NICE advice

Video laryngoscopes to help intubation in people with difficult airways

Medtech innovation briefing
Published: 19 December 2018
nice.org.uk/guidance/mib167

Summary

- The **technologies** described in this briefing are 11 video laryngoscopes. They are used to help the placement of breathing tubes in people with difficult airways.
- The **innovative aspects** are that the devices use an integrated camera and video display monitor to provide an indirect view of the airway.
- The **intended use** would be in people of any age who need tracheal intubation, but there are anticipated difficulties in visualising the glottis. It could be used in emergency or secondary care settings.
- The **main points from the evidence** summarised in this briefing are from 9 studies (4 systematic reviews with meta-analyses and 5 user survey studies). These include a total of 5,467 laryngoscopy procedures (in people with difficult airways, mainly adults) in the emergency and secondary care settings. They show that video laryngoscopy works at least as well as direct laryngoscopy to help intubation of adults with difficult airways and gives better visualisation of the glottis. One systematic review suggested that video laryngoscopy is associated with a higher severe complication rate in critically ill people in hospital. User surveys show that availability, routine use and positive attitudes towards video laryngoscopy have increased over time.
- **Key uncertainties** around the evidence are a lack of evidence for use in children and babies and any published economic evidence.

- The **cost** of video laryngoscopes range from £245 to £7,149 per unit for integrated display models and £7,589 to £13,003 per unit for cart-based models (exclusive of VAT). The **resource impact** would be greater than standard care because of the price differential between direct and video laryngoscopes. This may be offset by staff time savings from improved intubation success rates and fewer postponed procedures because of failed direct laryngoscopies.

The technology

Video laryngoscopes incorporate an integrated camera and display monitor. These provide indirect visualisation of the upper airway to help placement of a breathing tube between the vocal cords and into the trachea, to maintain the airway. Record and display features of the technology are also useful for teaching intubation techniques, particularly in people with difficult airways.

A video laryngoscope consists of 4 main components:

- Interchangeable reusable or single-use blades of various shapes and sizes for different airway anatomy; blades can be curved (Macintosh), angulated or straight (Miller). Some blades are available with a channel to guide the introduction of appropriately sized endotracheal breathing tubes. Blades can have an anti-fog coating or warming feature to prevent moisture from affecting the camera lens.
- A high-resolution small camera at the distal tip of the device, with a light source to illuminate the airway.
- An integrated (attached) or stand-alone (cart-based) monitor with colour display and adjustment controls to view images of the airway. Integrated monitors can be angled, rotated or flipped to improve the airway view. Monitors can incorporate a video output port to connect an external monitor and a USB or memory card to download and save images and recordings.
- Single or multiple internal power sources (rechargeable or non-rechargeable batteries) are used to power the camera, light source and display monitor. A separate charging unit is used for rechargeable components.

Video laryngoscopes may comprise reusable (monitor and camera) and disposable components (blades) when used in acute settings but can also be fully disposable for use in remote locations and emergency situations.

This briefing focuses on 11 video laryngoscopes that are used to help intubation in people with difficult airways. Other similar technologies may be available but are not included in this briefing (for example, if they were not identified, or the company chose not to take part). Video

laryngoscopes may also be used in routine intubations, but this is outside the scope of this briefing.

Five of the 11 included video laryngoscopes can also be used as standard, direct view laryngoscopes and have been identified in table 1, along with their key technical features.

Table 1 Summary of key features of included video laryngoscopes

VL Device (Company)	Camera: resolution and type	Monitor: Type, size, resolution and features	Blades: available types and sizes	Power: battery type and operating time
King Vision aBlade (Ambu Ltd)	2 types of video adapter (depending on blade size) with 640×480 pixel VGA, CMOS technology and LED light source.	Integrated 2.4 inches, 320×240 pixel TFT-LCD; video output.	Non-sterile, single-use: sizes 1 (infant), 2/2c (paediatric), 3/3c (adult); the 'c' option is channelled.	3×AAA size, non-rechargeable alkaline batteries; 90 minutes.
C-MAC System with C-MAC monitor (KARL STORZ)	Reusable blades have an integrated camera; 640×480 pixel CMOS technology with white LED light source.	Stand-alone 7 inches, 1,280×800 pixel TFT-LCD; HDMI video output, SD memory card and USB port.	Reusable: Macintosh #4, #3, #2, #0; Miller #1, #0; D-Blade and D-Blade Ped. Direct view functionality.	Rechargeable 3.7V lithium-ion battery; 120 minutes.
	Single-use blades fit to 1 of 2 C-MAC S reusable imagers (depending on blade size); both use 640×480 pixel CMOS technology with white LED light source.		Non-sterile, single-use: Macintosh #4, #3; Miller #1, #0; D-Blade. Direct view functionality.	

C-MAC System with C-MAC pocket monitor (KARL STORZ)	Reusable blades have an integrated camera; 640×480 pixel CMOS technology with white LED light source.	Integrated 3.5 inches 640×480 pixel TFT-LCD with optional extension cable for remote viewing.	Reusable: Macintosh #4, #3, #2, #0; Miller #1, #0; D-Blade and D-Blade Ped. Direct view functionality.	Rechargeable 3.7V lithium-ion battery; 90 minutes.
	Single-use blades fit to 1 of 2 C-MAC S reusable imagers (depending on blade size); both use 640×480 pixel CMOS technology with white LED light source.		Non-sterile, single-use: Macintosh #4, #3; Miller #1, #0; D-Blade. Direct view functionality.	
Marshall VL (Marshall Airway Products Ltd)	1,600×1,200 pixel, CMOS technology with LED light source.	Integrated 3.5 inches 640×480 pixel LCD; HDMI video output and 4GB SD memory card.	Sterile, single-use: Macintosh sizes 3 or 4; Direct view functionality.	Rechargeable lithium-ion battery; 120 minutes.
McGrath MAC (Medtronic; UK supplier: Healthcare 21)	CMOS technology with LED light source.	Integrated 2.5 inches 240×320 pixel LCD.	Sterile, single-use: Macintosh sizes 1, 2, 3 or 4 and X3 hyper-angulated blade.	Proprietary non-rechargeable 3.6V lithium battery pack; 250 minutes.

