 14. Clockwise rotation of ETT off a preformed rigid stylet



An alternative approach is the “backward” loading of the ETT onto the stylet. This effectively means the ETT is already rotated when it is loaded. By loading the ETT with its natural curve in the opposite orientation when it is advanced off the stylet at the glottis, its tip should follow the descending path of the trachea. In practice, standard pre-curved tubes tend to be unrotated on their own by the time intubation is attempted.

## THE AIRWAY IS SOILED – IS IT BETTER TO USE DL OR VL?

A prospective observational study by Sakles et al. in 2017 examined first-pass success during rapid sequence intubation with direct laryngoscopy compared to Glidescope hyperangulated videolaryngoscopy for clean and soiled airways.<sup>18</sup> There were a total of 1985 intubations included, of which 590 were soiled with either blood, vomitus or both.<sup>18</sup> A summary of the first pass success results is displayed in Table 2.

Table 2. First pass success intubation

	Glidescope	Direct laryngoscopy
Clean	91%	75.8%
Soiled	81.4%	65.5%

Data sourced from Sakles et al. (2017)<sup>18</sup>

These results show that both devices perform worse in a soiled airway; however, importantly, the videolaryngoscopy group still outperforms direct laryngoscopy. To the authors' knowledge, there is no study directly comparing Macintosh and HAVL in soiled airways. Given that the hyperangulated Glidescope performed well in the Sakles trial, it would seem appropriate to use it in this circumstance, although one potential advantage of a Macintosh VL blade would be the ability to also be utilised for direct laryngoscopy in the low instance of airway soiling that obscures the video imaging.

A useful technique to optimise soiled airway management with videolaryngoscopy is suction-assisted laryngoscopy and airway decontamination, or SALAD.<sup>19</sup> This technique involves using a large-bore suction

to perform oral decontamination and simultaneous compression of the tongue to create a clear space for the insertion of the laryngoscope. The laryngoscope is inserted, hugging the tongue to avoid interfering with the optics. Once a view of the glottis has been achieved, the suction catheter is moved to the left of the laryngoscope blade to provide continuous suction but also to a clear path for the intubation to occur.

## HOW DO I IMPROVE MY SKILLS IN HAVL?

### Training

Feeling comfortable using hyperangulated blades is like any other practical skill; it requires practice. It is essential that this skill is honed on normal airways initially. This ensures that when the device is used in a truly difficult airway, where there are limited alternative options, the operator is more comfortable, confident, and skilled with the equipment.

A sub-analysis of a randomised controlled trial by Ott et al. examined the number of intubations required to achieve proficiency when using hyperangulated videolaryngoscopes. The study evaluated 4312 intubations performed by 223 clinicians.<sup>20</sup> The median number of procedures to achieve proficiency in tracheal intubation with hyperangulated videolaryngoscopy was 12 (12-26).<sup>20</sup> This number was achieved by clinicians independent of their previous experience with direct laryngoscopy, suggesting that the learning curve is relatively independent of previous experience. The low number required to achieve proficiency serves as a reassurance that this is an effective airway technique that can be easily and quickly mastered with some education and practice. To gain further practice and experience, the following link is for a HAVL skills and instruction video:

### Technique training video



### High-flow nasal oxygen

There is no evidence that, in the hands of a skilled and practised clinician, hyperangulated blades result in longer intubation times. It is important, however, that training conditions are optimal for novice users or those upskilling with these devices. The use of high-flow nasal oxygenation to provide pre- and intraprocedural oxygenation is helpful to prolong the apnoeic time, allowing a calm and non-time pressured environment to hone this skill. The authors find using high-flow nasal oxygen alongside a video-assisted fiberoptic intubation (VAFI) particularly beneficial.

With the advent of the Optiflow Switch Nasal Interface, the use of high flow during induction and airway management has become seamless.<sup>21</sup> Some caution with interpreting the end tidal oxygen and capnography must be exercised when using this system.

## HOW DO I DOCUMENT MY AIRWAY GRADE WITH HAVL?

Given that HAVL is a purely indirect method of intubation, the traditional Cormack-Lehane grading is not applicable. Alternative scoring systems have been developed to try to address this problem. The Fremantle score is shown in Figure 15. It demonstrates good accuracy and intra- and inter-rater reliability in a study comparing its use for documenting videos of intubation with the Cormack-Lehane grading and POGO (percentage of glottic opening).<sup>22</sup> A Video Classification of Intubation (VCI) score has also been developed.<sup>23</sup> This is a three-part score that evaluates the type of blade used (MAC vs hyperangulated), POGO, and the subjective ease of intubation, as summarised in Figure 16. There is no absolute consensus on a classification of videolaryngoscopy intubation; however, both systems include most of the pertinent information that a subsequent anaesthetist would use for planning. As with any airway documentation, other parameters are important to include, such as ease of mask ventilation and any adjuncts needed for successful management.

Figure 15. Fremantle score




Fremantle score component			Comparison scores
View	F (full)		CL grade 1 POGO 100%
	P (partial)		CL grade 2a POGO 50%
	N (none)		CL grade 3 POGO 0%
Ease	1 - Easy	TT passed first time using manufactures technique	
	2 - Modified	TT passed with more than 1 attempt or a modified technique or adjunct used	
	3 - Unachievable	Unable to pass TT	
Device		Name of the device and blade used	

Image sourced from O'Loughlin et al. (2017)<sup>22</sup>

Figure 16. VCI score

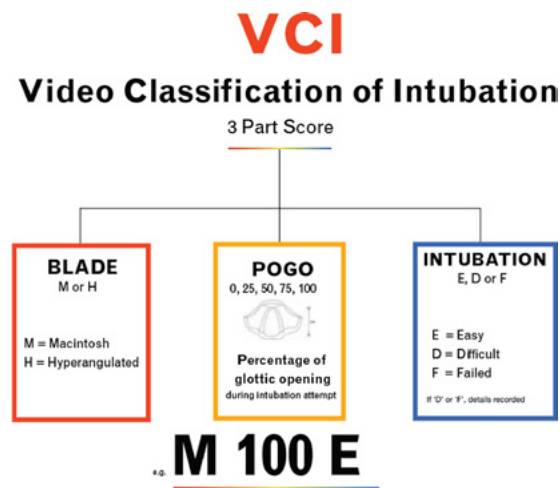


Image sourced from Chaggar et al. (2021)<sup>23</sup>

## CONCLUSION

Hyperangulated videolaryngoscopy is a purely indirect airway technique using a blade with an acute curve to look "around the corner" for glottic visualisation. HAVL offers significant benefits, including reduced failed intubation rates, particularly in predicted difficult airways. Despite often providing a good view, a challenge with HAVL is reliably delivering the ETT into the trachea. This challenge can be easily overcome by using an introducer and incorporating specific techniques, such as accepting a slightly restricted glottic view and rotating the ETT at the cords. Learning HAVL proficiency is relatively quick and largely independent of prior direct laryngoscopy experience. Standards for documenting HAVL intubation require alternative scoring systems like Fremantle or VCI, as the traditional Cormack-Lehane grade does not apply to this indirect method.

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