Airtraq Avant (Prodol Meditec; UK supplier: Fannin UK Ltd)	640×480 pixel VGA, Wi-fi CMOS camera with LED light source and proprietary wireless image transmission to additional remote display (PC, phone or tablet).	Wi-fi camera has integrated 2.8 inches, 320×240 pixel, touch-screen TFT-LCD; Mobile phone adapter to use phone camera and display with 'Airtraq Mobile' iOS/Android app.	Reusable optics with 2 single-use disposable adult regular #3 or small #2 blades.	Avant reusable optics: rechargeable 3.7V lithium-polymer battery, 15×10 minute intubations. Wi-fi camera and display: rechargeable 3.7V lithium-polymer battery, 180 minutes with Wi-fi; 240 minutes without Wi-fi.
Airtraq SP (Prodol Meditec; UK supplier: Fannin UK Ltd)	640×480 pixel VGA, Wi-fi CMOS camera with LED light source and proprietary wireless image transmission to remote display (PC, phone or tablet).	Wi-fi camera has integrated 2.8 inches, 320×240 pixel, touch-screen TFT-LCD; Mobile phone adapter to use phone camera and display with 'Airtraq Mobile' iOS/Android app.	Non-sterile, SP model with combined optics and blades in 6 sizes (adult regular #3, small #2, paediatric #1, infant #0, nasal and double lumen).	SP combined optics and blades: 2×AAA non-rechargeable or replaceable batteries, 40 minutes within 3 year shelf life Wi-fi camera and display: rechargeable 3.7V lithium-polymer battery, 120 minutes.

APA (AAM Healthcare; UK supplier: Vyaire Medical)	3 camera modules: MAC, MIL (small) and MIL (large) with CMOS technology and LED light source.	Integrated 3.5 inches, 320×240 pixel TFT-LCD; video output.	Non-sterile, single-use: MAC 3 or MAC 4 (with Oxy Blade oxygen assist options); MIL 1 or MIL 2; Difficult airway blades (DAB) (channelled or unchannelled); Direct view functionality.	Camera module: 1×AA alkaline battery; min. 48 hours continuous use; Display: rechargeable 3.7V lithium-polymer battery, 2.5 hours of intermittent use.
GlideScope Go (Verathon Medical UK Ltd)	Single-use spectrum blades have an integrated camera with 640×480 pixel CMOS technology and LED light source.	Integrated 3.5 inches, 320×240 pixel LCD; USB port.	Sterile, single-use spectrum blades in 6 sizes: LoPro S1, S2, S3, S4 and DirectView MAC S3 and MAC S4; Direct view functionality.	Rechargeable 3.7V lithium-ion battery; 100 minutes.
GlideScope AVL (Verathon Medical UK Ltd)	GVL Stats fit to 1 of 2 reusable video batons with 320×240 pixel CMOS technology and LED light source.	Stand-alone 6.4 inches, 640×480 pixel TFT-LCD; HDMI video output port and USB port.	Sterile, single-use GVL Stats in 6 sizes: 0, 1, 2, 2.5, 3 or 4.	Rechargeable 3.7V lithium-ion battery; 90 minutes.

GlideScope Spectrum single use (Verathon Medical UK Ltd)	Single-use spectrum blades have an integrated camera with 640×480 pixel CMOS technology and LED light source.	Stand-alone 6.4 inches, 640×480 pixel TFT-LCD; HDMI video output port and USB port.	Sterile, single-use Spectrum blades in 6 sizes: LoPro S1, S2, S3, S4 and DirectView MAC3 and MAC4; Direct view functionality.	Rechargeable 3.7V lithium-ion battery; 90 minutes.
GlideScope Titanium reusable (Verathon Medical UK Ltd)	Reusable Titanium blades have an integrated camera with 640×480 pixel CMOS technology and LED light source.	Stand-alone 6.4 inches, 640×480 pixel TFT-LCD; HDMI video output port and USB port.	Sterile, reusable Titanium blades in 4 sizes: LoPro T3, T4 and MAC T3, T4.	Rechargeable 3.7V lithium-ion battery; 90 minutes.
Abbreviations: CMOS, complementary metal-oxide semiconductor-based image sensor chip; GB, gigabyte; HD, high definition; HDMI, high definition multimedia interface; LCD, liquid crystal display; LED, light-emitting diode; PC, personal computer; SD, secure digital; SP, single patient; TFT-LCD, thin film transistor liquid crystal display; USB, universal serial bus; V, volt; VGA, video graphics array; VL, video laryngoscope.				

Innovations

A conventional direct laryngoscope moves the tongue to create an unobstructed, direct view of the glottic entrance, to help placement of the tracheal tube. However, it can be challenging to see the vocal cords in some patients. Video laryngoscopes are designed to improve visualisation of the glottis, with the aims of: a shorter time to successful intubation; higher first-attempt intubation success rate; higher overall intubation success rate; reduction in applied force; and reduction in intubation-related complications.

Current care pathway

The current NHS pathway for intubation varies according to setting and user, such as pre-hospital (ambulance, paramedic), emergency (hospital, emergency clinician) and critical care, anaesthetic rooms or operating theatres (hospital, anaesthetist). Users may have the choice of direct or video laryngoscopes according to local provision.

The Difficult Airway Society (DAS) guidelines for management of unanticipated difficult intubation in adults 2015 state that video laryngoscopy should be immediately available wherever intubation is done and that anaesthetists should be trained in the technique (Frerk et al. 2015).

The DAS Paediatric difficult airway guidelines state that, for unanticipated difficult tracheal intubation during routine induction of anaesthesia in a child aged 1 to 8 years, more research is needed in the use of newer airway devices such as video laryngoscopes, in paediatric clinical practice.

The following NICE guidance and advice have been identified as relevant to this care pathway:

- Head injury: assessment and early management
- Major trauma: assessment and initial management
- Spinal injury: assessment and initial management
- Major trauma: service delivery
- Chronic obstructive pulmonary disease in over 16s: diagnosis and management
- Caesarean section
- Ambu aScope2 for use in unexpected difficult airways
- Translaryngeal tracheostomy
- PneuX for preventing ventilator-associated pneumonia in intensive care
- Shiley Endotracheal Tube with TaperGuard Cuff for intensive care patients at risk of ventilator-associated pneumonia

Population, setting and intended user

Video laryngoscopy would be most likely to be used in people with an anticipated difficult airway in emergency or secondary care settings. They would be used by anaesthetists, non-clinician practitioners in anaesthesia, emergency medicine clinicians and paramedics in the hospital and pre-hospital settings. Video laryngoscopy is different to the conventional intubation technique. Therefore, human factors such as training, experience, device design, usability and control can affect patient outcomes.

Costs

Technology costs

The list prices, excluding VAT, for all included video laryngoscope components and accessories are shown in table 2. Most companies offer training as needed as part of post sales service. Although video laryngoscopes do not need routine calibration, some companies offer maintenance contracts, for example to cover accidental damage.

Table 2 Cost of included video laryngoscopes

Company	Device	Main components, consumables and accessories	List price (exc. VAT)
Ambu Ltd	King Vision aBlade	King Vision display	£750
		Video adapter (aBlade 3/3c)	£299
		aBlade size 3 or 3c, box (20)	£199.80
		Video adapter (paediatric)	£375
		aBlade size 1, 2 or 2c, box (5)	£60
		aBlade kit (display, video adapter, 4×channelled and 2×standard aBlades, case, batteries and USB)	£895
		King Vision display and video adapter (aBlade 3/3c)	£849
		Case	£12
KARL STORZ	C-MAC System	C-MAC monitor	£4,418
		Connecting cable	£475
		C-MAC pocket monitor set	£3,399
		C-MAC PM charging unit	£586
		Reusable blades	
		Mac #4	£2,754
		Mac #3	£2,755

		Mac #2	£2,696
		Mac #0, Miller #1 or #0	£3,492
		D-Blade or D-Blade Ped	£3,750
		C-MAC S Imager	£3,164
		Disposable blades (Adult): Mac #4, Mac #3 or D-Blade, box (10)	£160
		C-MAC S Paediatric Imager	£3,399
		Disposable blades (Paediatric): Miller #1 or #0, box (10)	£206
Marshall Airway Products Ltd	Marshall VL	VL system kit (video laryngoscope, USB power lead, UK mains cable, HDMI video lead and metal case)	£1,200
		Mac blades 3 or 4, box (10)	£29.50
Medtronic; UK supplier: Healthcare 21	McGrath MAC	Video laryngoscope	£1,600
		Disposable blades: Mac sizes 1 to 4	£6.50 each
		X3 difficult airway	£18 each
Prodol Meditec; UK supplier: Fannin UK Ltd	Airtraq Avant / Airtraq SP	Avant reusable optics	No charge
		Docking station charger	No charge
		Avant single-use blades, box (50)	£495
		SP single-use laryngoscope (all sizes), box (6)	£283.67
		Wi-fi camera	£235
		Wi-fi kit	£259
		Universal smart phone adaptor	£20
		Phone protection sleeve	£10

AAM Healthcare UK supplier: Vyaire Medical	APA	Video viewer and charger	£2,000
		Video viewer charger	£160
		Handle	£750
		MAC camera module	£880
		MIL (small) camera module	£850
		MIL (large) camera module	£880
		MIL 1 or 2 blade, box (10)	£70
		MAC 3 or 4 blade, box (10)	£75
		MAC 3 or 4 O2 blade, box (10)	£85
		DAB or Unchannelled-DAB, box (10)	£480
		Video cable (3m)	£105
Verathon Medical UK Ltd	GlideScope	GlideScope Go monitor kit	£2,300
		AVL single-use system: GlideScope video monitor, video baton 3-4, premium cart and 2 boxes of Stat blades	£8,050
		GlideScope video monitor, video baton 1-2, premium cart and 2 boxes of Stat blades	£8,800
		Video baton 3-4 kit or 1-2 kit	£2,600
		GVL Stat 0, 1, 2, 2.5, 3 or 4, box (10)	£120
		Spectrum single-use system: GlideScope video monitor, Spectrum smart cable, premium cart and 2 boxes of Spectrum blades	£8,400
		LoPro S1 or S2, box (10)	£310
		LoPro S3 or S4, box (10)	£270
		DirectView S3 or S4, box (10)	£270
		Spectrum smart cable	£2,790

		Titanium reusable system: GlideScope video monitor, video cable, premium cart and 1 reusable blade	£9,530
		LoPro T3 or T4	£3,141
		MAC T3 or MAC T4	£2,982
		Titanium video cable	£332

Costs of standard care

The NHS Supply Chain Online Catalogue lists 1,141 items under the search term 'laryngoscope' (23 August 2018). Removing video laryngoscope and fibre-optic laryngoscope devices and consumables leaves 363 items across 14 suppliers to the NHS. These 363 devices and consumables provide a range of costs for the following categories of direct laryngoscopes (delivery included and 20% VAT excluded):

- reusable handle with disposable blade ranges from £10.05 to £88.98 per device
- single-use handle with disposable blades ranges from £4.34 to £79.39 per device
- single-use handle and blade set ranges from £2.60 to £39.69 per device
- reusable handle with reusable blade ranges from £16.95 to £28.16 per device.

Resource consequences

The resource consequences of adopting video laryngoscopy instead of direct laryngoscopy would include any price differential in purchasing the device, accessories and consumables and the need for additional training in the use of the video technologies. Based on the information provided by companies for this briefing, the prices of video laryngoscopes range from £245 to £7,149 per unit for integrated display models and from £7,589 to £13,003 per unit for cart-based models (exclusive of VAT). Therefore the cheapest video laryngoscope is about 3 times the price of the most expensive direct laryngoscope.

Although list prices for video laryngoscopes are substantially more expensive than standard laryngoscopes, flexible pricing options can make device costs more comparable. For example, 1 manufacturer offers the reusable and rechargeable components of their system free of charge, only charging for disposables.

A recent NHS national survey (Cook and Kelly 2017) reported that 92% of respondents had video laryngoscopes available in at least 1 clinical area in their hospital. Of all clinical areas represented by the responses, 52% reported availability of a video laryngoscope, with some degree of restriction of use reported in 32% of anaesthetic departments, 58% of intensive care units and 78% of emergency departments. Of the 131 respondents who described elective use of video laryngoscopy in the operating theatre, none reported routine use, less than 33% reported regular use, and 10% reported rare use. For those surgical cases where direct laryngoscopy proves to be difficult or impossible, a readily accessible video laryngoscope may allow surgery to proceed as planned with no extra anaesthetic complications. Without a video laryngoscope in theatre, a patient with an unanticipated difficult airway and failed direct laryngoscopy would either be woken up and their operation would be postponed, or their operation would proceed with an increased risk of anaesthetic complications (which could be minor, intermediate or life-threatening).

No cost-effectiveness studies were identified in the evidence searches for this briefing, but potential improvements in patient outcomes could reduce time spent in higher cost intensive care units and overall hospital length of stay.

Regulatory information

All video laryngoscopes in this briefing have a Class 1 CE mark. Also, some single-use blades are supplied as Class 1 (sterile).

The following manufacturer field safety notices or medical device alerts have been identified.

The Medicines and Healthcare products Regulatory Agency (MHRA) has issued the following manufacturer field safety notices relating to the included technologies:

- 2015/006/025/291/007 (June 2015) For the Verathon GlideScope, revision of the operations and maintenance manual's approved cleaning and disinfection methods for the reusable GVL and AVL blades.
- 2016/002/015/291/002 and 2016/002/012/292/007 (February 2016) For the Verathon GlideScope, a recall of specific lots of Titanium single-use blades following reports of image flickering on the video display.
- 2017/003/010/291/016 (March 2017) For the Verathon GlideScope, a recall of 1 lot of GVL size 2 Stat single-use blades after being mistakenly packaged with GVL size 1 Stat single-use blades.

Equality considerations

NICE is committed to promoting equality, eliminating unlawful discrimination and fostering good relations between people with particular protected characteristics and others. In producing guidance and advice, NICE aims to comply fully with all legal obligations to: promote race and disability equality and equality of opportunity between men and women, eliminate unlawful discrimination on grounds of race, disability, age, sex, gender reassignment, marriage and civil partnership, pregnancy and maternity (including women post-delivery), sexual orientation, and religion or belief (these are protected characteristics under the Equality Act 2010).

The Difficult Airway Society guidelines for unanticipated difficult tracheal intubation during routine induction of anaesthesia in children aged 1 to 8 years, states that more research is needed in the use of video laryngoscopes. Age is a protected characteristic under the Equality Act 2010.

Clinical and technical evidence

A literature search was carried out for this briefing in accordance with the interim process and methods statement. This briefing includes the most relevant or best available published evidence relating to the clinical effectiveness of the technologies. Further information about how the evidence for this briefing was selected is available on request by contacting mibs@nice.org.uk.

Published evidence

Nine studies reporting on the clinical effectiveness of the devices and additional human factor outcomes are summarised in this briefing. Nine of the 11 devices were covered by 7 of the 9 studies; 2 of the 9 studies did not identify a video laryngoscope. A large number of relevant studies on video laryngoscopy were identified, including multiple systematic reviews with substantial overlap in the trials summarised. Because of this, only the most recent systematic reviews and meta-analyses summarising the most relevant primary evidence in the difficult airway population were selected for inclusion in this briefing. No more recent randomised controlled trials (RCTs) published since the systematic reviews were identified for inclusion.

Four systematic reviews with meta-analyses reporting on the clinical effectiveness of the devices across a total of 5,467 procedures (including 3,006 video laryngoscopy and 2,461 direct laryngoscopy procedures, with at least 313 video and 279 direct laryngoscope procedures double counted in these meta-analyses) are summarised in this briefing. Table 3 summarises the clinical evidence as well as its strengths and limitations.

Also, 5 user survey studies reporting on human factor outcomes, such as user preference and device usability, from a total of 2,285 survey responses, are also summarised in this briefing. Table 4 summarises the additional evidence on human factor outcomes as well as its strengths and limitations.

Overall assessment of the evidence

All evidence reviewed for clinical outcomes came from use in adults, which limits generalisability to use in children and babies.

Three systematic reviews reported favourable procedural outcomes for video laryngoscopy when compared with direct laryngoscopy, including: better overall success rate of intubation, reduction in intubation time, superior visualisation of the glottis (Hoshijima et al. 2018), fewer intubation failures (Lewis et al. 2017) and greater first-attempt success rate with video laryngoscopy (Pieters et al. 2017). However, the latter systematic review also reported no statistically significant differences in time until successful intubation, Cormack–Lehane grade of the view obtained during laryngoscopy (the Cormack–Lehane grades range from I, full view of glottis, to IV, neither glottis nor epiglottis visible), number of attempts, or dental trauma between video and direct laryngoscopy (Pieters et al. 2017). Another systematic review reported no statistically significant difference in survival to hospital discharge, overall success rate of intubation or first-attempt success rate with video laryngoscopy when compared with direct laryngoscopy (Cabrini et al. 2018). This systematic review further reported a higher in-hospital severe complication rate with video laryngoscopy in patients who were already critically ill.

A limitation of all of these studies was that, because of the nature of the intervention, patients and users could not be blinded and this could present some potential risk of bias. However, this risk was decided to be relatively low.

Three of the 5 user survey studies reporting human factor outcomes were done in a UK NHS hospital setting (Cook et al. 2018; Jones et al. 2018; Cook and Kelly 2017), with the Airtraq (Prodol Meditec), GlideScope (Verathon UK) and C-MAC (KARL STORZ) being the video laryngoscopes reported to be most widely used in the UK. Availability, routine use and positive attitudes towards video laryngoscopy appear to increase over time; however there are common concerns expressed in these studies including: cost, device tracking or availability, device failure, sterilisation or cleaning, and need for formal training.

Further research that would address uncertainties in the evidence base includes: large cohort studies in unselected populations looking at difficulty and failure rates of different video

laryngoscopes; use of video laryngoscopes for rescue when direct laryngoscopy has failed; further studies in a paediatric population and further consideration of reported outcome measures, to standardise learning curve comparisons with the degree of training and competence in using newer devices.

Table 3 Summary of selected studies describing clinical outcomes

Cabrini et al. (2018)	
Study size, design and location	Systematic review and meta-analyses of 9 RCTs comparing video laryngoscopy with direct laryngoscopy in critically ill adults; 4 of which analysed anticipated difficult airway subgroups (including a total of 1,342 laryngoscopy procedures in these populations). Multiple settings including: trauma resuscitation unit, emergency department, and ICU. Multiple users including: emergency medicine residents, anaesthesiology residents, attending anaesthesiologists, nurse anaesthetists, senior residents, ICU clinicians. Locations of primary studies not reported.
Intervention and comparator(s)	Intervention: Video laryngoscopes (n=667): GlideScope (n=303), McGrath Mac (n=186) and C-MAC (used in 2 studies: n=178). Comparator: Direct laryngoscopes (n=675).
Key outcomes	Primary outcomes included: survival to hospital discharge, overall successful intubation, first-pass success rate. No study found any difference in these primary outcomes in patients with difficult airways. The 2 largest RCTs reported an increased incidence of severe complications with video laryngoscopy in post-hoc analyses in a critically ill population, including: increased time to intubation, greater incidence of severe desaturation episodes, highest mortality rate in the group with severe head injury and increased incidence of life-threatening complications.
Strengths and limitations	There was no meta-analysis conducted on the 4 studies that reported anticipated difficult airway subgroups. The comparator direct laryngoscopy devices were not identified. Non-UK findings may not be generalisable to clinical practice in the NHS.

Hoshijima et al. (2018)	
Study size, design and location	Systematic review and meta-analyses of 11 studies describing 13 RCTs of video laryngoscopy versus direct laryngoscopy with Macintosh blades in adults with obesity (including a total of 1,044 laryngoscopy procedures). Setting and user: operating room, by experienced laryngologists. Locations of primary studies not reported.
Intervention and comparator(s)	Intervention: Video laryngoscopes (n=527): Airtraq (used in 5 studies, n=286), GlideScope (used in 2 studies, n=80), McGrath (n=40), Airwayscope (n=50), X-Lite (n=40), McGrath or GlideScope or Video-Mac (1 study using multiple devices, n=31). Comparator: Direct laryngoscopes with Macintosh blades (n=517).
Key outcomes	Success rate of tracheal intubation was significantly higher, intubation time significantly lower and glottis visualisation superior with video laryngoscopes than the direct laryngoscopes with Macintosh blades. Video laryngoscopes with and without tracheal tube guide channel were superior to direct laryngoscopes with Macintosh blades for all outcomes, except for video laryngoscope intubation time without a channel.
Strengths and limitations	Using the GRADE approach, the quality of evidence was low for success rate, very low for intubation time and very low for glottis visualisation. The findings are specific to difficult airways associated with obesity. Non-UK trials may not be generalisable to clinical practice in the NHS.
Lewis et al. (2017)	
Study size, design and location	Systematic Cochrane review and meta-analyses of 64 RCTs of video laryngoscopy compared with laryngoscopy with Macintosh blades in adults. Of the 64 RCTs, 6 studies reported on a population with known or predicted difficult airway (including 2 studies that specified inclusion of patients with restricted cervical mobility), and 9 studies included patients whose airway was manipulated to simulate a difficult laryngoscopy (a total of 1,640 laryngoscopy procedures in a difficult airway population). Multiple settings, including general anaesthesia, ICU and emergency department. The experience of users was not reported. Locations of primary studies: Ireland (4 studies), Germany (3 studies), Japan (3 studies), USA (2 studies), Canada (2 studies), Singapore (1 study).

Intervention and comparator(s)	Intervention: Video laryngoscopes (n=912): C-MAC (4 studies, n=318), Pentax AWS (6 studies, n=252), GlideScope (5 studies, n=160), McGrath (1 study, n=44), and unknown device name in 5 studies (n=138). Comparator: Direct laryngoscopes with Macintosh blades (n=728).
Key outcomes	Fewer intubation failures with video laryngoscopes when compared with direct laryngoscopes with Macintosh blades in patients with a known or predicted difficult airway, and in those with a simulated difficult airway.
Strengths and limitations	This Cochrane review provides a good summary of earlier evidence (up to February 2015). Non-UK trials may not be generalisable to clinical practice in the NHS.
Pieters et al. (2017)	
Study size, design and location	Systematic review and meta-analyses of 9 studies (RCTs and observational studies, including a total of 1,441 laryngoscopy procedures) of adults, with suspected difficult airway. Setting and user: elective surgery intubations by anaesthetists with more than 2 years' experience with direct laryngoscopy. Locations of primary studies not reported.
Intervention and comparator(s)	Intervention: Video laryngoscopes (n=900): GlideScope (used in 3 studies, n=184), C-MAC (used in 2 studies, n=204), Pentax AWS (n=320), McGrath (n=40), Airtraq (n=20), C-MAC D-Blade (n=32), Berci-Kaplan VLS (n=100). Comparator: Direct laryngoscopes (n=541): Macintosh blade (used in 9 studies), Henderson straight blade (used in 1 study), not defined in 1 study.
Key outcomes	First-attempt success of intubations was greater for video laryngoscopes. No significant differences in time until successful intubation, Cormack–Lehane grade, number of attempts, or dental trauma were found between video and direct laryngoscopy.
Strengths and limitations	The systematic review protocol excluded simulated difficult airways and specified anaesthetist user experience with direct laryngoscopy. Non-UK trials may not be generalisable to clinical practice in the NHS.
Abbreviations: GRADE, Grading of Recommendations Assessment, Development and Evaluation; ICU, intensive care unit; RCT, randomised controlled trial.	

Table 4 Summary of selected user survey studies reporting human factor outcomes

Cook et al. (2018)	
Study size, design and location	User survey study with 2 month feasibility trial stage. Series of user surveys: pre-trial (anaesthetists), mid-trial (anaesthetists and anaesthetist assistants), end-of-trial (anaesthetists), 6 months after trial (anaesthetists) and 8 months after trial (anaesthetic trainees who were in department during 2 month feasibility trial). Single centre (UK).
Intervention and comparator(s)	Intervention: C-MAC video laryngoscopes (mandated in use during the 2 month feasibility stage). Comparator: C-MAC laryngoscopes with Macintosh blades used as direct vision laryngoscopes. Video laryngoscopes remained available to users at the end of the feasibility stage and anaesthetists were able to choose between direct and indirect (video) C-MAC devices.
Key outcomes	Pre-trial survey (n=47 responders): 32% supported change to video laryngoscopy, 28% were against it (reasons included: training, patient safety, team dynamics). Mid-trial survey (n=56 responders): approximately 830 intubations and extubations reported. 7 cases of delay of induction of anaesthesia or extubation, due to a C-MAC not being immediately available, were reported, 2 reports of device power failure, 1 failed intubation with device. 57% reported C-MAC video laryngoscopy had a positive effect on their practice, 8% a negative effect. End-of-trial survey (n=44 responders): no new reports of clinical delays, device failures or failed intubations. 82% reported positive effect, 2% negative. Six-month post-trial survey (n=27 responders): 89% supported change to video laryngoscopy, 4% against. Eight-month post-trial survey (n=19 responders): 84% positive effect, 16% neutral, 0% negative effect.

Strengths and limitations	C-MAC device used due to its multipurpose design as a video laryngoscope or direct laryngoscope. Feasibility stage would have included a difficult airway subgroup, but not exclusively, limiting the generalisability of this study to a difficult airway population. UK user survey directly generalisable to clinical practice in the NHS.
Jones et al. (2018)	
Study size, design and location	User survey (48 anaesthetic assistants) Single centre (UK).
Intervention and comparator(s)	Intervention: C-MAC video laryngoscope. Comparator: None.
Key outcomes	88% had over 2 years' experience of using the C-MAC device. All responders reported that patient safety was improved using C-MAC when compared with standard laryngoscope with Macintosh blade: 63% strongly agreed, and 18% agreed. Most reported that C-MAC made it easier to see when laryngoscopy was difficult: 88% strongly agreed, 10% agreed. Most reported that training of laryngoscopy and intubation was improved: 75% strongly agreed, 23% agreed. Most reported that training of cricoid pressure for trainee operating department practitioners and anaesthetic nurses was improved: 54% strongly agreed, 33% agreed, 13% neither agreed nor disagreed. 42% reported that the need for decontamination of C-MAC was disadvantageous aspect of its use, 38% disagreed and 21% neither agreed nor disagreed. Need to share C-MAC screens between theatres was reported to be disadvantageous in 69%. 49 positive free-text comments were reported, including, for anticipated or unanticipated difficult airway management: improved ease of intubation, improved laryngeal view, and intubation of high-risk patients. 40 negative free-text comments were reported, including: logistics in decontamination, device availability, concerns over short battery life or possibility of power failure, concerns that anaesthetists could become deskilled in direct laryngoscopy.

Strengths and limitations	Not exclusively in difficult airway. UK user survey directly generalisable to clinical practice in the NHS.
Cook and Kelly (2017)	
Study size, design and location	Multi-centre (national survey sent to 335 NHS hospitals in UK).
Intervention and comparator(s)	Intervention: All video laryngoscopes including rigid intubation devices that use digital or optical imaging with intent of facilitating tracheal intubation: Airtraq, AP Venner, Bonfils, Bullard, C-MAC, C-MAC D-Blade, Coopdech, C-Trach, GlideScope, King Vision VL, Levitan FPS, McGrath 5, McGrath Mac, Pentax AWS, Shikani intubating stylet, Upsherscope, Wuscope. Comparator: none.
Key outcomes	Total of 164 responses (teaching hospitals 26%, district general hospital with teaching affiliation 44%, district general hospital 16%, specialist paediatric hospital 3%, other specialist hospital 3%); 160 from consultants, 3 by associate specialists, 1 by senior specialist registrar. 92% reported availability of video laryngoscopy in at least 1 clinical area. Of 804 NHS clinical areas in the 164 respondents' NHS hospitals, 52% reported availability of a video laryngoscope. In all locations and overall, the top 3 devices were Airtraq (48% of all video laryngoscopy locations), GlideScope (18%), C-MAC (with or without D-Blade, 15%). 3 video laryngoscopy devices were not reported to be used at all (Coopdech, Upsherscope and Wuscope), and a further 4 by fewer than 5 respondents (Bullard, C-Trach, Levitan FPS, King VL). Some degree of restriction of use was reported in 32% of anaesthetic departments, 58% of ICUs, 78% of emergency departments. Of the 131 respondents who described elective use of video laryngoscopy in the operating theatre, none reported routine use, less than one-third reported regular use, and 10% reported rare use. A minority (4%) had formal clinical training on use of a video laryngoscope device, 4% practised "see one, do one, teach one" approach, 9% had no structured introduction, 48% trained on a mannequin, 34% had informal introduction into clinical practice.

Strengths and limitations	Survey closed 2014, therefore gives historic view of video laryngoscopy use. Not exclusively in difficult airway population, includes adult and paediatric patients. UK user survey directly generalisable to clinical practice in the NHS.
Green et al. (2017)	
Study size, design and location	Multi-centre (national survey sent to 1,758 non-trainee clinicians in Canadian hospitals).
Intervention and comparator(s)	Intervention: Video laryngoscopy Comparator: Direct laryngoscopy Survey included 3 clinical scenarios: 1) 67-year old female with congestive heart failure 2) 59-year old female with pneumonia 3) 29-year old male trauma patient in a cervical spine immobilisation collar and abrasions on head, chest, and abdomen.
Key outcomes	Responses from 882 clinicians: 73% emergency medicine, 27% ICU clinicians. Most practised at an academic hospital (79%) and had more than 5 years of experience (83%). Across all 3 clinical scenarios, most clinicians selected a preference of direct laryngoscopy with a Macintosh blade (85%), followed by video laryngoscope (38%) and bougie-assisted direct laryngoscopy (20%). Back-up devices used by clinicians if their primary intubation strategy was unsuccessful were: extraglottic device (59%) followed by percutaneous cricothyrotomy (5%).
Strengths and limitations	Gives an estimate of video laryngoscope use in Canada specific to emergent endotracheal intubation in critically ill patients. Specific video laryngoscopy devices in use are not described. Non-UK studies may not be generalisable to clinical practice in the NHS.
Wong et al. (2014)	
Study size, design and location	Multi-centre (national survey sent to 2,532 anaesthesiologists in Canadian hospitals).

Intervention and comparator(s)	Intervention: Video laryngoscopy Comparator: Direct laryngoscopy Survey included 2 clinical scenarios: including: 1) an unanticipated difficult intubation 2) failed direct laryngoscopy.
Key outcomes	Responses from 997; 71% from teaching practice. 90% chose video laryngoscopy for the unanticipated difficult intubation scenario (where direct laryngoscopy had failed). Previous experience with video laryngoscopy was reported as 27% on mannequin (one of lowest proportions alongside optical stylet with 26%), 99% reported use of video laryngoscopy on patients (the highest proportion when compared with awake/asleep flexible bronchoscope intubation, intubating laryngeal mask airway, optical stylet, retrograde wire set), 99% reported comfort in using video laryngoscopy.
Strengths and limitations	Potential selection bias in results (from 40% response rate, non-translation of survey into French excluding specific Canadian provinces, distributed via email only). Non-UK studies may not be generalisable to clinical practice in the NHS.
Abbreviations: ICU, intensive care unit; RCT, randomised controlled trial.	

Recent and ongoing studies

Thirty recruiting interventional trials with video laryngoscopes were listed on clinicaltrials.gov (search date 14 August 2018), only 2 are within a UK setting and both are in paediatrics:

- Video Laryngoscopy in Newborn Babies V1. ClinicalTrials.gov identifier: NCT03265548. Status: Recruiting. Condition: Respiratory Distress Syndrome. Devices: Video laryngoscope. Outcome measures: Number of attempts to successful intubation, team confidence around tube placement at the time of tube placement. Participating site (single centre): UK (Royal Devon and Exeter NHS Foundation Trust).
- The Videolaryngoscopy in Small Infants. ClinicalTrials.gov identifier: NCT03396432. Status: Recruiting. Condition: Surgery, Endotracheal Anaesthesia. Devices: Video Laryngoscopy for ET placement, Device: Direct Laryngoscopy for ET Placement. Outcome measures: First-attempt success, Hypoxia. Participating sites (multi-centre): USA, Australia, UK (Royal Aberdeen

- Children's Hospital, Scotland).

Specialist commentator comments

Comments on this technology were invited from clinical specialists working in the field. The comments received are individual opinions and do not represent NICE's view.

All 3 specialists were familiar with and had used this technology before.

Level of innovation

One specialist commentator confirmed that the technology is innovative when compared with current standard of care (direct laryngoscopy). However, there was a general consensus from all specialist commentators that the technology has been available in the NHS for some time and is evolving, but has not been superseded or replaced. Video laryngoscopes are therefore used as well as the current standard care, but have the potential to replace direct laryngoscopes in the future.

Potential patient impact

All specialist commentators agreed that video laryngoscopes have the ability to provide better visualisation of the larynx (when compared with direct laryngoscopy). This allows the passage of a tracheal tube under improved view more frequently, promoting safer intubation. One specialist commentator considered that the technology would particularly benefit patients with anticipated difficult airways (first-line use). However, 1 described their reservation for paediatric practice, because video laryngoscopes are still rather bulky and can interfere with the placement of nasogastric tubes and pharyngeal packs.

Potential system impact

Specialist commentators described improved training, fewer failed or difficult intubations and reduction in escalation of care (including front of neck access, wake-ups and subsequent postponements of surgery) as associated effects of using video laryngoscopes. One specialist commentator also stated that the use of video laryngoscopes may also provide improved operator ergonomics.

All specialist commentators confirmed that video laryngoscopes are already used in training, with 2 stating that video laryngoscopes ease training because both trainer and trainee see the same view (which does not happen with direct laryngoscopy). Specialist commentators also highlighted

differences between video laryngoscopes (for example, in blade shape) that influence training, and are likely not interchangeable between different video laryngoscopes.

Infection control concerns in the use of reusable devices were raised, with 1 describing a general trend towards disposable handles and blades. One commentator also highlighted that power failure would be a concern if a video laryngoscope was the only device available. Another specialist commentator stated the potential for trauma, different to that seen with direct laryngoscopy.

General comments

Three specialist commentators agreed that all tracheal intubations would be eligible for video laryngoscopy. However, 1 specialist commentator stated that they currently only ask for video laryngoscopes to be on standby for about 10% of patients who need to be intubated, as well as standard direct laryngoscopes. Another stated that only 1% to 4% of the 1.5 million intubations done in the UK would be expected to be difficult to intubate with direct laryngoscopy. However, because these cases can be difficult to predict, operators would have to either switch to routine video laryngoscopy (that is, replacing standard direct laryngoscopy) or users would have to become skilled in video laryngoscopy and use frequently enough to stay competent when used as well as standard direct laryngoscopy. This commentator noted a general trend towards video laryngoscopes replacing direct laryngoscopes. Another specialist commentator advised that the incidence of failed intubation and therefore the need for rescue video laryngoscopy varies according to the population and setting, citing around 1 in 1,500 in the elective setting; 1 in 300 during rapid sequence induction in the obstetric setting and 1 in 75 in the emergency department.

All specialist commentators stated that the capital cost would be higher if video laryngoscopes became first choice for all patients. However, 1 specialist commentator stated that the cost differential is reducing. Another commented that unless the price can match direct laryngoscopes, video laryngoscopes should not be used in all patients. This commentator stated that cost assessments should consider both disposable and reusable technologies (including sterilisation).

One specialist commentator described the experience at their trust, in which most of their 40 consultants now use video laryngoscopes regularly, some exclusively. Historically, 5 to 10 patients from 5,000 to 7,000 intubations a year were woken and had their surgery postponed because tracheal intubation was not successful with direct laryngoscopy. Since video laryngoscopes were made widely available in their institution, the rate of unsuccessful intubation leading to wake up and postponement has dropped to 1 to 2 cases per year.

Specialist commentators

The following clinicians contributed to this briefing:

- Dr John Andrzejowski, consultant anaesthetist, Sheffield Teaching Hospital NHS Trust, has received paid consultancy from The 37° Company and Smiths Medical for advice on warming products in anaesthesia.
- Dr Chris Frerk, consultant anaesthetist, Northampton General Hospital, was Chair of the Difficult Airway Society 2015 Airway Guidelines group (cited in this briefing).
- Dr Jon Smith, consultant paediatric cardiothoracic anaesthetist, The Newcastle-upon-Tyne Hospitals NHS Foundation Trust, is involved with the NICE External Assessment Centre Airway Intervention Registry (AIR) project, in an advisory capacity (unpaid).

Development of this briefing

This briefing was developed by the Newcastle and York External Assessment Centre. The interim process and methods statement sets out the process NICE uses to select topics, and how the briefings are developed, quality-assured and approved for publication.

ISBN: 978-1-4731-3202-3